Connected Full-Self Driving Vehicles: A Political, Economics, Social, and Technical (PEST) Analysis

Hyeseong Bak - 114180869
Jinsu Beom -11593577
On Hyuck Choi - 114742243
Jonghyun Moon - 113949636
Jihye Yoon - 115960721

EST 320.90

Anthony J. Pennings, PhD

December 10, 2024

Table of Contents

Abstract

The advent of Connected cars with Full-Self Driving (FSD) vehicles represents a significant technological leap in modern transportation, integrating artificial intelligence (AI), big data, and advanced sensor systems to redefine mobility. This paper provides a comprehensive Political, Economic, Social, and Technical (PEST) analysis to examine the multifaceted implications of FSD technology. On the technical front, the study explores the role of diverse sensors, such as cameras, LiDAR, radar, and ultrasound, alongside sensor fusion techniques, mapping systems like SLAM, and real-time path-planning algorithms. These innovations enable accurate navigation, obstacle avoidance, and improved safety.

The political discussion addresses regulatory challenges, international standards, and the geopolitical dynamics shaping autonomous vehicle adoption. Economic insights focus on the transformative effects of FSD on the automotive value chain, emphasizing the emergence of CASE (Connected, Autonomous, Shared & Service, Electric) and Mobility-as-a-Service (MaaS) business models. Social and ethical considerations are also highlighted, including public trust, cybersecurity concerns, and ethical dilemmas such as decision-making algorithms in critical scenarios.

By analyzing these dimensions, this paper underscores the transformative potential of FSD vehicles to create safer, smarter, and more sustainable transportation systems. At the same time, it identifies key barriers and challenges that must be addressed to achieve widespread societal acceptance and effective implementation. Through this PEST analysis, the study provides valuable insights into the future trajectory of connected FSD vehicles in shaping global mobility.

Introduction

Through the development of technologies, we are not only benefiting but also changing our lives in different ways. Full self-driving cars are one of the innovative technologies that various companies are striving to invent. The convergence of Full-Self Driving (FSD) technology, big data, and artificial intelligence (AI) is reshaping the landscape of modern transportation. By integrating advanced sensor systems and machine learning algorithms, FSD vehicles aim to deliver safer, more efficient, and more sustainable mobility solutions. This transformation is not merely technological; it extends to societal structures, economic systems, and regulatory frameworks, fundamentally altering how individuals and communities engage with mobility.

This paper conducts a Political, Economic, Social, and Technical (PEST) analysis to examine the multifaceted impact of connected FSD vehicles. It delves into the technologies underpinning FSD systems, including sensor fusion, localization, and path planning. Moreover, it explores the political and ethical dilemmas arising from autonomous vehicle adoption, the economic implications for industries and consumers, and the social challenges in fostering public trust. Through this comprehensive analysis, we seek to illuminate the transformative potential of FSD vehicles in shaping the future of mobility. Conducting a PEST analysis for Connected cars with Full Self-Driving (FSD) Cars helps in understanding the broader external factors that influence their development, adoption, and integration into society. Below is a comprehensive PEST analysis covering Political, Economic, Social, and Technological aspects. PEST analysis is a strategic tool used to evaluate the Political, Economic, Social, and Technological factors influencing an industry or innovation. Here’s a PEST analysis of Connected and Fully Self-Driving Cars (CAVs and FSDs):

Technical Aspects

Introduction

The technical aspects of Connected cars with Full-Self Driving (FSD) vehicles are the cornerstone of their functionality and success, enabling these systems to navigate complex environments and make real-time decisions with precision. Understanding these technical foundations is essential for readers to fully grasp the broader implications of our paper, as the capabilities and limitations of FSD vehicles are deeply rooted in their underlying technologies. This section explores the essential components powering FSD systems, including advanced sensors like cameras, LiDAR, radar, and ultrasound, as well as the sensor fusion frameworks that integrate these inputs into a cohesive understanding of the environment. Additionally, localization and mapping technologies, such as GNSS, Inertial Navigation Systems (INS), and Simultaneous Localization and Mapping (SLAM), are examined to highlight their critical roles in navigation and obstacle avoidance. Recognizing the importance of these technologies, we have placed this section at the beginning of our paper to establish a strong foundation for discussing the political, economic, and social aspects of Connected cars with FSD vehicles.

Cameras

Self-driving cars depend on a combination of advanced sensors to navigate their environments safely and efficiently. These sensors enable the vehicle to perceive its surroundings, interpret critical data, and make decisions in real time. Among these, RGB cameras play a vital role by capturing detailed visual information such as colors, textures, and shapes.[1] This information helps the system recognize traffic signs, lane markings, and

[1] Nguyen, T.-T.-N., Phan, T.-D., Duong, M.-T., et al. (2022). Sensor Fusion of Camera and 2D LiDAR for Self-Driving Automobile in Obstacle Avoidance Scenarios. *2022 International Workshop on Intelligent Systems (IWIS)*. https://doi.org/10.1109/IWIS56333.2022.9920917

pedestrians, providing a foundational understanding of the environment. However, raw image data alone cannot be directly used for decision-making.[2]

To address this, advanced Computer Vision algorithms, including Convolutional Neural Networks (CNNs), process visual data to extract essential features.[3] These features enable the system to identify objects and interpret lane positions, thus converting raw images into actionable insights.

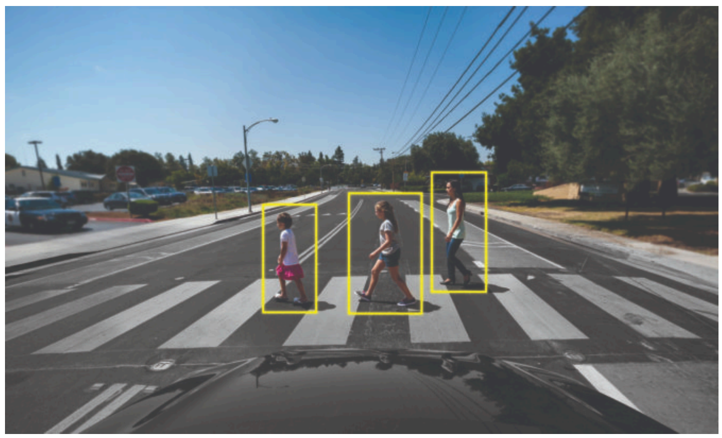


Figure 1. An autonomous vehicle utilizes camera data to detect and interpret objects in its surroundings. Adapted from *How Does a Self-Driving Car See?* NVIDIA Blog., CC BY.

LiDAR Sensors

While cameras provide valuable visual context, they are inherently limited in measuring depth and distance accurately. To overcome this, LiDAR Sensors (Light Detection and Ranging) are used.[4] LiDAR sensors emit laser pulses and measure the time it takes for these pulses to return after hitting an object. This process creates high-resolution 3D maps of the environment, allowing the system to identify the precise location of obstacles, lanes, and other objects.[5]

---

[2] Zheng, Y., & Su, J. (2023). Algorithm Design of Self-Driving Vehicle Based on Visual Sensing Technology. *International Journal of Intelligent Systems.* https://doi.org/10.1002/int.12345
[3] Yeong, D. J., Velasco-Hernandez, G., Barry, J., & Walsh, J. (2021). Sensor and Sensor Fusion Technology in Autonomous Vehicles: A Review. *Sensors*, *21*(6), 2140. https://doi.org/10.3390/s21062140
[4] Zheng, Y., & Su, J. (2023). Algorithm Design of Self-Driving Vehicle Based on Visual Sensing Technology. *International Journal of Intelligent Systems*. https://doi.org/10.1002/int.12345
[5] Tummala, M., & Pravin, A. (2023). LiDAR Sensor for Self-Driving Cars. *8th International Conference on Communication and Electronics Systems (ICCES)*. https://doi.org/10.1109/ICCES56333.2023.9920917

LiDAR excels at spatial mapping under various lighting conditions, making it indispensable for creating a detailed environmental model.[6] However, it cannot measure object velocity, which limits its utility in dynamic scenarios such as tracking moving vehicles.[7] This is where Radar Sensors come into play.

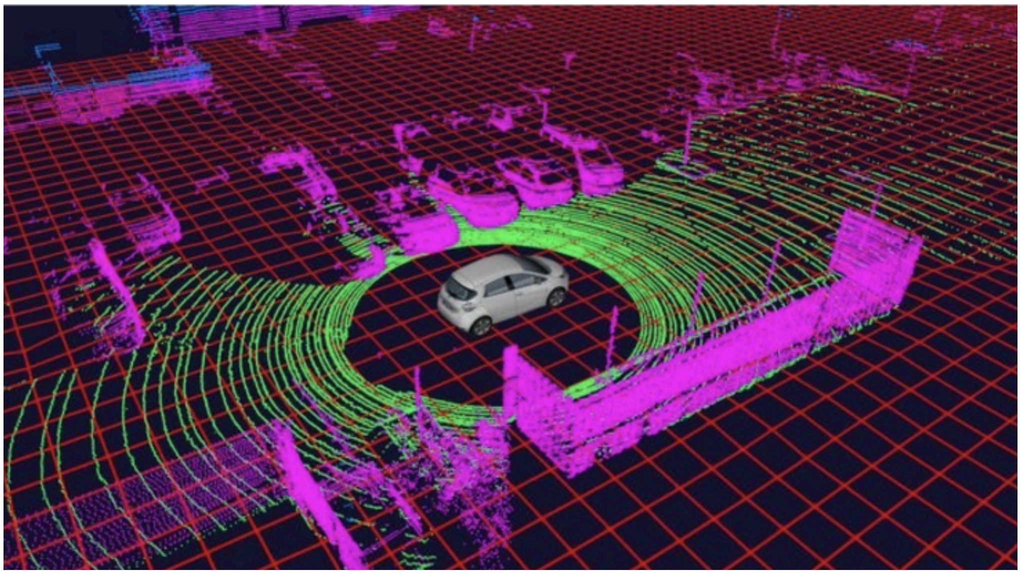


Figure 2. A visualization showing how a LiDAR sensor performs a 360° rotation to collect data of its surroundings. Adapted from *Ground Estimation and Point Cloud Segmentation Using SpatioTemporal Conditional Random Field. 1105-1110. 10.1109/IVS.2017.7995861.,* CC BY

Radar Sensors

Radar Sensors address the dynamic tracking limitation of LiDAR by providing accurate velocity and distance measurements.[8] Radar uses radio waves to detect objects and operates on the Doppler Effect, where the frequency of the returned signal shifts based on whether an object is moving toward or away from the sensor.[9] This allows Radar to accurately track the speed and direction of moving objects, making it invaluable for tasks like adaptive cruise control and

---

6 Ibid.
7 Yeong, D. J., Velasco-Hernandez, G., Barry, J., & Walsh, J. (2021). Sensor and Sensor Fusion Technology in Autonomous Vehicles: A Review. *Sensors*, *21*(6), 2140. https://doi.org/10.3390/s21062140
8 Ibid.
9 NASA. (2020). Doppler Lidar Makes Self-Driving Cars Safer. *NASA Spinoff*. https://spinoff.nasa.gov/Spinoff2020/t_8.html

collision avoidance.[10] Radar also performs reliably in adverse weather conditions, where other sensors like cameras might struggle.[11] Its ability to detect moving objects over long distances further strengthens its role in ensuring safety in highway scenarios.[12] However, at close ranges, Radar's resolution decreases, making it harder to detect small or precise movements, and therefore Ultrasound Sensors are adopted.[13]

Ultrasound Sensors

For short-range detection, Ultrasound Sensors provide the necessary precision. These sensors emit ultrasonic waves and calculate the distance to nearby objects by measuring the time it takes for echoes to return. Ultrasound sensors are particularly useful in close-range tasks such as parking assistance and low-speed obstacle detection.[14] Their high resolution at short distances ensures accurate detection in tight spaces. However, their performance diminishes significantly as distance increases, limiting their effectiveness in broader scenarios.

Sensor Fusion

The data from these various sensors are combined through Sensor Fusion, which integrates inputs from Cameras, LiDAR, Radar, and Ultrasound sensors into a cohesive environmental model.[15] Each sensor contributes unique strengths: Cameras deliver rich visual

---

[10] Yeong, D. J., Velasco-Hernandez, G., Barry, J., & Walsh, J. (2021). Sensor and Sensor Fusion Technology in Autonomous Vehicles: A Review. *Sensors*, *21*(6), 2140. https://doi.org/10.3390/s21062140
[11] Ibid.
[12] Ibid.
[13] Dominey, S. (2021, December). How radar outmaneuvers ultrasonic in automated parking. *Texas Instruments*. https://www.ti.com/lit/ta/sszt112/sszt112.pdf
[14] Texas Instruments. (2019, August). Using Ultrasonic Technology for Smart Parking and Garage Gate Systems. *Texas Instruments Incorporated.* https://www.ti.com/lit/ab/slaa911/slaa911.pdf
[15] Nguyen, T.-T.-N., Phan, T.-D., Duong, M.-T., et al. (2022). Sensor Fusion of Camera and 2D LiDAR for Self-Driving Automobile in Obstacle Avoidance Scenarios. *2022 International Workshop on Intelligent Systems (IWIS)*. https://doi.org/10.1109/IWIS56333.2022.9920917

context, LiDAR provides detailed 3D spatial mapping, Radar tracks motion and velocity, and Ultrasound ensures precise close-range detection. Sensor Fusion reconciles these different data streams, creating a comprehensive and accurate understanding of the environment. This allows the system to make well-informed decisions, such as determining the safest routes, avoiding obstacles, or stopping for pedestrians.[16]

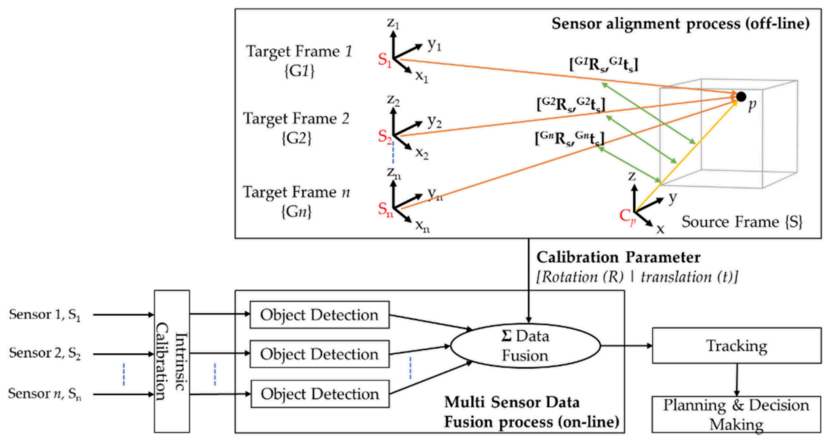


Figure 3. The image illustrates a multi-sensor data fusion framework, showing sensor alignment for object detection, tracking, and decision-making in autonomous systems, Adapted by *Sensor and Sensor Fusion Technology in Autonomous Vehicles: A Review. Sensors* 2021, CC BY.

To optimize Sensor Fusion, various advanced computational algorithms are employed, each tailored to specific tasks.[17] One such algorithm is LiteSeg, which performs semantic segmentation to distinguish safe driving areas from obstacles, assisting the vehicle in planning safe trajectories.[18] Additionally, Adaptive Breakpoint Detection (ABD) clusters LiDAR point clouds to identify objects, and the Random Sample Consensus (RANSAC) algorithm fits linear shapes to these clusters, enhancing obstacle boundary detection.[19] RANSAC is an iterative

[16] Yeong, D. J., Velasco-Hernandez, G., Barry, J., & Walsh, J. (2021). Sensor and Sensor Fusion Technology in Autonomous Vehicles: A Review. *Sensors*, *21*(6), 2140. https://doi.org/10.3390/s21062140
[17] Ibid.
[18] Nguyen, T.-T.-N., Phan, T.-D., Duong, M.-T., et al. (2022). Sensor Fusion of Camera and 2D LiDAR for Self-Driving Automobile in Obstacle Avoidance Scenarios. *2022 International Workshop on Intelligent Systems (IWIS)*. https://doi.org/10.1109/IWIS56333.2022.9920917
[19] Ibid.

algorithm that effectively estimates a model even when the data contains significant noise or outliers, making it ideal for extracting reliable obstacle boundaries from noisy point cloud data.[20]

However, these are just a few examples of the many algorithms used in Sensor Fusion. Other techniques, such as Kalman Filters for estimating the state of moving objects, Particle Filters for managing uncertainties, and Simultaneous Localization and Mapping (SLAM) for constructing and updating maps in real time, also play critical roles.[21] SLAM, in particular, will be discussed in more detail later in this paper. Together, these methods enhance the accuracy, robustness, and efficiency of the fused data, enabling the vehicle to make rapid and precise decisions under varying conditions.[22]

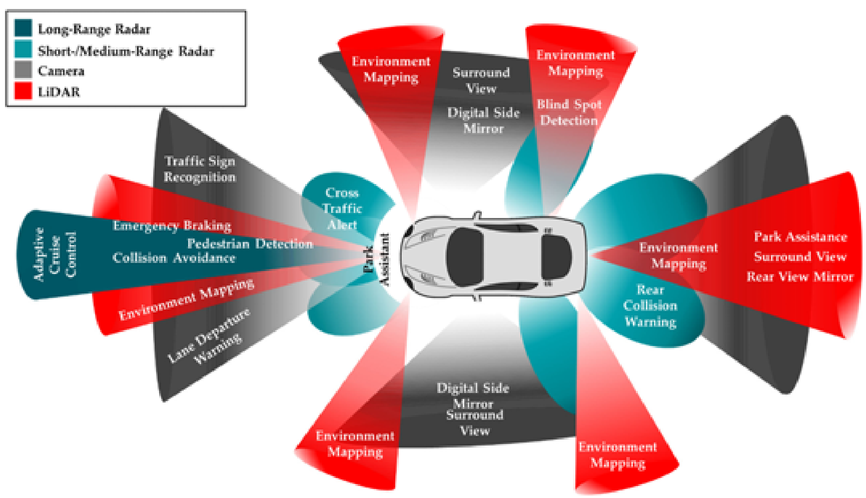


Figure 4. Overall visualization of how sensors collect data from their surroundings. Adapted from *Sensor and Sensor Fusion Technology in Autonomous Vehicles: A Review*. 2021, CC BY.

By leveraging the strengths of multiple sensors and integrating their data through Sensor Fusion, self-driving cars achieve a comprehensive understanding of their environment. This capability ensures that they can navigate complex and dynamic driving scenarios safely and

[20] Ibid.
[21]Yeong, D. J., Velasco-Hernandez, G., Barry, J., & Walsh, J. (2021). Sensor and Sensor Fusion Technology in Autonomous Vehicles: A Review. *Sensors*, *21*(6), 2140. https://doi.org/10.3390/s21062140
[22] Nguyen, T.-T.-N., Phan, T.-D., Duong, M.-T., et al. (2022). Sensor Fusion of Camera and 2D LiDAR for Self-Driving Automobile in Obstacle Avoidance Scenarios. *2022 International Workshop on Intelligent Systems (IWIS)*. https://doi.org/10.1109/IWIS56333.2022.9920917

efficiently.[23] The combination of cutting-edge sensor technology and advanced algorithms is crucial in driving the future of autonomous vehicles, enabling them to operate reliably under diverse conditions.[24]

Localization

Furthermore, not only the mentioned technologies are important aspects of the autonomous cars, but also localization and mapping technologies play important roles in such development. As mentioned in the previous paragraphs, through the data gathered by sensor systems and computer vision, this information then can be utilized to make autonomous driving more efficient and perfectly operate. Localization and mapping, for instance, are crucial for navigation, collision avoidance, and decision-making in fully self-driving vehicles. Therefore, errors in localization and mapping can lead to traffic disruptions or accidents, as high precision and accuracy are essential for FSD systems to function properly.

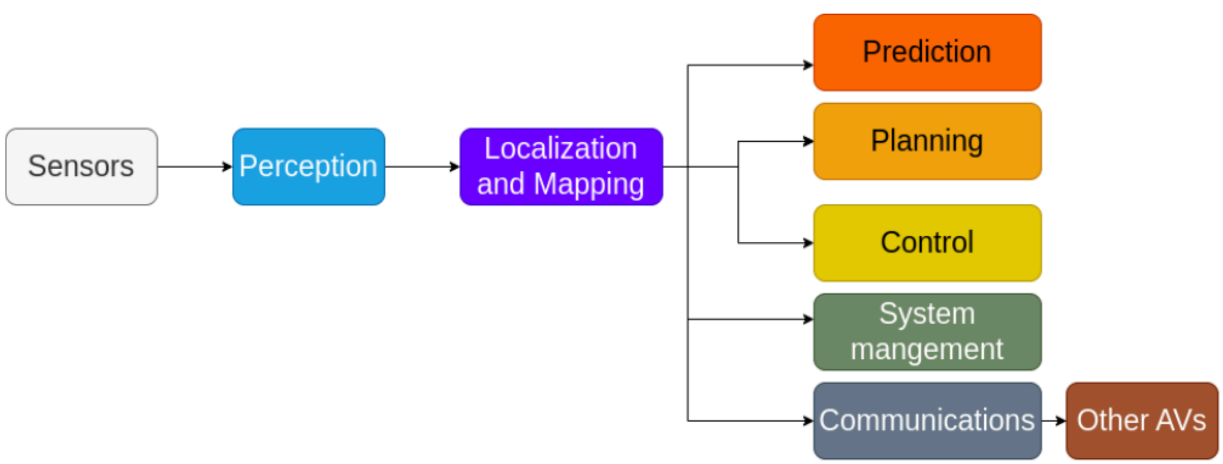


Figure 5. The process of Full-Self Driving systems. Adapted from *Localization and Mapping for Self-Driving Vehicles: A survey*, by Charroud et al., 2024, CC BY.

[23] Ibid.
[24] Zheng, Y., & Su, J. (2023). Algorithm Design of Self-Driving Vehicle Based on Visual Sensing Technology. *International Journal of Intelligent Systems.* https://doi.org/10.1002/int.12345

As shown in the figure 5, it shows the process of full-self driving systems. From the sensors, the computer gathers information of the environment to visualize and analyze. Then it begins to perceptualize through localization and mapping. Localization and mapping technologies are further developed into planning and control algorithms which then control the vehicle to find its way in the real world. Localization refers to the object that can localize and place in the map according to the various methods processed in different tools. This can be shown by the equation as indicated below:

$$x_t = [a_t, b_t, \theta_t]$$

where a_t *and* b_t are the cartesian coordinates of the vehicle on the X-axis and Y-axis, while θ_t is the rotation of the vehicle.[25] With this vector equation, the computer calculates the location of the car, and this is the fundamental theory of how the autonomous vehicle will settle its own location in the world.

Initially, GPS and Global Navigation Satellite Systems (GNSS) are engaged in localization.[26] These are used to gather information from three satellites, navigate and get information as the car self drives. GNSS provides global positioning but is weak to signal blockages. For example, in tunnels, autonomous cars cannot get appropriate signals of GNSS which errors can exceed up to 3 meters. Due to the limitation of GNSS, another method was able to be adapted to localization - Inertial Navigation Systems (INS), which rely on accelerometers and gyroscopes that drift errors over time. The combination of INS to GNSS definitely increased the accuracy of localization for autonomous vehicles. While INS takes place in the full-self driving technology, GPS is no longer reliable in Navigation. GPS depending on the external

---

[25] Charroud, A., Moutaouakil, K. E., Palade, V., Yahyaouy, A., Onyekpe, U., & Eyo, E. U. (2024). Localization and Mapping for Self-Driving Vehicles: A survey. *Machines*, *12*(2), 118. https://doi.org/10.3390/machines12020118
[26] Ibid.

signals is not effective and stable, yet INS does not require any external signals. It determines an object's position in relation to its origin location or the previous position. This is ultimately more reliable where GPS signals are weak or blocked such as in tunnels or concentrated urban areas.[27] The Inertial Navigation Systems functions with three equipment like gyroscope, accelerometer, and magnetometers or GNSS sensors. Gyroscope helps determine the position and orientation of the vehicle which is measured by the Coriolis effect.[28]

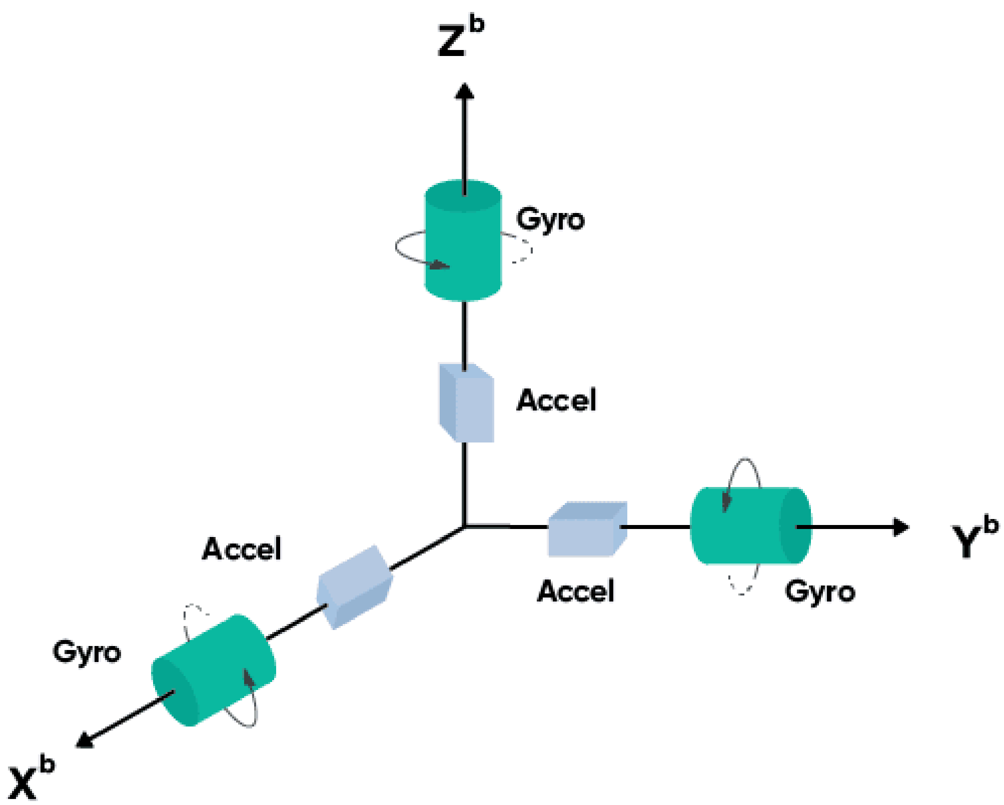


Figure 6. The system of gyroscope and accelerator in terms of the X, Y, and Z axes (INS). Adapted from *Inertial Navigation Systems (INS) – An Introduction,* CC BY

In figure 6, it shows the basic fundamentals of how Inertial Navigation Systems work.

[27] Wilkerson, M. (2024, June 20). *What is an INS? Inertial Navigation Systems Explained*. pointonenav.com. https://pointonenav.com/news/ins-inertial-navigation-system/
[28] Ibid.

To elaborate, Inertial Navigation Systems (INS) are crucial for determining a vehicle's position, orientation, and velocity without relying on external references like GPS. They achieve this through a combination of accelerometers and gyroscopes as shown in figure 6. They measure linear acceleration and angular velocity, respectively.[29] By integrating these measurements over time, an INS can calculate the vehicle's current state based on its initial position and orientation.

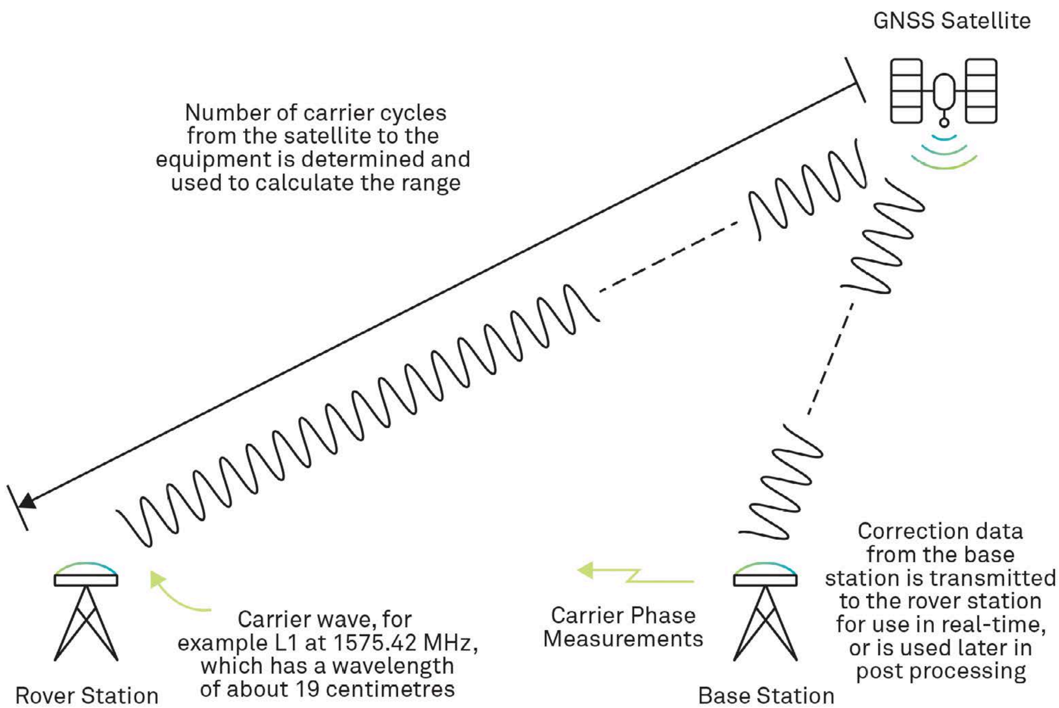


Figure 7. The overview of Real Time Kinematic, Adapted from *Real-Time Kinematic (RTK)*, by noVatel, CC BY.

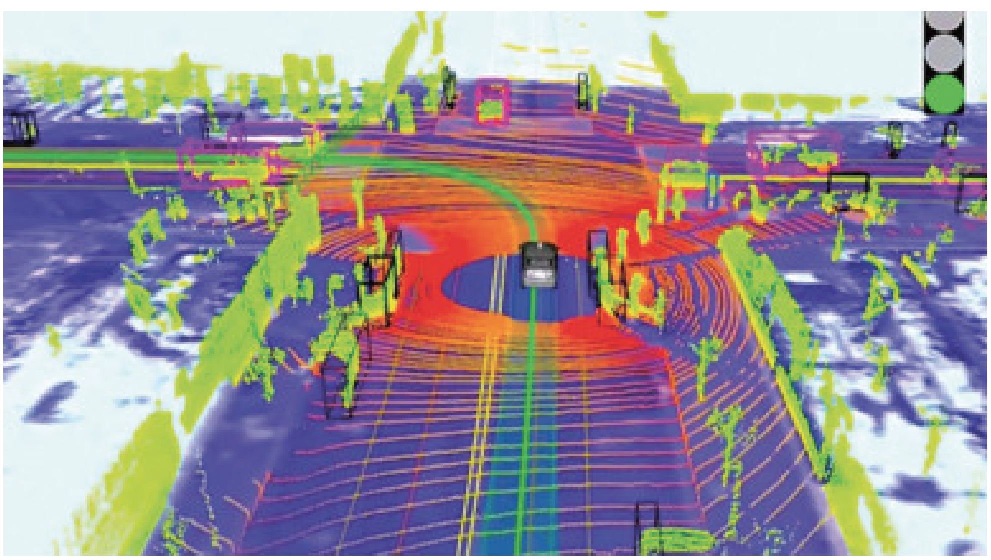
In the process of Inertial Navigation System, Real-Time Kinematic (RTK) is highly engaged technology as described in the figure 7. Real-Time Kinematic refers to the technique which enhances the positioning accuracy of Global Navigation Satellite Systems (GNSS). With the help of an RTK receiver, it can be possible for the object to maintain and raise the precision of its position up to centimeters.

[29] Noko, M. (2021, October 26). How to deploy inertial navigation sensors in automotive Systems. *IEEE Spectrum*. https://spectrum.ieee.org/inertial-navigation-system

As shown in the figure 7, the two stations called Base station and Rover station are the major components of the RTK system. The Base station receives signals from the satellites through multiple layers of atmosphere. In this process, the accuracy of the position would be imprecise. Therefore, the signals of the Base station are transmitted to Rover station while it also gets the new positioning information from the satellites. By comparing the data, Rover station reduces the rate of inaccuracy by eliminating errors.[30]

Mapping (SLAM)

In addition to these technologies, the advanced localization integrates multiple sensors in order to enhance their accuracy. Through the data collected from the localization system, mapping is another important factor in Full-Self Driving systems. Simultaneous Localization and Mapping (SLAM) is one of the major technologies adapted to raise the accuracy. This creates maps for visualization and eventually localizes vehicles within the new map created. This is especially useful in the unknown environment where the object needs to detect the surroundings to instantly create a new map.



[30] *Real-Time Kinematic (RTK)*. (n.d.). NovAtel. https://novatel.com/an-introduction-to-gnss/resolving-errors/rtk

Figure 8. The mapping illustration through SLAM method and data gathered by LiDAR, by Seif et al., 2016, CC BY.

In figure 8, it shows the illustration of how an autonomous car detects the surroundings through SLAM technology. Self-driving cars rely on SLAM software to detect various elements on the road, including lane markings, traffic signals, and other vehicles. This technology is more precise and responsive than GPS, making it a critical component in realizing the full potential of autonomous vehicles.[31] Mapping, the representation of an environment, is a high-definition (HD) map, pre-built and provides detailed environmental data, including geometric and semantic layers.

Path Planning with Connected Networks

With all these technologies together, autonomous cars can make their own choice in path planning. Path planning by detecting the surrounding objects and the road can make it possible to move by itself. This is also an example of how autonomous vehicles should be connected with other networks and technologies. Through path planning, autonomous vehicles can decide their own ways to make safer decisions in driving.[32] This is then controlled by different types of algorithms and artificial intelligence analyzed with huge data or just big data which is encoded in the computer. Over time, AI can come up with more precise and accurate decisions in various circumstances.

In the process of path planning, a full-self driving system detects and connects with networking systems. The network systems structured by a combination of public-switched wireless communications, GPS, satellites, and Vehicular Ad hoc Networks (VANETs) play

[31] McMinn, E. (2024, April 23). Understanding SLAM in Robotics and Autonomous Vehicles. *Flyability*. https://www.flyability.com/blog/simultaneous-localization-and-mapping
[32] Hui, J. (2018, June 19). Self-driving car: Path planning to maneuver the traffic. *Medium*. https://jonathan-hui.medium.com/self-driving-car-path-planning-to-maneuver-the-traffic-ac63f5a620e2

important roles for autonomous vehicles to function properly.[33] Firstly, public-switched wireless communications are more likely on the wireless network which differs from the fixed networking systems like broadband and World Wide Web with IP addresses. Public-switched wireless communications including Long-Term Evolution (LTE), 4th Generation (4G), and 5th Generation (5G) networks are changing the world where the spatial divisions do not serve as a limitation of signaling, but rather take advantage of being a new data center all around the world.[34]

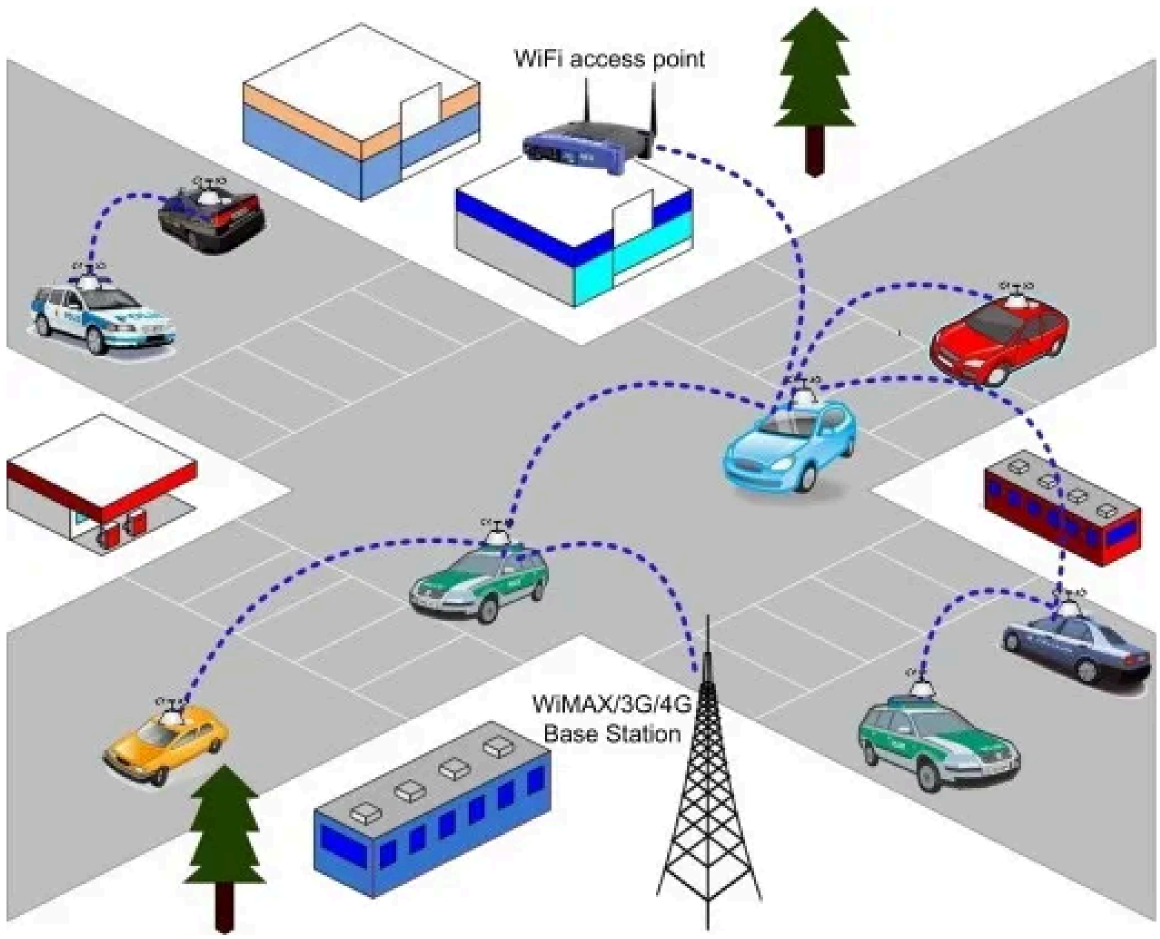


Figure 9. The illustration of how vehicles are connected through other networking systems. Adapted from *Networking Connected Vehicles in the Automatrix*, 2024, CC BY

[33] Pennings, A.J. (2024, Jan 15). Networking Connected Cars in the Automatrix. *apennings.com* https://apennings.com/telecom-policy/networking-in-the-automatrix/
[34] Ibid.

In Figure 9, it shows how autonomous cars are connected from different network infrastructures. The next network system is satellites. Through satellites, not only positioning the vehicles through localization and mapping is vital, but also cars being updated over time takes place with satellites. For example, Over-The-Air (OTA) is one of the technologies engaged in software updates and firmware upgrades. Since the updates are transmitted through satellite signals, there is no need for drivers to visit technicians for assistance.[35] Moreover, through Vehicles-to-Everything (V2X) is also done by satellites where vehicles can share information to sensors, cameras, and other types of vehicles.[36] Information such as traffic signals, surrounding data, and other vehicles can help the computer to have better data and background where all other network systems will be connected and share information in between each other. Lastly, improved vehicle performance is ensured via Vehicular Ad Hoc Networks, which altogether improve the quality of communications with roadside infrastructure. VANETs are extremely dynamic, with node vehicles frequently joining or leaving the system; hence, topological changes may also be frequent.

Vehicles can communicate directly with other vehicles (V2V - Vehicle to Vehicle) and with infrastructure (V2I - Vehicle to Infrastructure) to exchange some key information-such as their speed, location, and traffic conditions to enhance safety and efficiency. Operating in an ad hoc manner, vehicles are both nodes and routers, connecting with each other based on their proximity and broadcasting warnings related to traffic. Low latency communication is necessary for real-time applications such as collision avoidance, while security and privacy ensure data

---

[35] Ibid.

[36] *What is Vehicle-to-Everything (V2X)?* (n.d.). https://blackberry.qnx.com/en/ultimate-guides/software-defined-vehicle/vehicle-to-everything#:~:text=Vehicle%2Dto%2DEverything%20(V2X)%20is%20where%20a%20vehicle,systems%20using%20wireless%20data%20connectivity.

accuracy and confidentiality. Challenges regarding signal fading and attenuation in large urban areas are the limiting factors for maintaining good and reliable communication.[37] With connected systems for cars, they gather information from sensors, but they also get stored data from the data centers where big data takes place. While obtaining information from the data center increases the accuracy of the real-time traffic updates and road conditions or changes; places like not developed cities or environments without networking systems, this can eventually affect the way cars obtain information from the data centers. Since they have to solely depend on their onboard computer systems, this would hinder their abilities to make consistent updates on path planning.

Conclusion

In summary, self-driving cars leverage a combination of advanced sensor systems, computational algorithms, and connected network technologies to navigate complex environments safely and efficiently. Sensors such as cameras, LiDAR, radar, and ultrasound work together through sensor fusion to provide a comprehensive understanding of the surroundings, while localization and mapping techniques like GNSS, INS, RTK, and SLAM ensure precise positioning and adaptability in diverse scenarios. These systems are complemented by sophisticated path-planning algorithms and connected networks, including V2V and V2I communication, which enable real-time decision-making and data sharing. Despite challenges like signal blockages, dynamic environments, and data dependency, the integration of big data and artificial intelligence continues to enhance the reliability and safety of autonomous vehicles, paving the way for a transformative shift in modern transportation.

---

[37] Pennings, A.J. (2024, Jan 15). Networking Connected Cars in the Automatrix. *apennings.com* https://apennings.com/telecom-policy/networking-in-the-automatrix/

Political Issues

Introduction

The adoption of fully autonomous (FSD) vehicles introduces significant political challenges and opportunities. As autonomous technologies advance, policymakers and governments are tasked with developing regulations that balance innovation with public safety, cybersecurity, and ethical considerations. The political implications extend beyond national borders and impact global standards, international cooperation, and economic competition between nations.

This section explores the political landscape surrounding FSD vehicles, focusing on key areas such as regulatory frameworks, global policy coordination, and the role of governments in addressing cybersecurity risks and ethical dilemmas. By analyzing notable incidents such as the Uber self-driving car accident and examining international efforts such as the UNECE Code, this analysis highlights the complexities of integrating FSD vehicles into society while maintaining public trust and safety.

Uber Car Accidents

The 2018 Uber self-driving car crash in Tempe, Arizona, was the first known pedestrian fatality involving a self-driving car. The crash occurred when the vehicle, operating in autonomous mode, failed to recognize Ms.Hertzberg as she was crossing the street outside the crosswalk. The emergency braking system did not function instantly while the passenger was distracted by mobile devices.[38] As a result, an investigation revealed serious flaws in Uber's safety protocols, including poor system design and a lack of oversight.

The Uber self-driving car accident raised the importance and awareness of safety in autonomous vehicle development by exposing major flaws in technology and human supervision. The inaccuracy of identifying pedestrians with a distracted driver showed how a not fully developed technology or a system can have fatal consequences. The incident highlighted that public trust in autonomous vehicles depends on robust safety measures, including reliable emergency systems, comprehensive testing for edge cases, and clear regulatory standards. Therefore, it demonstrates how not prioritizing safety standards eventually leads to the different kinds of risks, undermining its potential to be improved in terms of road safety, industry and regulators.

UNECE

Due to accidents involved with self-driving vehicles, the United Nations Economic Commission for Europe (UNECE), developed safety and environmental standards for cars and self-driving cars through World Forum on Harmonization of Automotive Regulations (WP.29) which then spread throughout the world as discussed below:[39]

1) UN Regulation No. 155 - Cybersecurity and Cyber Security Management Systems

As a regulation to strengthen the cyber security of self-driving cars, vehicle manufacturers must establish a cyber security system that can prevent hacking, data theft, and

[38] Sottile, R. R. (2023, July 29). Uber self-driving car test driver pleads guilty to endangerment in pedestrian death case | CNN Business. CNN. https://edition.cnn.com/2023/07/29/business/uber-self-driving-car-death-guilty/index.htm

[39] *WP.29 - Introduction* | *UNECE*. (n.d.). Unece.org. https://unece.org/wp29-introduction

system damage. In addition, when a cyber security incident occurs, it is necessary to prepare a system to quickly respond to and modify it, and to be certified. This regulation is a global standard for protecting autonomous vehicles vulnerable to external attacks due to connected networks (Connected Cars with FSD), and contributes to the commercialization of safe and reliable autonomous driving technology.[40]

2) UN Regulation No. 156 - Software Updates and Over-the-Air (OTA) Updates

It is a regulation for securely managing software updates for self-driving cars, allowing vehicles to perform feature improvements and security patches through wireless updates (OTA). Manufacturers must design so that the safety and reliability of the system are not hindered during the update process, and the update record must be maintained and provided to regulators if necessary. This regulation ensures that self-driving vehicles continuously maintain the latest technology and security systems, ensuring technological development and user safety at the same time.[41]

3) UN Regulation No. 157 - Automated Lane Keeping Systems (ALKS)

This regulation applies to vehicles of autonomous driving level 3 or higher, allowing vehicles to maintain their own lanes and drive under certain conditions. To ensure safe auto driving on the highway, Automated Lane Keeping System (ALKS) must provide a minimum risk maneuver in which the vehicle stops itself safely in the event of an outbreak or gives control to

---

[40] *UN Regulation No. 155 - Cyber security and cyber security management system | UNECE*. (n.d.). Unece.org. https://unece.org/transport/documents/2021/03/standards/un-regulation-no-155-cyber-security-and-cyber-security
[41] *UN Regulation No. 156 - Software update and software update management system | UNECE*. (n.d.). Unece.org. https://unece.org/transport/documents/2021/03/standards/un-regulation-no-156-software-update-and-software-updat e

the driver. In addition, vehicles must accurately identify pedestrians, obstacles, vehicles, and etc. through the detection system, and meet periodic safety checks and data recording obligations.[42]

USA & China

The National Highway Traffic Safety Administration (NHTSA) in the United States is making various efforts such as providing guidelines, accident data analysis, technology testing, standard development, and providing consumer information to ensure the safety of autonomous vehicles.[43] Typically, through non-mandatory guidelines such as "Automated Driving Systems 2.0", the safety evaluation and design principles of autonomous driving systems are recommended, and in the event of a self-driving car accident, manufacturers are required to report it by analyzing data to improve technical limitations. [44]

In addition, the road safety of the system is checked and graded through the New Car Assessment Program, and the existing vehicle safety standards Federal Motor Vehicle Safety Standards (FMVSS) are updated to meet autonomous driving technology.[45] They also conduct campaigns to inform consumers of the use and limitations of autonomous driving technology, and are building an effective management system through regulatory harmonizing between the federal and state governments.

China is working with several government agencies to establish a regulatory system to ensure the development and safety of autonomous vehicles. The Ministry of Transport of China

---

[42] *UN Regulation No. 157 - Automated Lane Keeping Systems (ALKS) | UNECE*. (n.d.). Unece.org. https://unece.org/transport/documents/2021/03/standards/un-regulation-no-157-automated-lane-keeping-systems-alks

[43] Wikipedia Contributors. (2019b, October 23). *National Highway Traffic Safety Administration*. Wikipedia; Wikimedia Foundation. https://en.wikipedia.org/wiki/National_Highway_Traffic_Safety_Administration

[44] NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION. (2023). *NHTSA*. NHTSA. https://www.nhtsa.gov/

[45] Wikipedia Contributors. (2019a, August 17). *Federal Motor Vehicle Safety Standards*. Wikipedia; Wikimedia Foundation. https://en.wikipedia.org/wiki/Federal_Motor_Vehicle_Safety_Standards

is responsible for setting the safety and operating standards of autonomous vehicles, and the Ministry of Industry and Information Technology (MIIT) establishes industrial policies and technical standards related to the development of autonomous driving technology.[46] In addition, each local government is responsible for regulations and infrastructure construction related to the trial operation of self-driving vehicles, and prepares regulations that match the characteristics of each region.

SAE Level 0~5

As autonomous driving technology has developed, confusion has arisen due to different use of system functions and terminology by each manufacturer. To resolve this, the Society of Automotive Engineers (SAE) has proposed a Level 1 to 5 autonomous vehicle classification system to clearly define the development stages of autonomous driving technology and the degree of driver intervention, and to promote industry standardization and common understanding. SAE has subdivided autonomous driving into Level 0 (full driver control) to Level 5 (fully autonomous driving).[47] This system provides clear standards for technology development and regulatory establishment, and plays an important role in helping consumers and policymakers understand and accept autonomous driving technology.[48]

---

[46] CGTN. (2024, February 21). *MIIT advances China's formulation of autonomous driving standards*. Cgtn.com; CGTN. https://news.cgtn.com/news/2024-02-21/MIIT-advances-China-s-formulation-of-autonomous-driving-standards-1rn0t5nbIaI/p.html
[47] Kelechava, B. (2021, July 19). *SAE Levels of Driving Automation*. The ANSI Blog. https://blog.ansi.org/sae-levels-driving-automation-j-3016-2021/
[48] *Fresh guideline highlights autonomous vehicle tests*. (n.d.). English.www.gov.cn. https://english.www.gov.cn/policies/policywatch/202211/03/content_WS6363176ec6d0a757729e23ac.html

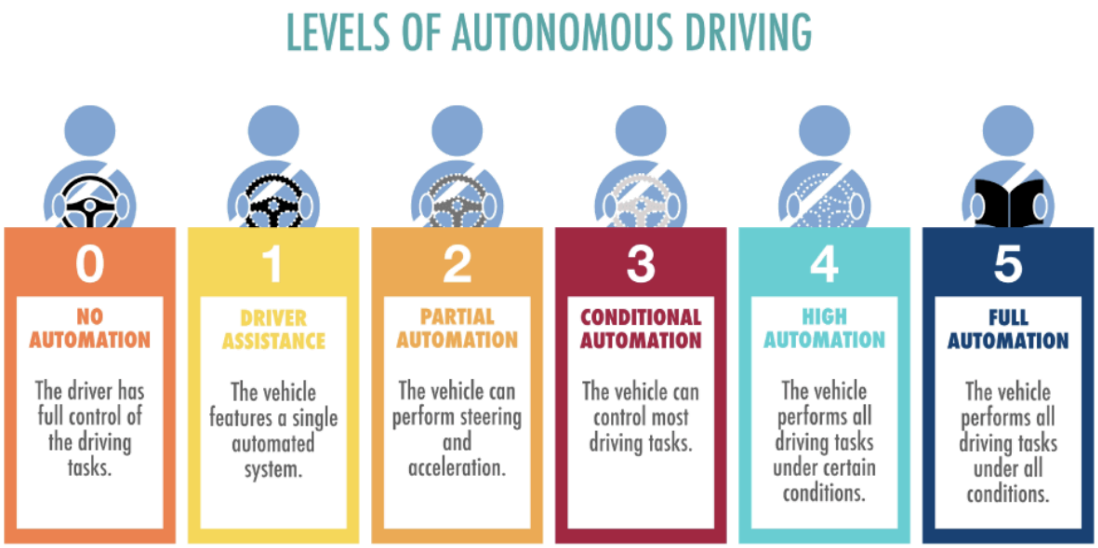


Figure 10. The illustration of autonomous driving levels from SAE, Adapted from AckoDrive, 2022, CC BY[49]

Geneva Convention & Vienna Convention

The Geneva Convention and the Vienna Convention are based on traditional traffic rules centered on human drivers, which has caused problems that conflict with the introduction of autonomous vehicles.[50] In particular, the Vienna Convention adhered to the principle that "the driver must control the vehicle," but was revised in 2016 to allow autonomous driving technology to be permitted under national laws. Currently, the member countries of the Convention are revising the existing regulatory system or preparing new laws to commercialize autonomous vehicles, and efforts are continuing to harmonize international standards with national regulations.[51]

---

[49] *Autonomous Cars: Levels of Autonomous Driving Explained*. (2022, May 11). AckoDrive. https://ackodrive.com/car-guide/autonomous-cars-and-levels-of-autonomous-driving/

[50] *Germany: Road Regulations Amended to Allow Autonomous Vehicles*. (n.d.). Library of Congress, Washington, D.C. 20540 USA. https://www.loc.gov/item/global-legal-monitor/2016-12-15/germany-road-regulations-amended-to-allow-autonomous-vehicles/

[51] *Vienna Conventions from 1968 are still at the core of automated driving development and road safety efforts - CLEPA – European Association of Automotive Suppliers*. (2018, November 19). CLEPA – European Association of Automotive Suppliers. https://clepa.eu/mediaroom/vienna-conventions-from-1968-are-still-at-the-core-of-automated-driving-development-and-road-safety-efforts/

In response to this, the United States has adopted special regulations for testing and operating autonomous vehicles through NHTSA(National Highway Traffic Safety Administration) to promote testing and commercialization of autonomous vehicles at the federal level.[52] Japan has revised the Road Traffic Act to allow autonomous vehicles to operate on highways and established a legal basis for entrusting vehicle control to the vehicle under certain conditions.[53]

Conclusion

Finally, the current member countries of the agreement are continuing their efforts to harmonize international standards with these national regulations for the commercialization of autonomous vehicles, and this is evaluated as an important turning point for simultaneously meeting technological advancement and social acceptance.

---

[52] *U.S. DOT ISSUES FEDERAL POLICY FOR SAFE TESTING AND DEPLOYMENT OF AUTOMATED VEHICLES | US Department of Transportation*. (2016). Transportation.gov. https://www.transportation.gov/briefing-room/us-dot-issues-federal-policy-safe-testing-and-deployment-automated-vehicles

[53] *Automated Driving｜National Police Agency*. (n.d.). National Police Agency. https://www.npa.go.jp/english/bureau/traffic/selfdriving.html

Social Issues

Introduction

While the political sector has been clearly demonstrated in the previous sections, cultural and social issues are also significant to connected cars with FSD. Connected Cars, introduced by Houdina Radio Control in 1925 as the ‘American Wonder,’ are still being developed with various technologies such as Full-Self Driving systems along with big data and AI. Due to different improvements, they cover humans' weaknesses, which can reduce unpredictable incidents and contribute to traffic efficiency. In addition, there are many attractive reasons why it's important for people to focus on connected cars.

Full Self-Driving (FSD) and connected car technology are rapidly developing in every country, including China, the United States, and the United Kingdom. Each country aims to alleviate traffic congestion, enhance road safety, and automate transportation. However, connected cars face significant challenges despite technology's potential benefits, including safety concerns, cybersecurity vulnerabilities, and ethical dilemmas. These issues raise questions about regulations, accountability, and public acceptance of intelligent vehicles. As we navigate these advancements, understanding technology limitations becomes essential to shaping a future where connected cars are effectively integrated into our daily lives.

Global Development and Adoption

Especially in China, because of its huge population, within metropolitan areas it usually meets with traffic issues. Thus, the government is pursuing the development of connected car or FSD technology. Also, in the US, such as Waymo, Cruise, and Zoox are giving positive examinations on an extended scale to improve technologies to assure safety and reliability.[54] Moreover, by 2030, the United Kingdom expects their infrastructures with cars being connected would be achieved.[55] This can be an example of how different countries worldwide are taking action to make and change the world through connected cars. Specifically, connected cars with FSD technology would be the primary industry sector of how countries will achieve their goals of automating cars in different regions.

Challenges and Safety Concerns

Although enough road infrastructures and technologies are created to support cars, there can still be other unprecedented circumstances that people doubt about such innovations. Researchers asserted that connected cars contribute to the safety of the drivers and passengers, but contrary to their expectations, there are frequent incidents because of the connected vehicles. Also, there are no exact regulations for some situations, so it is hard to take responsibility, and the companies also avoid acknowledging those incidents.

These days, people focus on the connected car issues because they usually advertise that autonomous cars decrease accident rates. Although there can be accidents in autonomous vehicles caused by different environmental factors, it is proven by an article that the incident rate is triple when the human drives and this is because automotive vehicles can avoid and minimize injury, emphasizing how AI and Full-Self Driving technologies are eventually decreasing accident rate compared to human-driven accidents.[56]

---

[54] Rajpal, S. (2024, October 10). *Mainland China autonomous vehicle development on a different track*. S&P Global Mobility. https://www.spglobal.com/mobility/en/research-analysis/China-autonomous-vehicles-development.html
[55] *New connected vehicles on roads UK 2018-2030*. (2022, April 20). Statista; Statista Research Department. https://www.statista.com/statistics/993364/new-connected-vehicles-on-roads-uk/
[56] *Autonomous vehicles cause fewer injuries and fatal crashes*. (2023, September 15). Warp News. https://www.warpnews.org/transportation/autonomous-vehicles-causes-less-injuries-and-fatal-crashes/

Figure 11. A Tesla autopilot accident avoided by driver intervention, showing FSD limits in fog, Adapted from *Heart-stopping moment Tesla owner nearly plows into a moving TRAIN in "self-drive" mode*, by Main, 2024, CC BY.

Recently, there might have been an accident with a Tesla car running on FSD that could have crashed into a running train.[57] The driver was using autopilot mode while she was grabbing the steering wheel. One of the reasons why Tesla recommends drivers to hold the steering wheel is because their systems are not fully automated, so they should be ready to interfere whenever they have to. But this is not the problem where there are two problems. First, even if the road's speed limit is 55 miles/hour, the cars run around 60 Miles/hour. Second, when cars are on Highway Driving Assist (HDA) or autopilot mode in fog, it cannot recognize the objects instantly. The car would have run into the train if the driver had not interfered at such moments. Even if it's human, and in that fog, the train can be distinguished because the red lights can see something passing.

[57] Main, N. (2024, May 20). *Heart-stopping moment Tesla owner nearly plows into a moving TRAIN in "self-drive" mode (and he says...* Mail Online; Daily Mail. https://www.dailymail.co.uk/sciencetech/article-13439727/tesla-owner-claim-self-driving-oncoming-train.html

Such incidents are not only shown by Tesla, but also similar situations happened on Waymo FSD taxis in San Francisco.[58] The five cars by Waymo with the FSD stopped in the middle of the road because of the fog. As a result, the road suddenly got into a traffic jam incompatible with the FSD's benefit - improving traffic efficiency. However, according to research, with the increase in the number of connected cars on the road, it is actually expected that the rate of traffic incidents will decrease by 5% in 2025 and 13% in 2035. The V2V and V2I are composed of the collected and collaborated traffic information in real-time and through Driving Monitoring Systems (DMS) and Human Machine Interface (HMI) interact with the driver. DMS collects drivers' driving habits; if HMI notices dangerousness, it can prevent future incidents.

Cybersecurity and Regulations

Also, DMS technologies are effective, but they can be a problem for data safety.[59] As the data is collected based on driver behavior, it should include numerous driver information that the driver can not accept. This advanced technology proposes problems with personal information protection and data ownership. This ambiguity creates disputes that can escalate without proper legal or contractual clarification. These conflicting interests leave consumers vulnerable to privacy violations and data misuse without clear regulations.

Beyond individual privacy, the risks of Connected Cars extend to national security. The data transmitted through vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) systems is essential for managing traffic and urban infrastructure in real time. This data could disrupt entire

[58] Brown, B., & Jensen, M. (2023, May 30). *Self-driving cars lack social intelligence in traffic*. University of Copenhagen. https://science.ku.dk/english/press/news/2023/self-driving-cars-lack-social-intelligence-in-traffic/
[59] Guan, W., Chen, H., Li, X., Li, H., & You, X. (2022). Study on the Influence of Connected Vehicle Fog Warning Systems on Driving Behavior and Safety. *Journal of Advanced Transportation*, *2022*, 1–11. https://doi.org/10.1155/2022/8436388

cities, paralyze emergency services, or expose sensitive routes used by military or government officials if intercepted or altered. Additionally, a breach in one connected system could propagate across networks, potentially crippling intelligent city traffic systems and causing widespread economic safety impacts. The interconnected nature of Connected Cars makes them particularly susceptible to cyberattacks. While widely used, wireless communication protocols like Wi-Fi, Bluetooth, and 5G often have exploitable weaknesses. Researchers have demonstrated how vulnerabilities in Vehicle-to-Everything (V2X) protocols can be exploited to gain control over critical vehicle functions. In one case, MIT researchers successfully hacked a V2X system, taking over vehicle operations remotely.

Another alarming example is that researchers discovered a flaw in KIA vehicles that allowed remote control of critical systems, including door locks and the engine. These weaknesses demonstrate the crucial need for manufacturers to prioritize cybersecurity in both hardware and software design. Moreover, the 2015 Jeep Cherokee hack exemplifies this risk, where attackers remotely turned off the vehicle's engine and brakes by exploiting vulnerabilities in the manufacturer's server infrastructure.

To prevent this danger, the White House, and Biden president, announced that particular technologies from China (PRC on the announcement) and Russia have the probability of a severe threat to national security.[60] These countries can use technology to monitor and attack the supply chain. For these reasons, they also announced that they would prohibit importing and selling all the products with the design, development, and manufacture associated with that country. They planned to apply a prohibition on software from modeling in 2027 and a ban on hardware from

[60] The White House. (2024, September 23). *FACT SHEET: Protecting America from Connected Vehicle Technology from Countries of Concern | The White House*. The White House. https://www.whitehouse.gov/briefing-room/statements-releases/2024/09/23/fact-sheet-protecting-america-from-connected-vehicle-technology-from-countries-of-concern/

modeling in 2030, and the others that are without a model year will be in 2029. Although there are concerns with the security data, these efforts with regulation are forward steps to ensure the safety-connected car.

Ethical Dilemmas in Connected Cars

Even vehicles with high intelligence also faced embarrassing situations. The Trolley dilemma is an experiment in ethical thinking, promoting discussion about what decisions are morally right when you have to make the best choice with limited resources. Connected cars, being based on intelligence, also come with this dilemma.[61] This dilemma should be applied to the human driver, and that incident is not with intent, whatever the result is. However, the connected car is programmed with various situations and the learned data from the programmer for the particular result.[62] Also, the problem arises of who will be responsible for these incidents, such as the manufacturing company and the driver. Also, there are no exact answers for the incidents. For example, a Tesla car avoids crossing a pedestrian even though he is a little far from the car, the car predicts an incident crash into another vehicle to protect him.[63] Even if the car saved lives, people see this situation negatively. This is the limit that connected cars should break. Their technology with FSD and autopilot function still needs to be fully acknowledged by people because the driver should be responsible for the driver, and they have to interfere according to situations. If the connected car shows these positive effects on the road, people will

---

[61] Wells, S. (2023, December 12). *The "Trolley Problem" Doesn't Work for Self-Driving Cars - IEEE Spectrum*. IEEE.ORG.https://spectrum.ieee.org/av-trolley-problem

[62] Andrade, G. (2019). Medical ethics and the trolley Problem. *Journal of Medical Ethics and History of Medicine*, *12*, 3. https://pmc.ncbi.nlm.nih.gov/articles/PMC6642460/

[63] Luchian, E. (2024, October 15). *Tesla Crashes Into Oncoming Car, Saves the Life of a Pedestrian*. Autoevolution. https://www.autoevolution.com/news/tesla-veers-to-avoid-pedestrian-who-fell-right-in-front-of-it-crashes-into-oncoming-car-241294.html

be accepted slowly with this surprising technology. People usually think intelligence should be better than people, so they strictly judge and avoid accepting technology.

Therefore, as time passes, technologies will be developed to adjust and adapt to our daily lives. Although it is challenging to accept sudden changes, they will eventually improve our lives, and technologies will be a component that people will not be able to live without. It can be challenging to accept the reliability of such technologies, but the day of overcoming these stereotypes should have come in the end.

Conclusion

Connected Cars and Full Self-Driving (FSD) technologies are not only just transportation but also have the potential to revolutionize urban and societal infrastructure. However, for these innovations to be entirely combined into our lives challenges such as safety, ethical dilemmas, cybersecurity vulnerabilities, and clear regulations must be addressed. Current limitations highlight the need for continued advancements in technological progress and societal dialogue will help overcome these barriers. In the future, connected cars will not merely serve as vehicles but will relocate mobility by creating safer, more efficient, and more interconnected ecosystems. Once these technologies transcend their current constraints and become indispensable to everyday life, connected cars will symbolize the peak of futuristic technology.

Economic Factors

The Impact of Connected Cars on Future Mobility Industries

Introduction

Connected Cars with FSD (Full Self-Driving) are not just cases of technological innovation, but are also key to creating new value in the modern economy and mobility industry. In particular, these two technologies are improving the efficiency and safety of transportation while having a ripple effect throughout the economy by the expansion of data-based services.

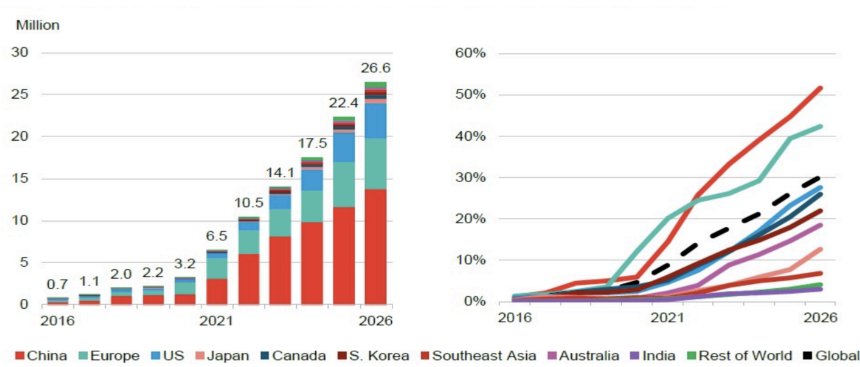
When combined with other elements, such as Electric Vehicles and Shared and service industries, these innovative technologies create extraordinary interplay. This goes beyond simple technological advancements to change the structure of the future economy and the industrial value chain, accelerating the growth of new business models such as MaaS (Mobility as a Service).

This section will examine the economic impact of Connected Cars with FSD, how the future mobility industry is changing, and what impact this change will have on the industry's value chain and market. In addition, the ultimate direction, which is MaaS, and its business prospects with economic value will be treated.

CASE (Connected, Autonomous, Shared & Service, Electric)

Before looking into the impact of Connected Cars with FSD, explain the future mobility industry more comprehensively. The future mobility industry is not a simple change in transportation but a massive stream of innovation that forms a new paradigm by intertwining technology, environment, and social demands. The characteristics of this change are primarily summarized into four categories: CASE. They represent Connected, Autonomous, Shared and service, and Electric. Each element is a core axis of the ongoing fourth mobility revolution and ultimately refers to a 'Shared Smart Car capable of Autonomous Driving.' These four technologies develop independently and are closely connected to each other, converging toward MaaS (Mobility as a Service).

First, *Electric*, that is, the electrification of vehicles. One may question the relationship between electric vehicles with Connected Cars with FSD. The fourth mobility revolution began with the electrification of vehicles, which replaced internal combustion engines with motors and batteries and laid the foundation for controlling all vehicle functions with high-performance computers, providing the possibility of mobility services. While existing engine-centered internal combustion engines and hybrids are not as efficient as electrics in software-based control due to their engine-centric structure, electrics are structurally more straightforward and thus allow for software-centric design. According to statistics, sales of internal combustion engines have been declining worldwide since 2016, and electrics are expected to increase to almost 30% of global car sales by 2026, as the chart below shows.[64] This means a rapid decline in existing internal combustion engines. At the same time, the foundation environment for the mobility revolution is being established along with the advanced spread of electrics.



[64] PwC. (2023, February). *Paradigm shift: The future of industries in transformation.* PwC Korea. https://www.pwc.com/kr/ko/insights/insight-research/samilpwc_paradigm-shift-feb2023.pdf

Figure 12. Global near-term passenger EV sales and share of new passenger vehicle sales by market. Adapted from *EV sales to make up nearly one-third of passenger vehicle sales in U.S.*, 2023, CC BY

Next, *Connected* Cars go beyond the level of receiving general information through two-way communication and become part of the IoT with smartphones and various infrastructures. The main services include remote control of vehicles from smartphones and at smarthome, safety services that automatically control emergency rescue, management services that enable wireless updates or driving information, and navigation services that provide real-time optimal route search and location sharing. For the future outlook, manufacturers are expanding Connected cars in response to the industrial changes centered on electrification and digitalization, and it is analyzed that the manufacturing rate will increase from the current 50% to 95% by 2030.[65]

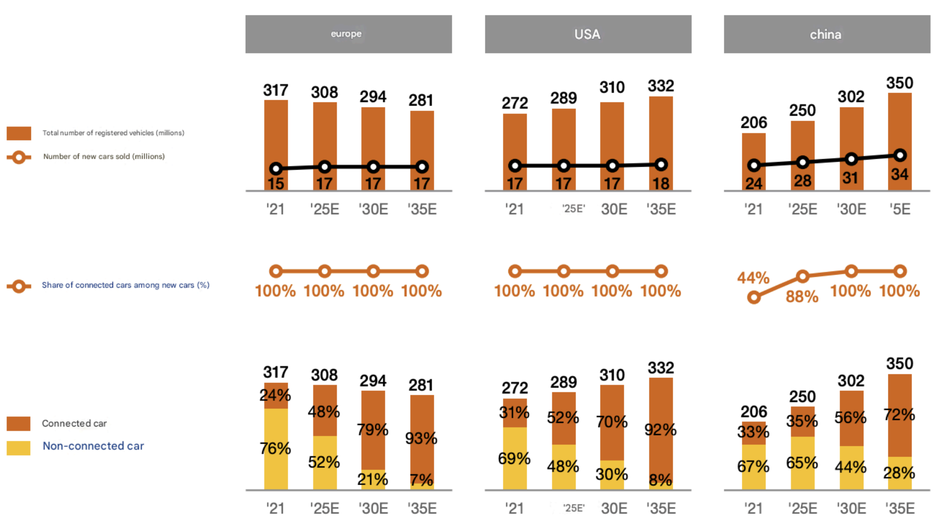


Figure 13. Connected cars market global forecast to 2035. Adapted from *The Future of Mobility Services Market: M.I.L.E.*, 2023, CC BY

[65] Ibid.

In addition, *Autonomous*, which means FSD, is currently being actively researched, but it is expected to be somewhat delayed compared to other aspects due to technological limitations, and Level 3 or higher autonomous vehicles are expected to be fully expanded after 2030. In terms of new car sales in 2035, 29% in Europe, 34% in China, and 16% in the US are expected to be Level 3 or higher, and Level 5, which are classified as FSD, will account for a small proportion of less than 1% of all new cars in 2035, so it seems that it will take a long time until they are commercialized.[66]

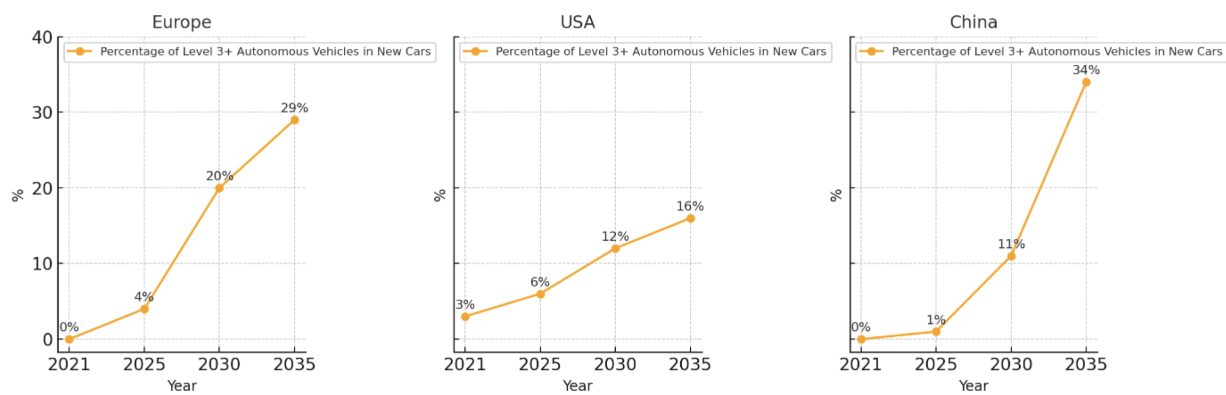


Figure 14. Autonomous market global outlook. Adapted from *The Future of Mobility Services Market: M.I.L.E.*, 2023, CC BY

In fact, the area that is most notable for growth in the mobility industry is *Shared & Service*, which means car sharing service. This links cars and users to provide optimized transportation, and with smartphones, the possibility of activation has also increased as navigation costs and transaction risks have been significantly reduced. Considering the price of cars and the fact that most of the total ownership time is spent parked, it is expected that the cost-effectiveness of vehicles can be maximized through sharing services, and the process will be

[66] Ibid.

made simpler through mobility platforms. The EU region is expected to show the most active movement in car sharing, with 28% of total travel volume in 2035.[67] It is expected that these businesses will maximize their profit models by combining with the aforementioned connected and autonomous driving.

As such, each element of CASE acts as a key factor in changing the nature of mobility and the way value is created. Electric cars (Electric) overcome the limitations of internal combustion engines and promote digitalization, while Connected Cars (Connected) integrate vehicles into the IoT ecosystem. FSD (Autonomous) minimizes human intervention to increase the efficiency and safety of transportation, and car sharing service (Shared & Service) innovates

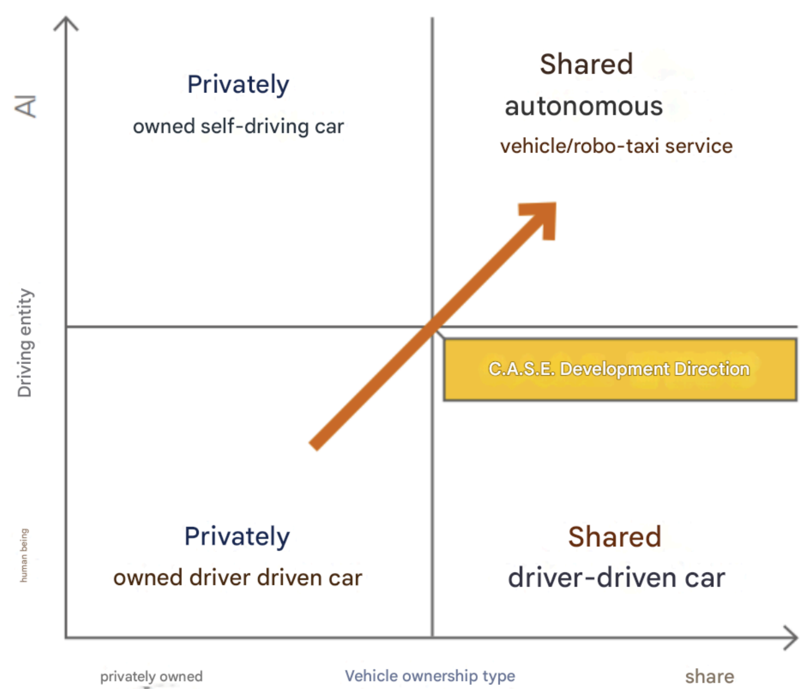


Figure 15. C.A.S.E Development Direction: Completion as a Robo-taxi. Adapted from *The Future of Mobility Services Market: M.I.L.E.*, 2023, CC BY

[67] Ibid.

the model centered on individual ownership and provides new value to both consumers and companies. As the figure 15, driving subject and ownership method change, it will move towards shared autonomous vehicles, such as robotaxis, a vehicle that aims for the sharing economy.

Changes in the Value Chain of the Mobility Industry

CASE features are leading transformative changes in the future mobility industry and its value chain. The value chain is a series of activities that add value in the process of a company providing products or services, it provides an important framework for explaining how a company can achieve and maintain a competitive advantage. Traditionally, the automotive value chain followed a six-stage structure: ‘design & planning → parts → systems and modules → system integration & assembly → marketing and sales → maintenance’, with automakers holding the most power and profit through vertical integration. However, the shift from "manufacturing to service" and "ownership to sharing" is reshaping the value chain into: ‘parts supplier → module/system supplier → vehicle assembly → mobility service provider → after-sales service provider.’

In this new structure, digital technology-based specialized companies, system integrators, and data-driven mobility service providers are gaining prominence. IT companies are entering connected and autonomous vehicle markets, while platform companies like Uber, Grab, and Kakao Mobility are leading the car-sharing sector. The traditional dominance of a few automakers is giving way to a cooperative ecosystem among diverse stakeholders, with the mobility service sector (MaaS) emerging as the primary driver of future value creation.

MaaS

All of the above factors ultimately point to the activation of the business called MaaS. MaaS, which is *'Mobility as a Service'*, the fundamental concept of this is to provide convenience and efficiency in transportation by combining all means of transportation in the area, including privately owned transportation. The core of MaaS is to integrate transportation planning, reservation, electronic ticketing, and payment services into a single digital platform by considering possible alternatives across all transportation methods and the preferences of each user, thereby implementing a truly user-centered mobility environment.

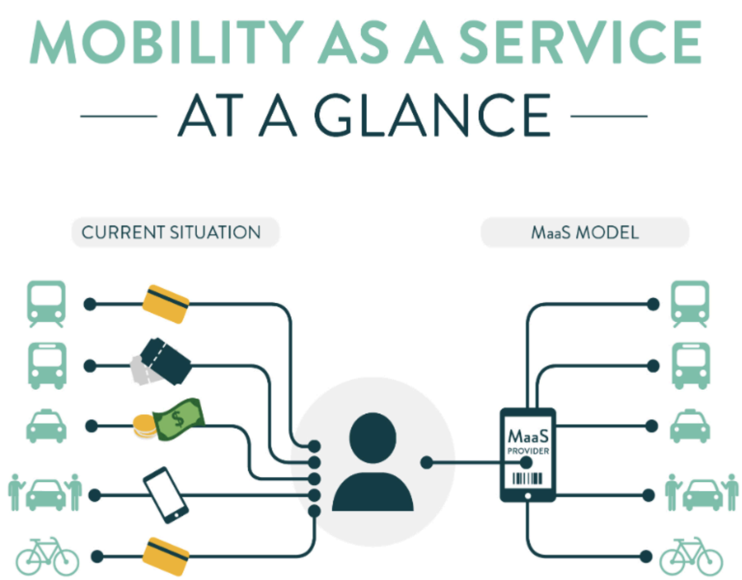


Figure 16. Mobility as a Service. Adapted from *The Future of Mobility Services Market: M.I.L.E.*, 2023, CC BY

Figure 17. MaaS level. Adapted from *Proposed topology of MaaS including Levels 0-4 (left) and examples (right)*, 2022, CC BY

As shown in the table above, MaaS is categorized into stages based on the degree of service connection and integration. Currently, it remains at the early stages of commercialization, around levels 1 to 2, however, it is expected to rapidly penetrate consumers' daily lives, establishing itself as a growth axis of the mobility industry. At the same time, urban planning and transportation policies are anticipated to evolve to support its progression to a fully developed stage. MaaS is expected to grow exponentially in the future, combined with autonomous driving and car sharing, it is expected to form a market worth 1.8 trillion dollars by 2030, 19% of the entire mobility industry.[68] As MaaS grows, the influence of related companies will grow, and competition in various sectors will intensify until an absolute monopoly emerges.

[68] Ibid.

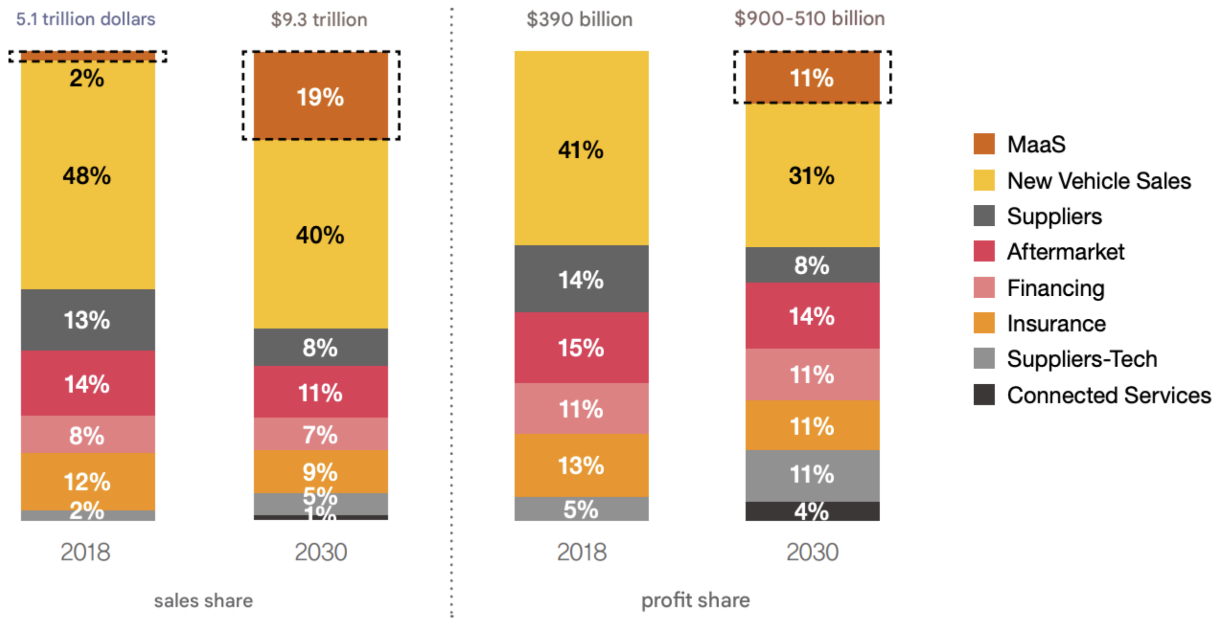


Figure 18. MaaS statistics. Adapted from *The Future of Mobility Services Market: M.I.L.E.*, 2023, CC BY

Based on this, the entire mobility market (including hardware and services) from a Total Addressable Market (TAM) perspective is projected to reach approximately 117 trillion KRW domestically and 7,070 trillion KRW globally by 2030, based on personal mobility. Furthermore, the global MaaS market size is anticipated to expand to $1.7 trillion in 2032, with a projected Compound Annual Growth Rate (CAGR) of 19.4% during this period.[69]

Conclusion

This section analyzed the changes and direction of the mobility industry, which is an extension of Connected Cars with FSD, focusing on the fact that the 4th mobility revolution centered on CASE is fundamentally changing the structure & value creation method of the mobility industry.

[69] Fortune Business Insights. (n.d.). *Mobility as a Service (MaaS) market: Global industry analysis, insights, and forecast, 2023–2030.* Fortune Business Insights. https://www.fortunebusinessinsights.com/mobility-as-a-service-maas-market-102066

Starting in 2030, MaaS is expected to grow rapidly by combining autonomous driving, car sharing, and electric vehicles. The core of mobility services is optimized one-stop services and real-time supply-demand connections, so the status of platform operators is being strengthened as payment integration algorithms emerge. Therefore Companies should pursue platform & data-centric services beyond vehicle manufacturing, and the government should prepare regulations & urban plans to support this. This will be the key to reconstructing lifestyles and urban environments beyond mobility.

Conclusion

This research analyzes Connected Cars with FSD technology using the political, economic, social, and technological (PEST) model. The rise of Connected Cars equipped with FSD capabilities marks an important landmark in transportation technology, providing significant changes across PEST model dimensions. This study highlights the multifaceted relationship between these factors, emphasizing their collective influence on shaping the future of transport.

From a technical standpoint, advancements in sensors, mapping, and path-planning algorithms have enhanced the feasibility of FSD systems. However, reliability in real-world situations remains a challenge, necessitating ongoing innovation. From a political perspective, the document highlights the essential requirement for unified global regulatory systems and stringent safety protocols to tackle public safety issues and build confidence. Socially, the acceptance of FSD technologies depends on tackling ethical issues, improving cybersecurity protocols, and confronting public doubts. From an economic perspective, integrating FSD into CASE and MaaS frameworks is set to transform the mobility sector, altering value chains and generating new business prospects.

Despite these improvements, significant obstacles remain. Tackling technological constraints, aligning international regulations, and cultivating public trust are essential for seamlessly incorporating FSD into everyday life. Connected Cars with FSD will revolutionize transportation and serve as a vital component for developing more advanced, safer, and greener urban settings as these challenges are overcome.

To conclude, achieving the full potential of FSD technologies requires a multidisciplinary approach that combines technological progress, regulatory knowledge, and community engagement. By addressing these factors thoroughly, Connected Cars with FSD systems can evolve from experimental advancements to crucial components of modern transportation.

References

Andrade, G. (2019). Medical ethics and the trolley Problem. *Journal of Medical Ethics and History of Medicine*, *12*, 3. https://pmc.ncbi.nlm.nih.gov/articles/PMC6642460/

Autonomous vehicles cause fewer injuries and fatal crashes. (2023, September 15). Warp News. https://www.warpnews.org/transportation/autonomous-vehicles-causes-less-injuries-and-fatal-crashes/

Automated Driving｜National Police Agency. (n.d.). National Police Agency. https://www.npa.go.jp/english/bureau/traffic/selfdriving.html

Autonomous Cars: Levels of Autonomous Driving Explained. (2022, May 11). AckoDrive. https://ackodrive.com/car-guide/autonomous-cars-and-levels-of-autonomous-driving/

Brown, B., & Jensen, M. (2023, May 30). *Self-driving cars lack social intelligence in traffic*. University of Copenhagen. https://science.ku.dk/english/press/news/2023/self-driving-cars-lack-social-intelligence-in-traffic/

Burke, Katie. (2019, April 15)"How Does a Self-Driving Car See?" *NVIDIA Blog*, NVIDIA, https://blogs.nvidia.com/blog/how-does-a-self-driving-car-see/.

Charroud, A., Moutaouakil, K. E., Palade, V., Yahyaouy, A., Onyekpe, U., & Eyo, E. U. (2024). Localization and Mapping for Self-Driving Vehicles: A survey. *Machines*, *12*(2), 118. https://doi.org/10.3390/machines12020118

CGTN. (2024, February 21). *MIIT advances China's formulation of autonomous driving standards*. Cgtn.com; CGTN. https://news.cgtn.com/news/2024-02-21/MIIT-advances-China-s-formulation-of-autonomous-driving-standards-1rn0t5nbIaI/p.html

Fresh guideline highlights autonomous vehicle tests. (n.d.). English.www.gov.cn. https://english.www.gov.cn/policies/policywatch/202211/03/content_WS6363176ec6d0a757729e23ac.html

Fortune Business Insights. (n.d.). Mobility as a Service (MaaS) market: Global industry analysis, insights, and forecast, 2023–2030. Fortune Business Insights. https://www.fortunebusinessinsights.com/mobility-as-a-service-maas-market-102066

Germany: Road Regulations Amended to Allow Autonomous Vehicles. (n.d.). Library of Congress, Washington, D.C. 20540 USA. https://www.loc.gov/item/global-legal-monitor/2016-12-15/germany-road-regulations-amended-to-allow-autonomous-vehicles/

Guan, W., Chen, H., Li, X., Li, H., & You, X. (2022). Study on the Influence of Connected Vehicle Fog Warning Systems on Driving Behavior and Safety. *Journal of Advanced Transportation*, *2022*, 1–11. https://doi.org/10.1155/2022/8436388

Hui, J. (2018, June 19). Self-driving car: Path planning to maneuver the traffic. *Medium*. https://jonathan-hui.medium.com/self-driving-car-path-planning-to-maneuver-the-traffic-ac63f5a620e2

Kelechava, B. (2021, July 19). *SAE Levels of Driving Automation*. The ANSI Blog. https://blog.ansi.org/sae-levels-driving-automation-j-3016-2021/

Luchian, E. (2024, October 15). *Tesla Crashes Into Oncoming Car, Saves the Life of a Pedestrian*. Autoevolution. https://www.autoevolution.com/news/tesla-veers-to-avoid-pedestrian-who-fell-right-in-front-of-it-crashes-into-oncoming-car-241294.html

Main, N. (2024, May 20). *Heart-stopping moment Tesla owner nearly plows into a moving TRAIN in "self-drive" mode (and he says...* Mail Online; Daily Mail. https://www.dailymail.co.uk/sciencetech/article-13439727/tesla-owner-claim-self-driving-oncoming-train.html

McMinn, E. (2024, April 23). Understanding SLAM in Robotics and Autonomous Vehicles. *Flyability*. https://www.flyability.com/blog/simultaneous-localization-and-mapping

Nguyen, T.-T.-N., Phan, T.-D., Duong, M.-T., et al. (2022). Sensor Fusion of Camera and 2D LiDAR for Self-Driving Automobile in Obstacle Avoidance Scenarios. *2022 International Workshop on Intelligent Systems (IWIS)*. https://doi.org/10.1109/IWIS56333.2022.9920917

Noko, M. (2021, October 26). How to deploy inertial navigation sensors in automotive Systems. *IEEE Spectrum*. https://spectrum.ieee.org/inertial-navigation-system

NASA. (2020). *Doppler Lidar Makes Self-Driving Cars Safer*. NASA Spinoff. Retrieved November 16, 2024, from https://spinoff.nasa.gov/Spinoff2020/t_8.html

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION. (2023). *NHTSA*. NHTSA. https://www.nhtsa.gov/

Pennings, A.J. (2024, Jan 15). Networking Connected Cars in the Automatrix. *apennings.com* https://apennings.com/telecom-policy/networking-in-the-automatrix/

PwC. (2023, February). *Paradigm shift: The future of industries in transformation*. PwC Korea. https://www.pwc.com/kr/ko/insights/insight-research/samilpwc_paradigm-shift-feb2023.pdf

Rajpal, S. (2024, October 10). *Mainland China autonomous vehicle development on a different track*. S&P Global Mobility.

https://www.spglobal.com/mobility/en/research-analysis/China-autonomous-vehicles-development.html

Real-Time Kinematic (RTK). (n.d.). NovAtel. https://novatel.com/an-introduction-to-gnss/resolving-errors/rtk

Reda, M., Onsy, A., Haikal, A., & Ghanbari, A. (2024). Path planning algorithms in the autonomous driving system: A comprehensive review. *Elsevier*, *174*. https://www.sciencedirect.com/science/article/pii/S0921889024000137

Rummelhard, Lukas & Paigwar, Anshul & Nègre, Amaury & Laugier, Christian. (2017). Ground Estimation and Point Cloud Segmentation Using SpatioTemporal Conditional Random Field. 1105-1110. 10.1109/IVS.2017.7995861.

Sottile, R. R. (2023, July 29). *Uber self-driving car test driver pleads guilty to endangerment in pedestrian death case | CNN Business*. CNN. https://edition.cnn.com/2023/07/29/business/uber-self-driving-car-death-guilty/index.html

Texas Instruments. (n.d.). *Ultrasonic sensing: Theory and applications* (Application Report No. SLAA911). Texas Instruments Incorporated.https://www.ti.com/lit/ab/slaa911/slaa911.pdf

The White House. (2024, September 23). *FACT SHEET: Protecting America from Connected Vehicle Technology from Countries of Concern | The White House*. The White House. https://www.whitehouse.gov/briefing-room/statements-releases/2024/09/23/fact-sheet-protecting-america-from-connected-vehicle-technology-from-countries-of-concern/

Tummala, M., & Pravin, A. (2023). LiDAR Sensor for Self-Driving Cars. *8th International Conference on Communication and Electronics Systems (ICCES)*. https://doi.org/10.1109/ICCES56333.2023.9920917

U.S. DOT ISSUES FEDERAL POLICY FOR SAFE TESTING AND DEPLOYMENT OF AUTOMATED VEHICLES | US Department of Transportation. (2016). Transportation.gov. https://www.transportation.gov/briefing-room/us-dot-issues-federal-policy-safe-testing-and-deployment-automated-vehicles

UN Regulation No. 155 - Cyber security and cyber security management system | UNECE. (n.d.). Unece.org. https://unece.org/transport/documents/2021/03/standards/un-regulation-no-155-cyber-security-and-cyber-security

UN Regulation No. 156 - Software update and software update management system | UNECE. (n.d.). Unece.org. https://unece.org/transport/documents/2021/03/standards/un-regulation-no-156-software-update-and-software-update

UN Regulation No. 157 - Automated Lane Keeping Systems (ALKS) | UNECE. (n.d.). Unece.org. https://unece.org/transport/documents/2021/03/standards/un-regulation-no-157-automated-lane-keeping-systems-alks

Vienna Conventions from 1968 are still at the core of automated driving development and road safety efforts - CLEPA – European Association of Automotive Suppliers. (2018, November 19). CLEPA – European Association of Automotive Suppliers. https://clepa.eu/mediaroom/vienna-conventions-from-1968-are-still-at-the-core-of-automated-driving-development-and-road-safety-efforts/

Wells, S. (2023, December 12). *The "Trolley Problem" Doesn't Work for Self-Driving Cars - IEEE Spectrum*. IEEE.ORG. https://spectrum.ieee.org/av-trolley-problem

Wilkerson, M. (2024, June 20). *What is an INS? Inertial Navigation Systems Explained*. pointonenav.com. https://pointonenav.com/news/ins-inertial-navigation-system/

What is Vehicle-to-Everything (V2X)? (n.d.). https://blackberry.qnx.com/en/ultimate-guides/software-defined-vehicle/vehicle-to-everything#:~:text=Vehicle%2Dto%2DEverything%20(V2X)%20is%20where%20a%20vehicle,systems%20using%20wireless%20data%20connectivity.

Wikipedia Contributors. (2019a, August 17). *Federal Motor Vehicle Safety Standards*. Wikipedia; Wikimedia Foundation. https://en.wikipedia.org/wiki/Federal_Motor_Vehicle_Safety_Standards

Wikipedia Contributors. (2019b, October 23). *National Highway Traffic Safety Administration*. Wikipedia; Wikimedia Foundation. https://en.wikipedia.org/wiki/National_Highway_Traffic_Safety_Administration

WP.29 - Introduction | UNECE. (n.d.). Unece.org. https://unece.org/wp29-introduction

Yeong, D.J.; Velasco-Hernandez, G.; Barry, J.; Walsh, J. Sensor and Sensor Fusion Technology in Autonomous Vehicles: A Review. *Sensors* 2021, *21*, 2140. https://doi.org/10.3390/s21062140

Zheng, Y., & Su, J. (2023). Algorithm Design of Self-Driving Vehicle Based on Visual Sensing Technology. *International Journal of Intelligent Systems*. https://doi.org/10.1002/int.12345