Communication Infrastructures for Self-Driving Vehicles

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PRACTICES Autonomous Transportation

Significant advancements in the car manufacturing industry have led to true self-driving vehicles. Last year, Mercedes-Benz became the first company to obtain approval of their Level 3 autonomous driving system. Tesla has claimed to be very close to having the ability to manufacture fully self-driving cars. However, as of the end of 2021, no vehicle sold in the U.S. market had a Level 3 or higher automated driving system. Last year, Germany amended its Road Traffic Act to accommodate the deployment of Level 4 systems. The development of autonomous vehicles still faces many technological and legal challenges. One important question is whether self-driving cars can navigate safely without a consistent internet connection, something Tesla recently claimed to be possible. Would flawless data transfer be inevitably required to elevate driving systems to a higher, more automated level? The amended German law requires a self-driving car to have a technical supervisor who deactivates the vehicle or authorizes driving maneuvers. Assuming that the technical supervisor remotely monitors one or more automated vehicles, a certain level of internet connectivity would be required to use self-driving cars. This article will explore the available options of data transmission and the attendant technical and legal challenges.

Cellular Connectivity

Autonomous vehicles are expected to generate about forty (40) terabytes of data from sensors and download data as they are connected to each other and other equipment on the road. One of the key technologies that may provide an adequate platform to transmit this enormous amount of data with a transmission speed that enables self-driving cars to make effective decisions in real-time road conditions is 5G technology. However, cellular networks do not have 100 percent coverage; access in rural areas coverage is typically spotty; and vehicles are unable to function safely in the absence of required data. In big cities where tall buildings are clustered together, the concrete and metal structures often disrupt cellular communication. Cellular networks alone, therefore, would not be able to provide the global data transmission platform required to operate self-driving vehicles.

High Latency of GSO Satellite Connection

There is a new generation of satellite terminals that are designed to provide broadband communication to moving vehicles. Known as Earth Stations in Motion (ESIM), these terminals use small antennas with tracking systems that allow two-way, high-speed communication with land vehicles, maritime vessels, and aircraft. ESIM platforms are different from those of fixed ground stations. ESIM terminals use very small antennas, small enough to be installed on a vehicle. The system also features a tracking device that is required to maintain accurate orientation to the target at all times. Automakers are already exploring the use of satellite technology to support their self-driving vehicles. The Chinese Zheijiang Geely Holding Group has plans to use a satellite to guide self-driving cars. Last March, SpaceX filed an application for a license to operate its Starlink constellation with ESIM.

The problem with using geostationary (GSO) satellites for self-driving cars is high latency. Latency is the time it takes for a data packet to travel across the network, from one point on the network to another. In the case of self-driving vehicles, it is the time it takes for the data packet to travel between the vehicle and the satellite. Because they are very far from Earth, over 22,000 miles away, GSO satellites have at least 250 milliseconds (ms) latency. By comparison, cellular network signal latency is about 10ms. Real-time data is a critical component to ensure safe operation for self-driving cars. Because of the distance that the data must travel, it is very doubtful that GSO satellites would ever provide a feasible communication method for self-driving vehicles.

Low Earth Satellite Constellations may be the Solution

Conversely, very low Earth orbit (VLEO) satellite systems operate at an altitude range of 200-330 km (124 miles–186 miles). These VLEO systems have the potential for very low latency of less than 10ms. VLEO communication could potentially be very similar or even better than terrestrial broadband communication. Therefore, satellite constellations like SpaceX’s Starlink system could be a feasible way to safely operate autonomous cars.

Latency, however, is not the only obstacle that must be overcome for self-driving cars to operate safely while relying on satellites for data transmission. The communication between the vehicle and the satellite may be delayed by signal loss because of signal obstructions, weather conditions, or antenna misalignment, which would require thorough regulatory oversight to ensure that ESIM activity did not disrupt other satellite communication.

Legislative History of Satellite Connection on Moving Objects

The rules and regulation of the Federal Communication Commission (FCC) are laid out in Title 47 of the Code of Federal Regulations (CFR). The FCC defines the term *mobile Earth station* as an Earth station in the mobile-satellite service intended to be used while in motion or during halts at unspecified points [47 CFR § 25.103]. The FCC has divided the mobile Earth station into three categories: Earth stations on vessels (ESV), which are Earth stations onboard craft designed for traveling on water, receiving from and transmitting to fixed-satellite service space stations [47 CFR § 25.103]; Earth stations that operate aboard an aircraft that receives from and transmits to fixed-satellite service space stations [47 CFR § 25.103]; and vehicle-mounted Earth stations (VMES), which is defined as an Earth station operating from a motorized vehicle that travels primarily on land that receives from and transmits to fixed-satellite service space stations and operates within the United States [47 CFR § 25.103].

Since low latency and uninterrupted data transmission are essential for automated driving systems, orientation errors would be a great problem for VMES systems and self-driving vehicles. Errors in orientation toward a satellite could cause interference to other communication systems in the same frequency band. To limit interference, the International Telecommunication Union (ITU) and FCC have established limits on effective isotropic radiated power (EIRP) spectral intensity (ESD) of a transmit terminal in its off-axis directions [47 CFR § 25.218]. Anytime the off-axis limit is exceeded, the signal must shut off from the antenna [47 CFR 25.228(b)]. That might cause significant delay in data transmission that would prevent self-driving cars from receiving information necessary to safely operate.

Just as with human drivers, automated systems are relying on real-time data to make driving decisions when on the road. The necessary information might be gathered by the car using cameras and sensors. Other critical information might be transmitted through cellular or satellite networks. Since none of these methods alone could provide uninterrupted data transmission, the technical solution would likely be an integrated network composed of low-latency VLEO and 5G cellular networks. The FCC retains a crucial role in the development of necessary support for intelligent, self-driven transportation. Last year, the agency unanimously approved a First Report and Order reallocating a majority of the 5.9 GHz band endorsing the new cellular vehicle-to-everything (C-V2X). This new solution combined with VLEO and 5G network might be a step toward creating a communication infrastructure stable enough to support true self-driving cars.