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Advanced Autonomous Vehicle with 5G Technology

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***Abstract* - The main motivation for automotive vehicle is safety and eliminating the excessive cost of traffic collisions. Vehicular networks can help in avoiding congestion and finding better routes by processing real time data. This in return saves both time and fuel and has significant economic advantages. Vehicles are considered an Electronics sensors in smart transportation system .Autonomous Vehicle(AV) must help the drivers or drive the motor without driver in critical situations such as less congestion, accident warning, road exploration etc. AV are equipped with advanced wireless communication module for supporting vehicular communication. Different vehicular technology like Wireless Access for Vehicular Environment (WAVE) , Dedicated Short Range Communication (DSRC), Communication Access for Land Mobiles (CALM) standard mainly used AV communication. Potential Features of 5G technology help the automotive industries in great way with its advantages over the other technologies which makes the advanced AV.**

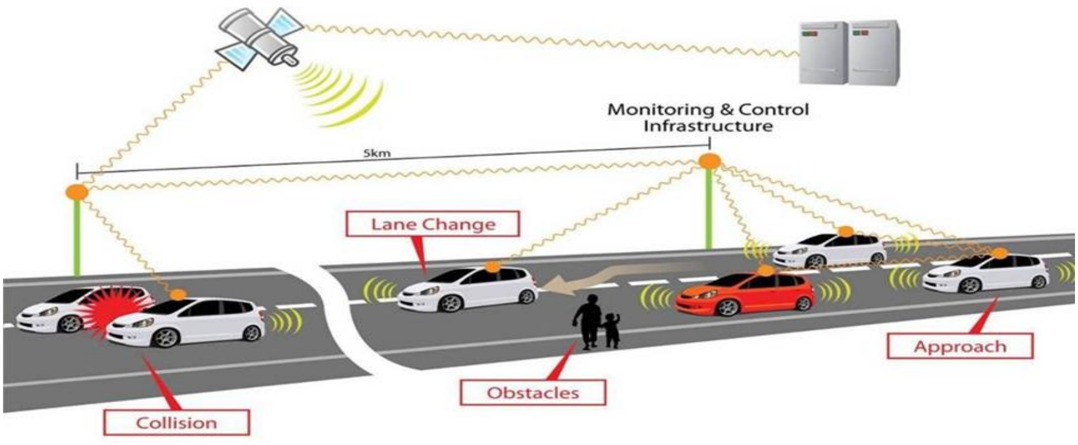
***Index Terms* - AV, V2V ,V2I,WAVE, DSRC, CAM, latency, 5G**

I. INTRODUCTION

According to World Health Organizations (WHO), road accidents annually cause approximately 1.2 million deaths World wide; one fourth of all deaths caused by injury. However the deaths caused by car crashes are in principle avoidable. US Department of Transport states that 21,000 of the annual 43,000 road accident deaths in the US are caused by roadway departures and intersection-related incidents [1]. This number can be significantly lowered by deploying local warning systems through vehicular communications. Departing vehicles can inform other vehicles that they intend to depart the highway and arriving cars at intersections send warning messages to other cars traversing that intersection.[2]

Automatic braking when the car detects an obstacle will also likely reduce a significant number of rear-end collisions . AV are equipped with on board unit /systems to enables services for driver, other vehicle on road and third party recipients. Different types of communication modules with storage and computing .Types of vehicles communication are 1) between vehicles, known as vehicle-to-vehicle (V2V) communication, 2) between vehicles and infrastructure (V2I and 2 I2V), or 3) between vehicles and any neighboring object (V2X). Improvement in wireless technology make the communication with less latency.5G technology with its specific potential feature can make advance AV with smart features.

II. VEHICLE COMMUNICATION REPRESENTATION [3]



Source: www.pinterest.com/stevekeifer/connectedcar

III. TECHNOLOGY USED IN VEHICLE COMMUNICATION

Vehicle-to-vehicle (V2V) communications comprises a wireless network where automobiles send messages to each other with information about what they're doing. This data would include speed, location, direction of travel, braking, and loss of stability. Vehicle-to-vehicle technology uses dedicated short-range communications (DSRC), a standard set forth by bodies like FCC and ISO. Sometimes it's described as being a WiFi network because one of the possible frequencies is 5.9GHz, which is used by WiFi, but it's more accurate to say "WiFi-like." The range is up to 300 meters or 1000 feet or about 10 seconds at highway speeds (not 3 seconds as some reports say).[4]

The vision of V2I Communications is that a minimum level of infrastructure will be deployed to provide the maximum level of safety and mobility benefits for highway safety and operational efficiency nationwide. Importantly, V2I communications have the potential to resolve an additional 12 percent of crash types not addressed under V2V communications.Additionally, the research will concentrate on the key FHWA and FMCSA application areas of interest, including intersection safety, run-off-road prevention, speed management, and commercial vehicle enforcement and operations [5]

Another is the Communication Access for Land Mobiles (CALM) standard. In addition some Zigbee communication modules and Visible Light Communication (VLC) are also used n vehicle [6] The mobile broadband standards, having deterministic MAC methods together with QoS support, cannot be used in *ad hoc* mode (vehicle-to-vehicle) but could with advantage be used for other types of data traffic (e.g. Internet access). The IEEE 802.11p standard together with the WAVE protocol stack could be used for *ad hoc* vehicle-to-vehicle communication.

IV. AUTONOMOUS VEHICLE EQUIPMENT AND SERVICE REQUIREMENTS

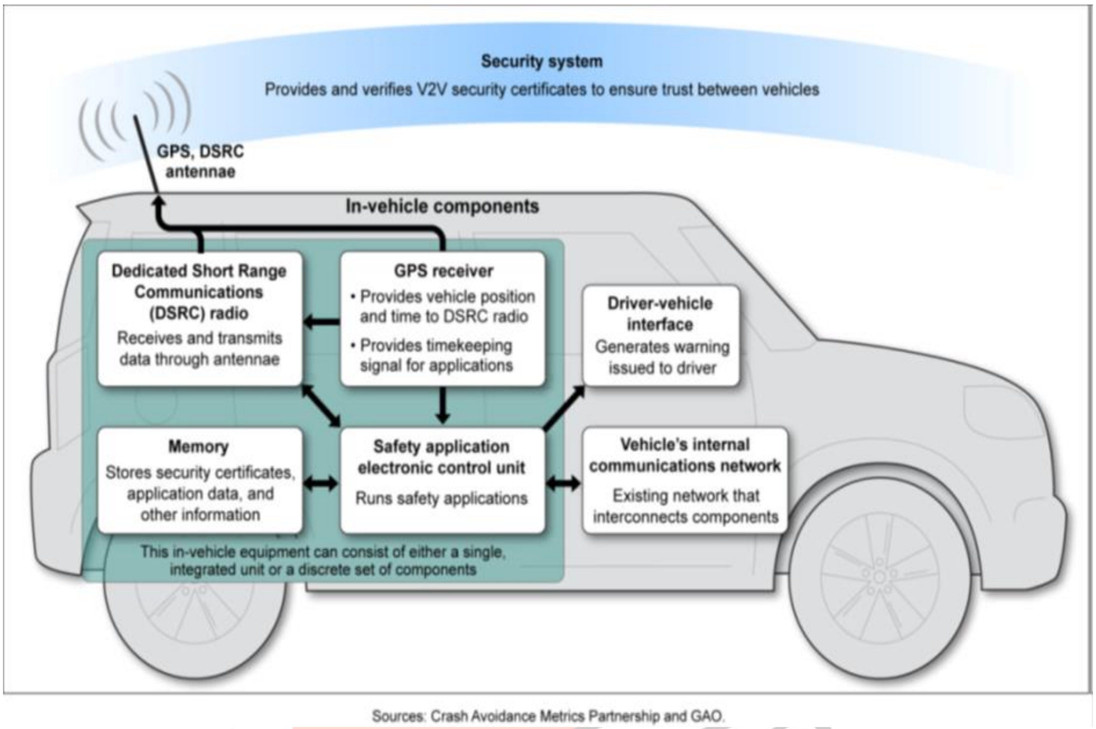


Fig.1 In-Vehicle Components
Source: Crash Avoidance Matrics Partnership and GAO

Components required for AV

1. Automatic Transmission
2. Diverse and redundant sensors (Optical , infrared, ,ultrasonic and laser) capable of operating in diverse conditions(rain, snow, unpaved road, tunnels etc.)
3. Wireless network, short range system for vehicle – to – vehicle communication and long range system to access maps, software upgrades, road condition report and emergency messsge.
4. Navigation including GPS system and special maps.
5. Automated controls(steering, breaking signals etc.)
6. Servers, software and poer supplies for high reliability standards.
7. Additional testing , Maintenance and repair costs for critical components such as sensors and controls. **[7]**

An On-Board Unit (OBU) Interact with driver with display warning, alerts, offering automotive services and communication with a vehicle's surroundings the MobEyes platform uses V2V communication.[8]
A prominent road monitoring platform is CarMote [9].

Due to advances in data storage technologies, it is anticipated that in-vehicle storage capacity will reach multiples of Terabytes in the future, enabling the vehicle to act as a mobile data server.[10]

While moving, other vehicles harvest the meta-data and send queries to obtain data of interest. Another example is the FleaNet platform [11] Vehicular clouds has advantage of their autonomous formation. Neighbouring vehicles can autonomously form a cloud to provide instantaneous services (e.g., collecting traffic information at congested intersections for traffic light management). [12]

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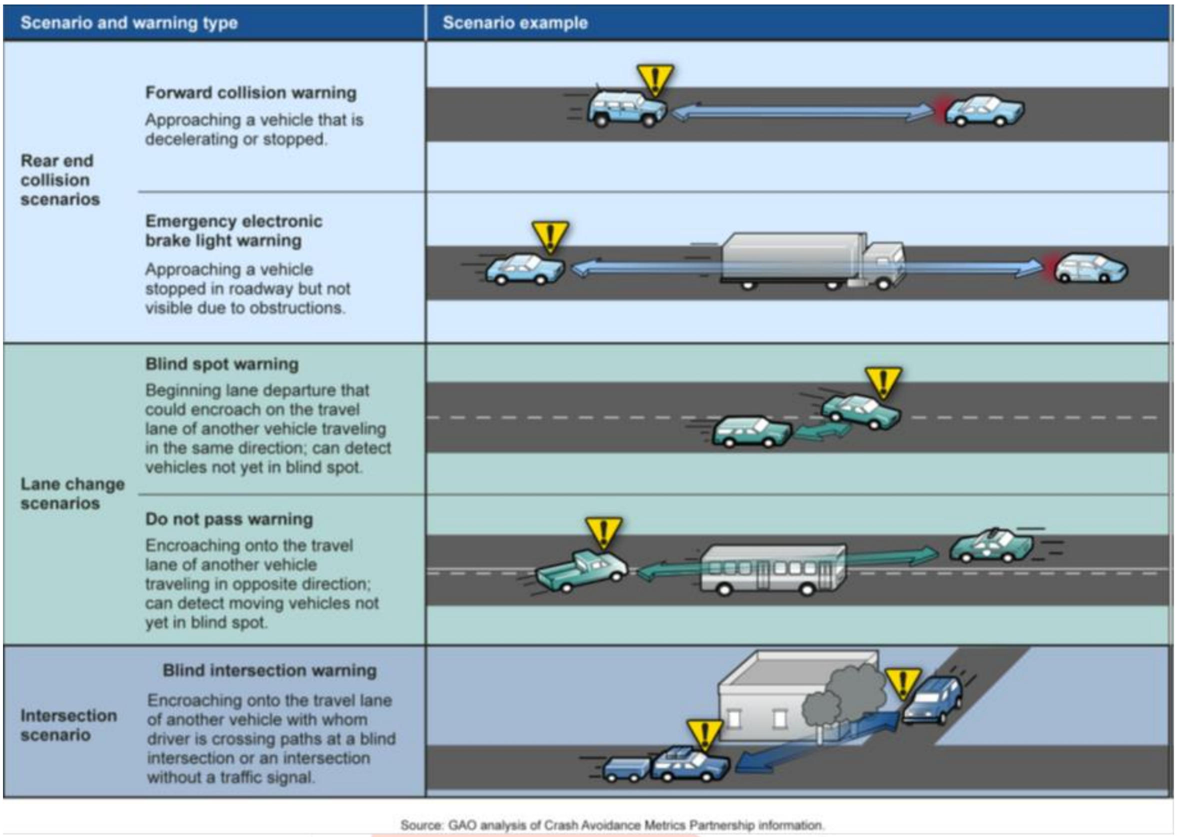

Fig 2- Examples of Crash Scenarios and Vehicle-to-Vehicle Applications
Source: Crash Avoidance Matrics Partnership and GAO

Enhanced Safety in AV [13]

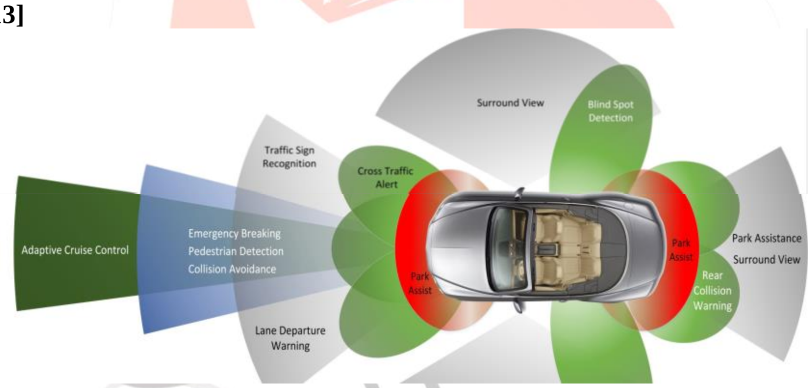

Fig 3

- Long-Range Radar
- Lidar
- Camera
- Short/Medium Range Radar
- Ultrasound

V. 5G IN VEHICULAR COMMUNICATION

a)Feature of 5G

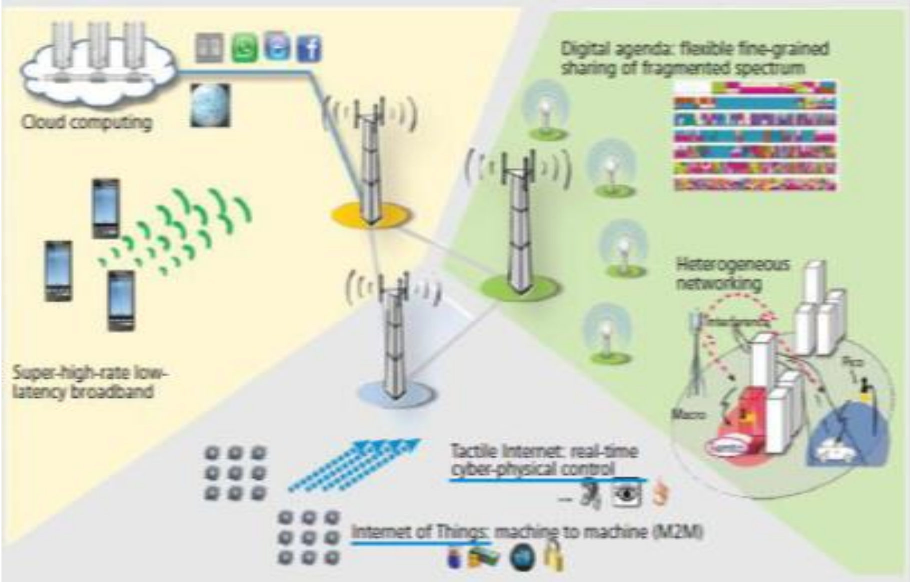

Fig. 4 : 5G architecture

Source: An Example of 5G Application Scenarios with Multiple Access Requirements, IEEE Comm. Magazine, Feb 2014

Key Features of 5G Technology:
i)Data rate : 1000 Mbps
ii) Mobility : 1000 Km/h
iii) Traffic volume density : 500 Tbps/Km2
iv) Connection Density : 106 (Users /Km2)
v) End to End latency =1ms
vi)Battery Life : 1000 Days

b)Use of 5G in vehicle Communication

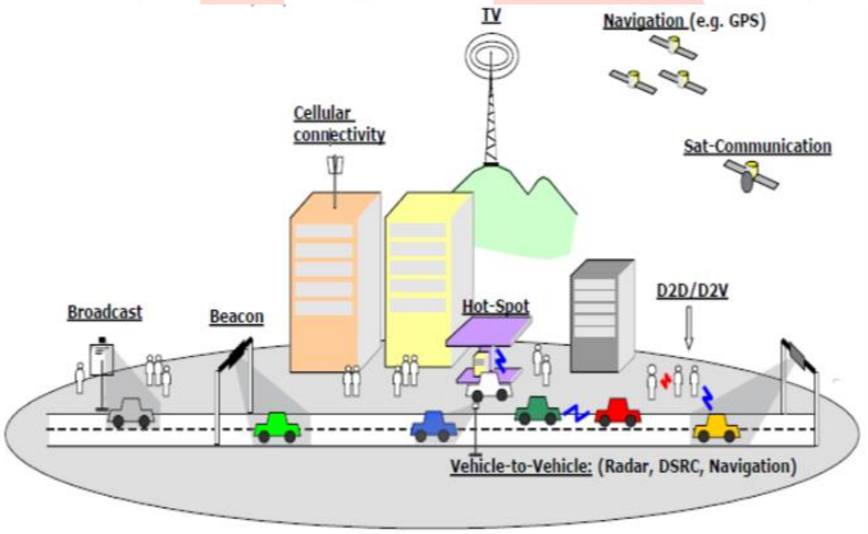

Fig 5 Source: http://www.safecare.gov/v2v/index.html

5G will also look at a "Reliability/latency oriented" use case, which will fit into the needs of services like Industry automation, critical information broadcast or self-driving cars. In this case, 5G technology should adapt itself to a much optimized network in terms of coverage, latency and mobility. [14]

New types of services

Several networks are currently providing connectivity for end-user devices: cellular, Wi-Fi, mm-wave, and device-to-device are a few examples. 5G systems are likely to tightly coordinate the integration of these domains to provide an uninterrupted user experience. However, bringing these different domains together has proven to be a considerable challenge and Hotspot 2.0/Next Generation Hotspot are perhaps the first examples of cellular/Wi-Fi integration.

New frequencies for radio access

It is clear that 5G will need Gbits backhaul and, so far, only fibre optics and wireless can provide this service. s. The disadvantage is t mmW needs Line of Sight (LOS) operation. It can be resolve by electrically steerable antennas and directional mesh for a true SON backhaul in a Non Line of Sight (NLOS) environment. NLOS mmW links, which use advanced MIMO to enable high data rate links into a dense urban environment where the complex multipath environment may be used to synthesize many different spatial paths to support a dense backhaul.

Massive MIMO
Massive MIMO has become a key term and attractive technology for 5G, offering significant gains in traffic density as well as data throughput peak rates.

Traffic Management
As the full deployment of IP based networks is being rolled out, already currently in LTE networks using IPv6, then the ability to offer differentiated traffic quality according to the needs of the service is being deployed.

The safety applications
V2V safety applications that address common rear-end, opposite direction, junction crossing, and lane change crash scenarios, information that another vehicle in an adjacent lane is positioned in the original vehicle's "blind spot" zone when a lane change is not being attempted.

c) Potential Vehicular use cases for 5G [15]

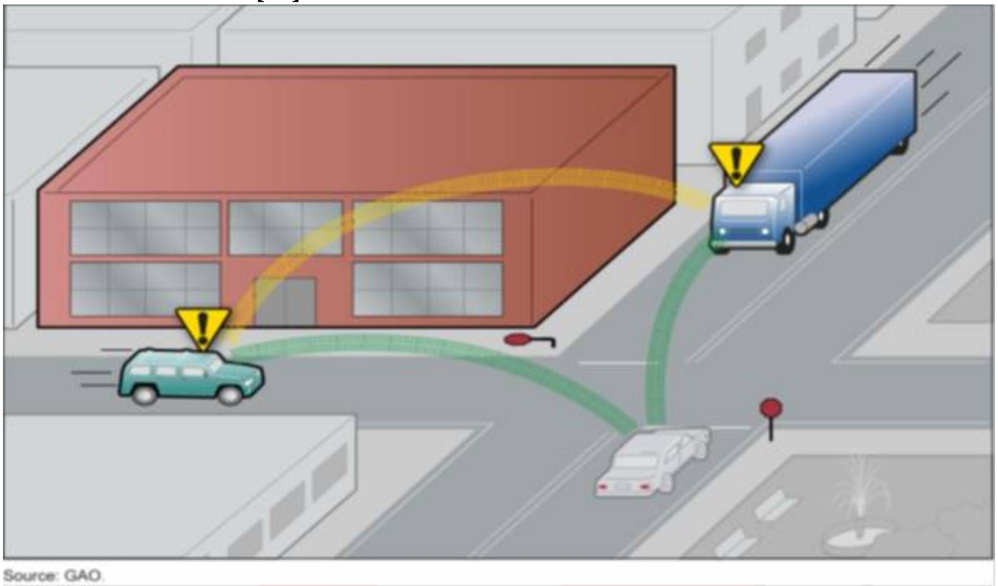

Fig 6

Note: In this scenario, the truck and sports utility vehicle are at risk of colliding because the drivers are unable to see one another approaching the intersection and the stop sign is disabled. Both drivers would receive warnings of a potential collision, allowing them to take actions to avoid it.

Vehicular Internet/Infotainment: The vehicles themselves form another group of Internet users for map, traffic data and high-resolution picture download, as well as sensor data and image upload.

Pre-Crash Sensing and Mitigation: Pre-crash sensing enables vehicles to sense imminent collisions and exchange relevant data among vehicles involved, allowing vehicles and drivers to take counter-measures to mitigate the impact of the collision. Pre-crash sensing requires highly reliable and extremely low latency vehicle-to-vehicle communications.

Inter-Vehicle Information Exchange: Peer-to-peer inter-vehicular communication using D2D cellular technology under the guidance of the operator policies can allow vehicles to communicate information related to road safety and traffic congestion directly in a mesh fashion, thus offloading data from the traditional RAN infrastructure. This is just one possible example of the type of information that can be exchanged

Public safety: Allowing a public safety responder to push a button (push-to-talk) to communicate with other public safety responders. This needs to be extremely reliable, working both on and off network without any delay for dialing phone numbers. The feature needs to allow communication with one or more groups (e.g., local police, regional police, and local public safety) in real time. Public safety users must be able to monitor multiple groups simultaneously (scanning communication on different groups) and allow additional users to join an on-going group discussion.

VI. CONCLUSION

Autonomous vehicle having the components discussed in preceding section can make the vehicle autonomous so that chance accident is very less. AV can do sensing, data storage, computing, cloud, data relaying, infotainment and a means for locating other objects. In particular, vehicular communication requires a significant latency reduction with respect to 4G,leading to a challenging 5 ms end-to-end delay. Additionally, reliable vehicular services shall be provided in a variety of cases, including the out-of-coverage scenario, where one or both devices in communication cannot get network connectivity .IoT traffic requires an extended device ID space (enhanced addressing schemes), well beyond IPv6. Moreover, *flexibility* is also about backward compatibility: 5G architecture shall be able to support and coexist with legacy (e.g. 4G) systems Thus with potential characteristics of 5G e.g. bandwidth, latency, low power consumption, Advanced computing capability can make the Autonomous vehicle advanced and accident free.

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