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Technology Driven | Futuristic Vehicle

FIREFLY 1, WAYMO'S FULLY AUTONOMOUS REFERENCE VEHICLE

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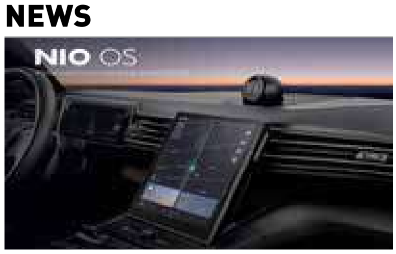

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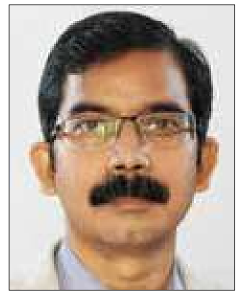
If we look at the research and development activities around autonomous vehicle in India, there is not much to read in news or media as compared to what we read about autonomous vehicle developments from US, UK, Germany or even in not so friendly neighbour- China. Although Motor Vehicle (Amendment) Bill 2017 has a window for seeking government permission to carry out autonomous vehicle research and development in India, few companies have come up with initiatives in this space. KPMG report on Autonomous Vehicle Readiness Index 2019 puts India at 24th position in readiness(20th in 2019). Talking to some industry experts they opine that India may not be so low in adaptability of autonomous vehicle. Given the heterogeneity in our ecosystem, there may be pockets which will see faster adoption of such technologies, once they are available. They also point out that though we may not be seeing press releases or policies for autonomous vehicle, but our large software development base, is working quietly towards the autonomous vehicle of future.

Some point out to lack of infrastructure which will inhibit plying of autonomous vehicle on Indian roads, hence low interest amongst technology developers to test such vehicles in India or to produce one for India. Not sure if we can draw an analogy from what we saw in the domain of digital maps and its use for navigation in India in early 2000s. Partly due to policy hurdles and partly due to naming of roads & localities and maybe some other factors, there was hardly any viable business model for digital maps in India. Utility was overshadowed by convenience of rolling down of window or stopping by to ask for directions. Fast forward to the decade of 2010, digital city map is primary building block of vibrant shared mobility, e-commerce supply chain and more. According to a research report from Rand Corporation, "Countries with limited existing vehicle infrastructure could "leapfrog" to AV technology. Just as mobile phones allowed developing countries to skip the development of expensive landline infrastructure, AV technology might permit countries to skip some aspects of conventional, human-driver centered travel infrastructure."

Whatever may appear, India will be one of the prolific user of autonomous vehicle, unless there is any policy restriction on its use. At least in areas like, captive mining, movement of goods through new upcoming expressways/corridors and more. Considering that almost 30% of the goods transport vehicle are idle at any point of time, due to shortage of drivers and the situation does not seem to improve in near future, semi-autonomous vehicle or fleet platooning could be a way forward.

In view of the benefits, important amongst them being- lesser accidents on roads, lesser lives lost of those in productive age group, lesser fuel used and possibly freeing up parking space; the government should consider opening discussion on autonomous vehicle. We can hope for method evolving in the present maddening traffic situation where brinkmanship is at best on road. Not that autonomous vehicle will not be bullied, as pointed out in news related to self driving shared mobility being bullied in UK (2019). But, in our view, government push for new technologies go a long way in realisation of benefit from them. Electric vehicle for an example has seen a huge uptake, starting with electric rickshaws and now in electric scooters and electric cars etc. Role of government policies(FAME 1, FAME 2) and its proactive initiatives(States having their own EV policies) have been helping the growth of EVs in India. More so in view of fast paced development of highways and expressways in India, it maybe worthwhile to introduce some small elements at design phase which could assist the autonomous vehicle of tomorrow. A small step today may lead to big saving in reincorporating those features at a later date.



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VEHICLE AUTONOMY – THE CASE FOR COMMERCIAL FLEETS

ROHAN DUTTA
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Terrestrial mobility has progressed into an era where Autonomous Vehicles (AVs) are not "just around the corner" anymore. The technology is rapidly evolving and witnessing an unprecedented pace of development through the convergence of edge computing, AI and Data Analytics.

We see two types of players in this segment - well-capitalized entities (big car companies) with dedicated R&D teams and full stack autonomy start-ups who are developing innovative AV technologies while figuring out the business model. With no clear path to funds outside of venture capital, full-stack startups are forced to:

1. get acquired for the tech and talent or
2. shut down operations completely (Peters, 2019)

Autonomous passenger car projects have attracted a lot of capital and talent in the past decade and have created tremendous technological advances in vehicle perception, path planning and control. Recent exits like Uber ATG getting acquired by Aurora in December-2020, Argo AI acquisition by VW in June-2020, etc has indeed resulted in creation of many different types of products related to vehicle autonomy but none of them could generate profits or even revenue in their respective business case.

All these developments indicate that autonomous passenger vehicles are still a long way from commercial deployment owing to the business and regulatory challenges with expectation of further delay due to COVID-19 creating additional anxiety towards shared mobility.

Current Status

Advanced Driver Assistance Systems (ADAS) have been around for decades and are proven to make the driving experience safer, smoother and cleaner. Features like Active lane keeping functions, Lane departure warning, Reverse Assist, Adaptive Cruise Control, etc are already available in production vehicles readily.

However, the Indian commercial vehicle industry has lagged in the adoption of ADAS. We are now witnessing gradual adoption of ADAS in the industry along with proliferation of connected features. This has resulted in revamping of the vehicles for deployment of new hardware like cameras, radars, advanced lane keeping systems, reverse assist kits, etc.

Advent of EV technology will only accelerate the adoption of vehicle connectivity and vehicle ADAS as EVs require constant connectivity and monitoring to deliver on its promise of operational cost savings.

Driver assistance increases safety while driving

As control starts moving from the driver to the vehicle, data that aids decision-making on the road is essential to a safer ride. More advanced ADAS use cases, such as highway assist, combine adaptive cruise control with lane keeping assist. By controlling acceleration, coasting, braking and steering, the on-board computer enables driving at the right speed.

Driver assistance enables higher energy efficiency

For some businesses, success depends on meeting delivery times while minimizing costs. Leveraging data to enable real-time location intelligence based alerts to the driver will aid in optimizing operations for a fleet. Optimal routes will be suggested to the driver based on realtime traffic and weather conditions.

On-board ADAS features utilize the power of edge computing to provide driving assistance features like Accident Prediction and automated braking, highway autopilot with lane-keeping and accident prediction. Such features will not only make it easier for the driver, but also maximize up-time.

Transition to Vehicle Autonomy

A gradual shift is expected from ADAS to full vehicle autonomy. However we believe that this change will be primarily driven by automation of trucks, industrial, agriculture, construction and mining vehicles instead of passenger cars. This will enhance existing autonomous programs, open up new ROI use cases in those sectors and reshape the autonomous vehicle business model in some of the sectors.

The approach for this transition can vary from few players gradually upgrading their ADAS to Level-2 autonomous systems and developing them further to Level 4 and Level 5 autonomy while some players directly attempting to build Level 4 and/or Level 5 autonomous systems.

AV Technology Stack

The major technology developments for AVs happen in the domains of machine perception, sensor fusion, SLAM, reinforcement learning for robotic motion planning and establishment of functional safety for autonomous vehicles.

Perception systems deployed on vehicles will include radars, cameras, etc., for safety, environment awareness, driver monitoring, and lane assist. Camera and radar-based perception systems will be key for autonomous vehicles to understand elements in their environment

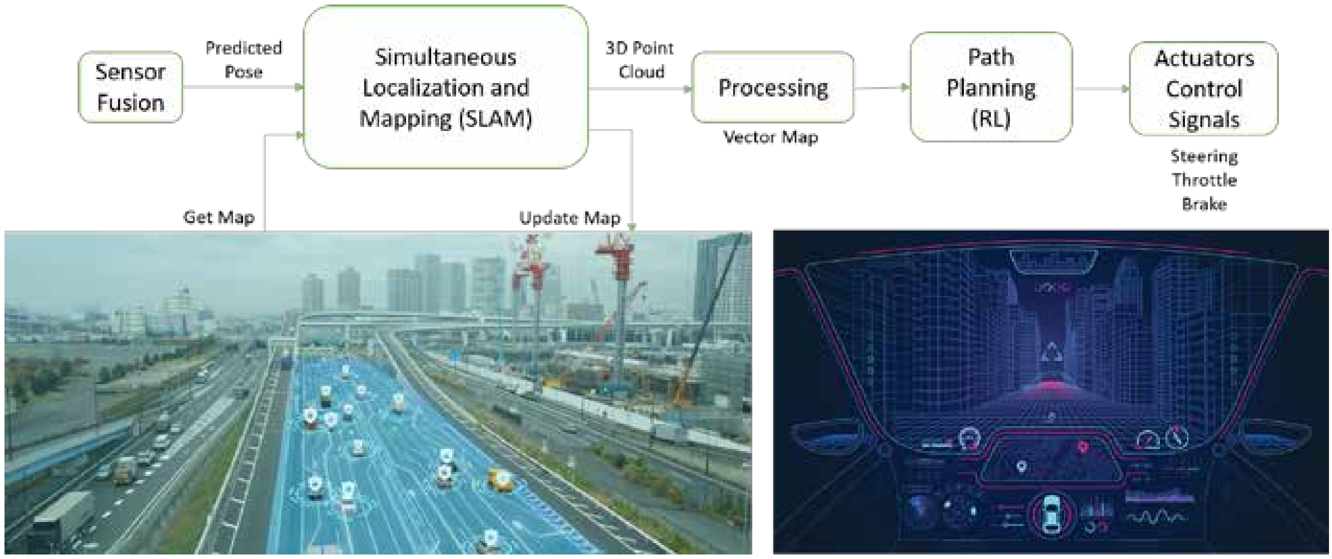
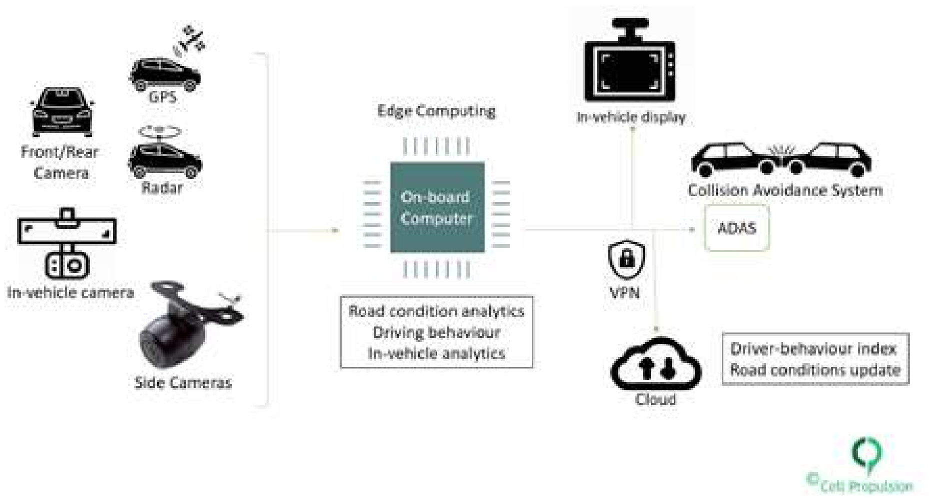


Figure 1 Architecture diagram for information flow from sensors to actuators (copyright – Cellprop Pvt. Ltd.)



— allowing them to perform complex navigational tasks and operations.

Sensor fusion algorithms will allow commercial vehicles to take decisions on the road or mining vehicles to understand ore characteristics to increase productivity per scoop.

SLAM algorithms take the sensor output (predicted pose) and perform the complex task of simultaneous localization and mapping. Using deep learning, the vehicle places itself in a 3D map and then also updates the map at the same time.

Reinforcement learning algorithms are extensively used as the AI driving agent of an AV. The agent learns to drive on the road in a simulation environment and can easily adapt to the physics on the road using transfer learning. SLAM output is taken as an input and based on the scenario, throttle, steering and brake commands are sent to the vehicle actuators.

Finally, the most important criteria for the success of AV technology are high reliability and safety. Autonomy only achieves its full potential if the solution works with minimal downtime and improves safety (which is also tied to equipment replacement costs, driver compensation and insurance).

Autonomy for Commercial Vehicles

The DARPA Grand Challenge is the driving force behind the Google self-driving car project (Waymo) and the subsequent explosion of passenger car AVs. The advances made during the challenge also spilled over to commercial vehicle fleets. Since then, autonomous vehicles have been developed and tested for long haul trucking as well as commercially in large-scale agriculture, mining and defense in various countries.

There is a prevailing consensus in this sector that the goods transport, industrial, agriculture, construction and mining applications are better suited for near-term autonomy. The environment is more-constrained, well-defined with fewer edge-case scenarios. The driving itself is much more linear making it easier for the driving agent (AI) to be trained and also take decisions in real time.

The Vision

Cellprop's team has developed level-2 autonomous vehicle technology stack and deployed on a pilot vehicle. Equipped with cameras and radars, the onboard RL agent drove the vehicle at cruise speed with success.

Now, a forerunner in connected electric commercial vehicles, Cellprop is developing electric CVs ranging from eLCVs to eHCVs. These vehicles are offered with internet connectivity as a default feature. Our in-house developed Mobility Platform leverages this connectivity to enable over-

the-air (OTA) updates for deploying advanced driver assist features while also offering battery health monitoring and fleet management solutions. In coming years this vehicle connectivity layer will form the basis of deploying software for vehicle autonomy and consistently improving its performance.

Recently, the Indian ministry of road and transport has cleared the fully automated GPS based toll collection system which eliminates the need of toll booths completely. Every vehicle on the road has an onboard GPS device which will track vehicle movements across the country and deduct the toll from the linked bank account of the vehicle owner, accordingly. The government also is enabling a plan to equip all existing vehicles with a telematics solution to achieve this future. Currently, all new commercial vehicles are already equipped with GPS tracking technology. (Mehra, 2020) Such intiatives by the government will boost R&D in the vehicle telematics industry and pave the way for AVs.

Our vision is of a future where large fleets of connected autonomous electric long-haul trucks transport goods across the length and breadth of the country and transform logistics and carrier industry for good.

Future Outlook

There is a prevailing misconception that AVs will render truck drivers jobless. Articles like "Self-driving technology Threatens Nearly 300,000 Trucking Jobs, Report Says" have been published numerous times. (Smith, 2018)

The author agrees that there will be fewer drivers on the road, but that doesn't mean the role of humans is eliminated. Humans will operate fleet operation centers, where drivers can be trained to take the role of a truck operator, who will manage a single truck or a convoy and monitor every aspect of the truck and road remotely and if needed, take control of the vehicle and drive it remotely.

Like Mission Operations centers that operate 24x7 to handle a network of remote sensing or communications satellites, CV fleet owners will operate fleet operations centers with a team to monitor and control all autonomous operations.

Autonomous trucks will eventually drive around the country solving all our logistics needs and fleet owners/operators will play a pivotal role in enabling and adapting to this technology in a structured manner to achieve connected electric autonomous mobility.

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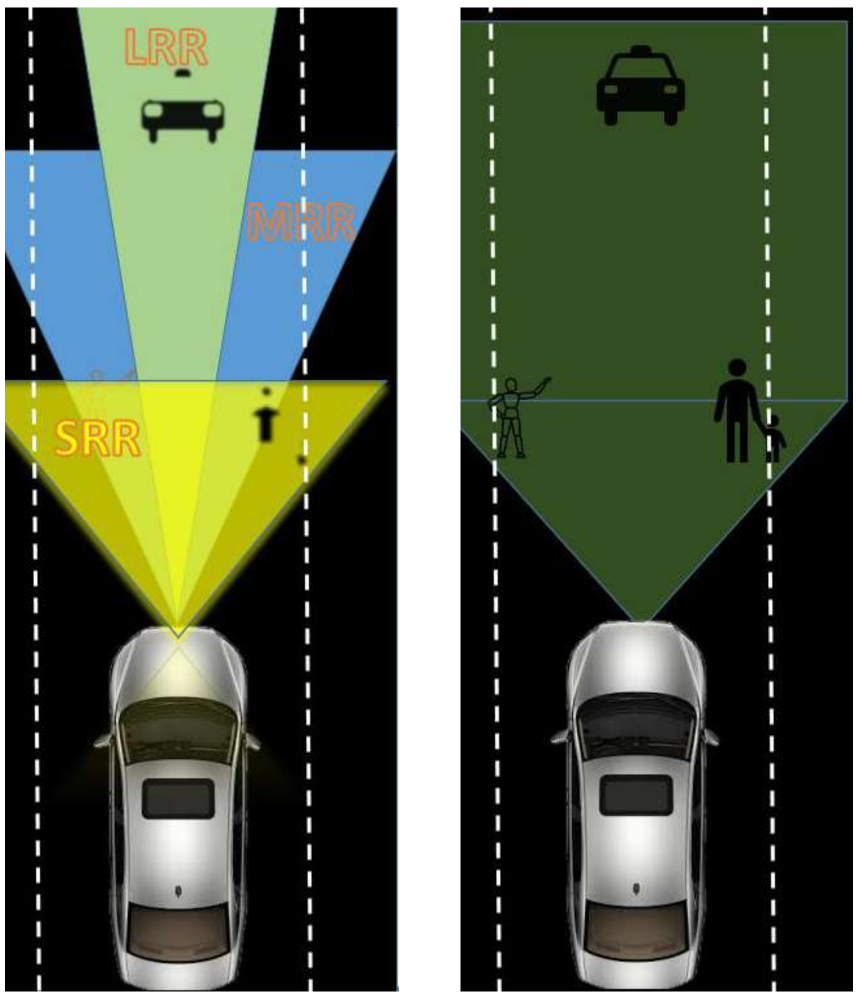
HIGH RESOLUTION IMAGING RADARS FOR HIGHER LEVELS OF AUTONOMOUS VEHICLES

DR. ANIL KAMMA, ASHISH LACHHWANI, RAKESH KUMAR
STERADIAN SEMICONDUCTOR

Active safety systems are becoming standard equipment in more and more vehicles. These systems rely on accurate information about the environment around the vehicle. This information is acquired using a whole suite of sensors. For Autonomous Vehicle's (AVs), Radar is a prevalent sensor to perceive the vulnerable road users/objects and can be easily integrated to estimate range, velocity, angle, and some cases elevation height of the target objects with respect to ego vehicle. Automotive Radar is the key sensor to evaluate relative velocity of the intended target.

Front cameras (SMPC or MPC) mounted high up behind the vehicle windshield dominate currently in ADAS applications like the lane/object detection and its related areas. However, the performance of the camera degrades when it encounters extreme lighting conditions. This degradation may not only be caused by adverse weather conditions like heavy fog, haze, rain, snow, etc., but can also arise out of challenging lighting conditions like the strong head- or taillight from other vehicles, the glaring sunlight from the sun. In some critical scenarios may be problematic for camera alone to detect, like the sudden change of the lighting when a vehicle drives into or out from a tunnel on a bright day, etc.

Historically Radar is associated with World War 2 technology. With advancements in Semiconductor technology and miniaturization, it got integrated into vehicles as a warning-based system. This was good enough for a highway scenario in certain geographies. Today, the world is transitioning from L1 to L2/L3 and even higher degrees of autonomy. With various mishaps in which AVs were entangled in their recent rollout phase from different OEMs, the need for Imaging Radars got emphasized.



(a) Conventional SRR, MRR and LRR (b) Imaging Radar
Fig.1

Being a reliable, all-weather sensor, the world is expecting Imaging Radars to deliver on counts of High resolution and a sensor which can be used in conjunction with Camera to produce a real-time reconstruction of the surroundings. In Essence, replacing human eyes on the road. Such a technology would also find use in many other applications. The key technical challenge of the automotive radar system is resolution, and classification in dense environments in all dimensions of space and time.

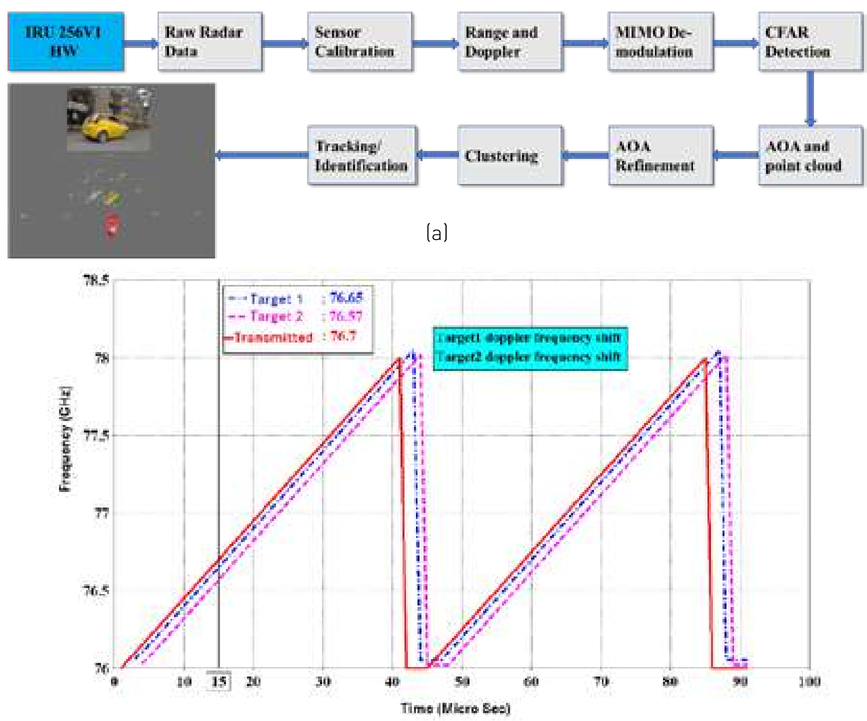
Since the advent of the Adaptive Cruise Control (ACC) application as part of Advanced Driver Assistance System (ADAS) at the end of the last century, radar sensors became more and more essential in the ADAS automotive area. The advantages of radar sensors (insensitive against dust, fog and darkness as well as instantaneous speed measurement) were quickly recognized and used in many ADAS, like Lane Change Assist (LCA), Rear Cross Traffic Alert (RCTA), Blind Spot Detection (BSD) or Automatic Emergency Braking (AEB). With the increasing level of applications complexity in ADAS, the demand on the imaging radar increases too. With these advanced imaging radar, the recognition of relatively small objects like pedestrians, cyclists, and stationary objects in a dense urban environment would be possible in more efficient manner than the conventional radars as shown in the below Figure 1.

Steradian Semiconductor Imaging Radar

Steradian Semiconductor has a proven track record of building Ultra-High-Resolution Imaging Radar solutions, with the current generation on the market offering 256 Multiple Input and Multiple Output (MIMO) channels. In addition, the developed module has capability to accomplish superior resolution (3cm range resolution and 1-degree angle resolution) at 15fps (Frames per second) (online) and 20fps (offline) for 50-meter distances. The module is a generation ahead of the present market solutions positioned at 10cm range resolution with range of only 20 meters. The module is able to manage massive data efficiently while enabling a real-time ultra-high resolution. In addition, with simply changing the software, the same platform can be used for LRR application offering tracking of objects till 300-meters distance. The simple block diagram of the steradian developed imaging radar SW stack is given below Figure 2. This high-resolution radar can be used for multiple fields, and not only ADAS, like traffic monitoring, human motion detection, security application without compromising on the privacy. IRU256V1 uses Frequency Modulated Continuous Wave (FMCW) modulation for its operation while extracting range, velocity, and position of the target to a very high degree of accuracy. A typical FMCW chirp configuration can be seen in the below Figure 2(b). The maximum frequency change in the echo signal with respect the transmitted signal provides velocity and range information, thereby placing the target in a relative sense to the ego vehicle.

IRU256V1 has self-test routines for customer debug and easily configured for different applications and platforms as it is designed for more generic software and hardware combination for range of possible applications. The RF front end of the radar unit is critical in deciding the radar overall performance. In front end, CMOS Radar IC is key module where all transceivers, registers, memory, and other routines for output data are implemented. Salient features of the IRU 256V1 sensor are summarized below:

- Single Radar unit for LRR and SRR at 76-81 GHz.
- Multi-Mode characteristics with ease of configurations.
- Real time Point-Cloud or tracked objects as the output.
- Based on SVR4410 High Performance CMOS Radar IC.
- Mapping of both stationary and moving targets.
- 256 Aggregate MIMO channels (16 Transmit and 16 Receive channels.)
- Azimuth and Elevation Scanning.
- Compact Size of 16.8cm × 11.4cm × 3.48cm
- Resolution details for different modes of the radar are tabulated in below Table 1
- Power emissions for different modes are as per the standards and given in below Table 2
- Maximum range for different modes and their Field of view (FoV) in both azimuth and elevation are given in Table 3



(b)

Fig. 2 (a)Simple block diagram of Imaging radar IRU256V1 and (b) typical FMCW chirp and target echoes

Table. 1: Range resolution doppler resolution and angle resolution for different modes of the imaging radar

Parameter	Value	Units	Comments
LRR – Range resolution	0.6	m	
MRR – Range resolution	0.15	m	
USRR – Range resolution	0.0375	m	
LRR/MRR: Max unaliased doppler	81	m/s	77GHz center frequency
LRR/MRR: Velocity resolution	0.42	m/s	
LRR/MRR: Azimuth resolution	1.2	degrees	
LRR/MRR: Elevation resolution	4.0	degrees	
LRR/MRR: Azimuth accuracy	0.1	degrees	1σ at 35dB SNR
LRR/MRR: Elevation accuracy	0.25	degrees	1σ at 35dB SNR

Table. 2: Power emissions and Beam forming techniques

Parameter	Values	Units	Notes
Beam forming	Digital and Analog		
Number of Receiving antennas	16		
Number of Transmitting antennas	16		
Maximum EIRP	36	dBm	Without radome losses
Modulation used	FMCW		

Table. 3: Radar maximum range and FoV for different modes

Parameter	Values			Units	Notes
	Min	Typ	Max		
Detection range for ±65° Azimuth FoV	0.3	20		m	USRR mode
	0.3	50		m	USRR offline mode
Detection range for ±10° Azimuth FoV		250		m	LRR mode
Elevation FoV		±15			SRR and LRR modes
ADC sampling rate			100		MSPS

Steradian Semiconductor is developing radar systems based on Hybrid Beam Forming (HBF) technology to integrate features like multi-mode configurations and application flexibility. As the operating frequency is 76 GHz and above, to avoid any losses associated on the packaging layout, PCB dielectric and conductors need to be carefully designed. From feedline to the antenna losses are minimized by avoiding sudden changes in the signal transmission paths (bends) and impedance matching techniques. Below Figure 3 shows the feedline line characterization by varying the width and length of the feed line to estimate characteristic impedance and guided wavelength at 79 GHz. The antennas are designed based on low loss substrate with dielectric constant 3.3 and loss tangent of 0.001. In the process, once the feed lines are characterized for desired impedance, antenna is fed through the feed line with minimal insertion loss and minimal impact on the radiation pattern.

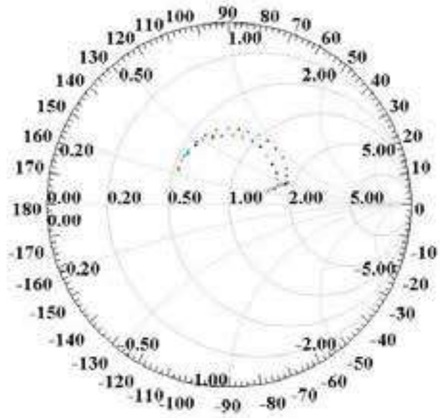


Fig.3 Feed line characterization using smith chart

As shown in below Figure 4 (a), (b), antenna exhibits wide azimuth and narrow elevation radiation pattern with high gain and low side lobes to cater the ADAS functional requirements. The antennas are designed based on series fed linear array with end feed technique. As mentioned, IRU256V1 has different modes of operation with different field pattern and intensities are facilitated through exciting multiple antennas simultaneously. Figure 4(c) shows the measured two-way magnitude pattern of the module with single transmitter- single receiver antenna channel and three transmitter-single receiver antenna channels. Modeled pattern and measured pattern are correlated with each other.

Radar IC is key component in the imaging radar, as it has transceiver modules for the respective MIMO channels. IRU256V1 uses fully integrated 16 channel E-band MIMO radar transceiver. Figure 5 shows the image of the Radar IC. This module has 19 dBm transmitting power and capable of high precision beam steering. The noise figure of the receiver channel chain is 8dB and can support the 100 MSPS ADC.

IRU256V1 device firmware runs from another host controller, enabling all the functions of the RF front end module or RFIC communication with Analog to digital converter (ADC) and GPU based processor. The firmware package that provides continuous monitor, control, and configuration for chirp Band Width (BW) and frequency as well as transmitter sequencing synchronization with the external world has been controlled in real-time. The processed point cloud for the scene in the image is depicted in below Figure 6.

3. Conclusion

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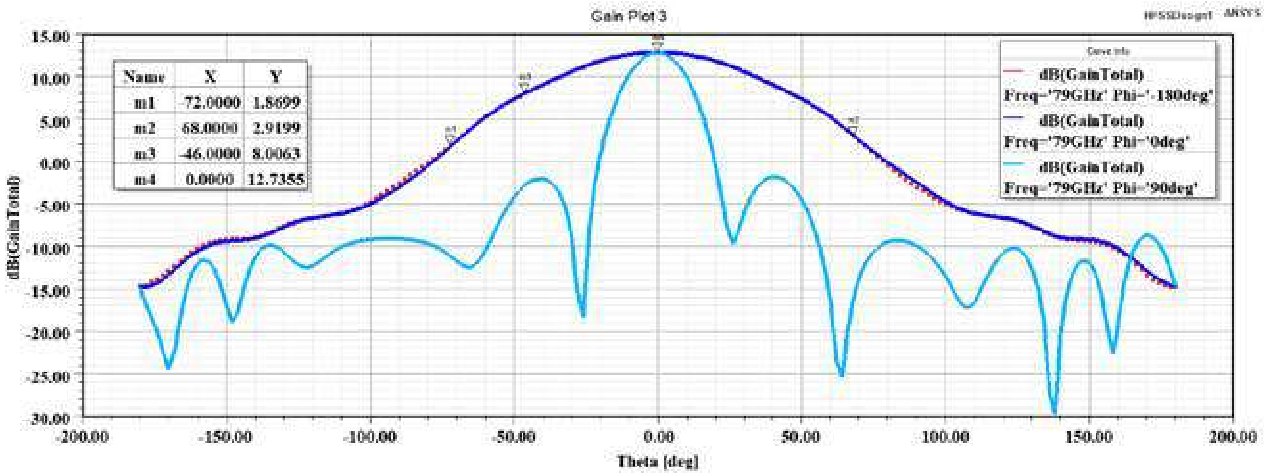
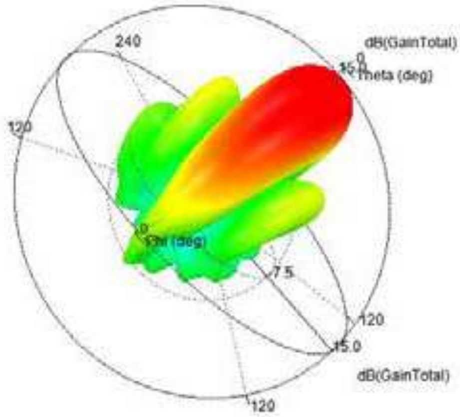
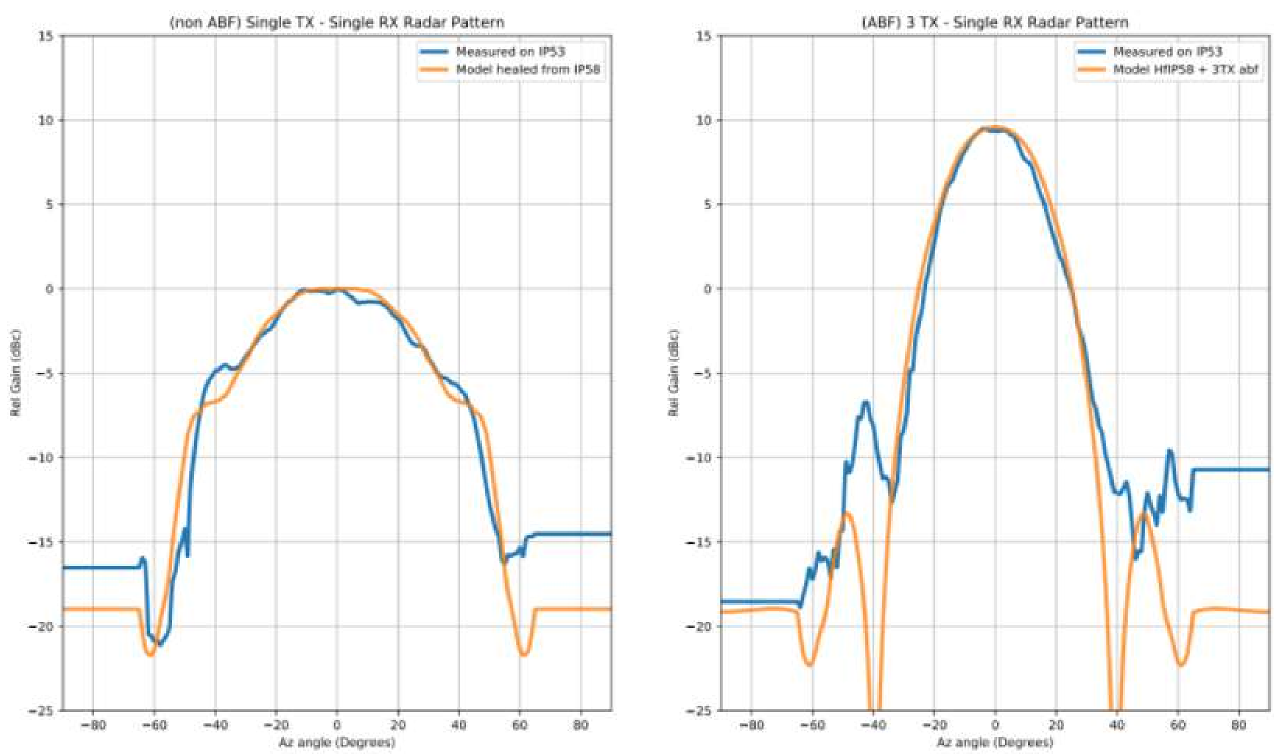


(a)



(b)

(c)



(d)

Fig. 4 (a) Simulated radiation pattern, (b) 3D radiation patter, (c) Measurement setup and modeled and measured patterns of the antenna used in IRU256V1.

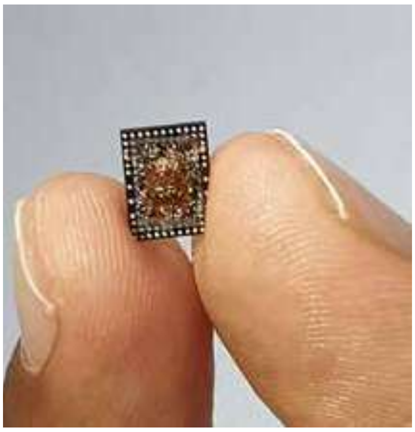


Fig.5 Radar IC image

environmental conditions makes the IRU256V1 a promising candidate for automotive AV/ADAS and other industrial applications. Tracking algorithm tracks all the objects physically small in size such as pedestrians, bicycles, scooters, in the vicinity of stationary objects like a parked vehicle and even traffic cones. The Imaging Radar is reliable to integrate ADAS and AV systems for perception of the environment as it can minimize false alarms, which are prevalent and undesirable with radars. An important design aspect of the imaging radar is to detect of the vulnerable road users thereby bringing safety at the core of the solution. The formfactor of the module

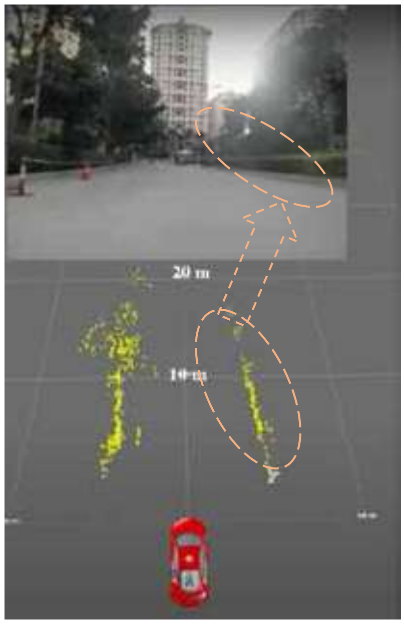


Fig. 6 Processed point cloud for the scenes.

is low to integrate in the AVs. An imaging radar with 256 channels is state-of-the-art and competent for the market. Summary of the IRU256V1 imaging radar specifications are given in below table.

S. No	Features	Description
1	4D Imaging	Antenna 6.5° elevation beam width
2	Multimode support	Wide field of view of 120° in azimuth and 30° in elevation
3	Quick evaluation	GUI for data collection and FoM testing.
4	Realtime application	15 fps refresh rate through standard ethernet interface

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ASHISH LACHHWANI

Ashish Lachhwani is a 2004 Institute Silver Medalist from IIT, Madras. He joined Texas Instruments (TI), Wireless Group in 2004 and was instrumental in developing 2 generations of TI low power Bluetooth Radio solutions called SimpleLink. He is a co-author for the book on Ultra-Low-Power Radios published by Springer. Ashish was the Frequency Synthesizer architect of Qualcomm Snapdragon 65x RFIC. He holds 8 issued patents.

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Rakesh Kumar is an alumnus of Delhi College of Engineering and has a proven track record of building lowest area RFIC. Rakesh led the WLAN RF for 2 generations in Texas Instruments. He was the Receiver lead for Snapdragon 65x RFIC of Qualcomm. He has wide experience in developing complete solution including Firmware & Systems. He has co-authored 2 IEEE papers and holds 8 issued US patents.

Real Autonomy in the Autonomous vehicle: A Neuroscience-computing Approach

SHAM SUNDAR RAO
CONIGITAL-ICAV TECH

The future of transportation braces the high level of automation and connectivity defined by software. An Autonomous vehicle (AV) will be a key enabler shaping driving automation. When successful with full automation and networking, AV allows passengers to travel more comfortably and safely with a new mobility paradigm. To capture the AV space many auto giants and technology companies are aggressively pushing the limits of science and technology to reach customers asserting the potential to gain an economic and social foothold. In the next decade, stakeholders are set to explore new frontiers to achieve human-like remarkable results in driving automation. SAE Level 2 to Level 3 is the current focus for automated-driving systems. Moving from SAE Level 3 to Level 4 and Level 5 (Human-Out-Of-The-Loop) is all on the continuum.

Driving without a human driver behind the wheels looks fascinating but Intel's study reveals that many consumers don't feel safe using AVs with current technology. But on the contrary, nearly 63 % of the U.S population will be driving fully automated vehicles by the year 2070.

Trust, safety, and security are three pillars on every OEM's and tech companies mind responsible for creating the brave new world of AVs. These three entities describe risks along with opportunities in making AVs accepted by the general public. True to its value comes with greater challenges.

To date, the AV industry is less confident to drive in real public driving scenarios with flawless operation irrespective of road condition, visibility, traffic density, and weather conditions due to sensor and algorithmic limitations. The fatal accident in recent times operated by Tesla and Uber self-driving is an admonishing reminder.

In contrast, in most cases, human drivers are not only known to drive comfortably and safely in a familiar environment but can also handle complex, fast-changing, and partially-observable unknown environments with ease. The reason for being successful is humans depend upon their knowledge gained through unsupervised and supervised exploration for experiencing the diversity of real-world settings and reuse the learned concepts and abstractions built from during lifetime driving to quickly adapt from only a few instances of evidence. This is one of the holy grails that engineers and researchers strive to develop and demonstrate in safety-critical applications like self-driving today. There is a lot of hype surrounding AVs. The reality is many automakers concedes highly-automated-driving (HAD) will take much more time than anticipated.

The current paradigm of AV functionality consists of:

1.AV Sensor suite: For the AV to handle complex driving scenarios,

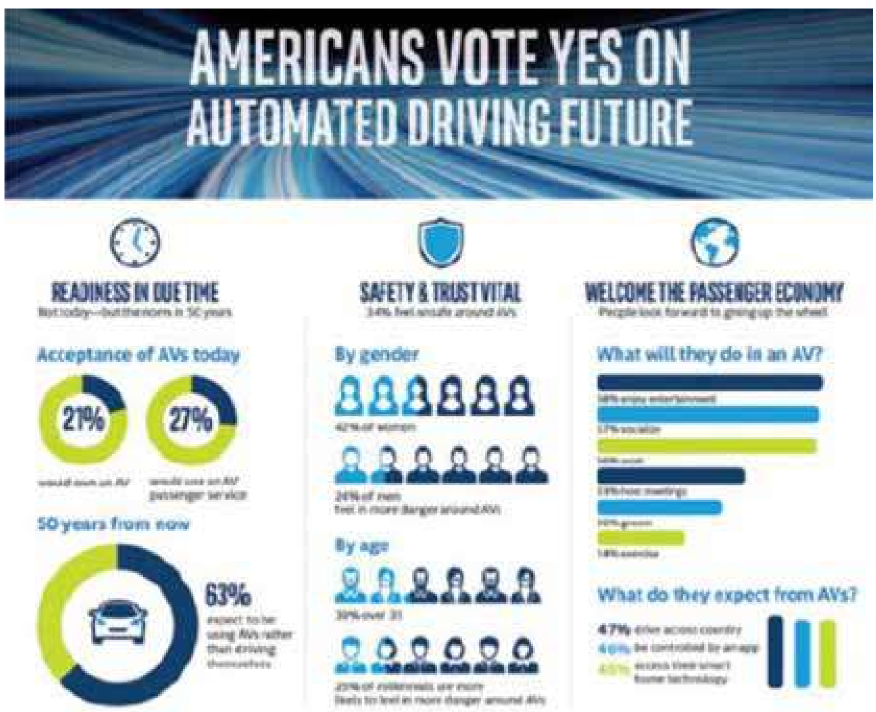

Figure 1: Intel's survey report (2019) of AV acceptance in U. S

Figure 2: Deployment Timeline by auto and other major players

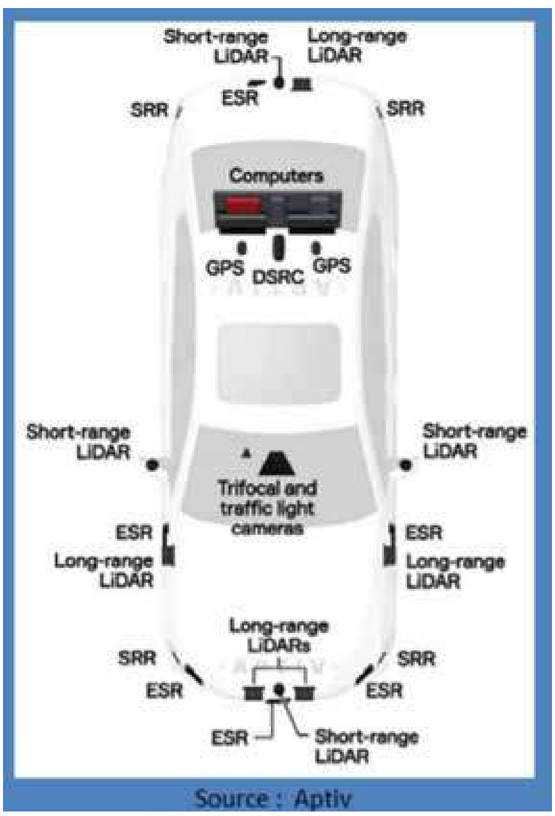

Figure 3: AV depends on powerful Sensors and computer for operation

information from the camera, lidar, radar, etc., must be intelligently connected as shown in figure 3 and brought into context. Different sensors are required to perceive the environment and unequivocally comprehend digitally every driving scene in less favorable environmental conditions. AV sensor suite powered by sensor fusion provides a sweeping and 360-degree view of the driving condition. AVs will be as good as its sensor suite and algorithm running it.

2. **Data-driven approach:** The widely adopted approach is the data-driven computing technique consisting of four modules like perception, localization & mapping, planning, and motion controls as depicted in figure 4.

In this paradigm, the information is processed and computed serially. The environment perception data is obtained by sensors suite which are used in localization, manoeuver decision, path, and speed profiling to derive motion controls. Driving tasks are accomplished either using a static rule-based engine or Artificial Intelligence (AI) techniques. Artificial neural network (ANN) is widely used to tackle the challenges like object detection of driving automation is called 'Narrow AI' as shown in the below figure 5 and 6.

However, the data-driven approach fails to address unfamiliar scenarios and hence poor in adaptability and self-learning. The current state-of-the-art ANN is quite not ready to be used in safety-critical applications like self-driving cars as it encounters a fast-changing world filled with noisy stimuli signals and detect unpredictable changes during its journey. It is being widely used as a 'magic wand' without knowing its limitations, background, and less emphasis on understanding the DNA of cognitive science underpinning them. Most of the ANN model works well with the simulation-based approach but fails when operated using hardware to conceptualize and generalize in the real world-a phenomenon called 'reality gap'. Moreover, ISO 26262 does not mention guidelines using AI.

To mitigate the challenges of SAE Level 4 and above we can take a cue from current developments in neuroscience. The next big wave of Artificial General Intelligence (AGI) with human-like cognitive is the long-term goal of AI is dogged from the cognitive neurobiology domain to address the current problems in the AV industry. Some of the concepts described below show promise and can be applied to make AVs more robust, safe, and, could reach nearer to an average human driver in terms of performance. The next section describes a few concepts stemmed from neuroscience:

1. **Learning algorithms:** The non-biological aspect of the majority of deep learning techniques applied in AV at present is the supervised training process with backpropagation algorithm that suffers from two problems: requiring a massive amount of labeled data and a non-local learning rule for changing synapse strength. A biologically plausible plasticity learning algorithm is comparable with standard backpropagation based ANN models minus two problems aforementioned. These algorithms banks upon an unsupervised way of learning and utilizes local learning rules leading

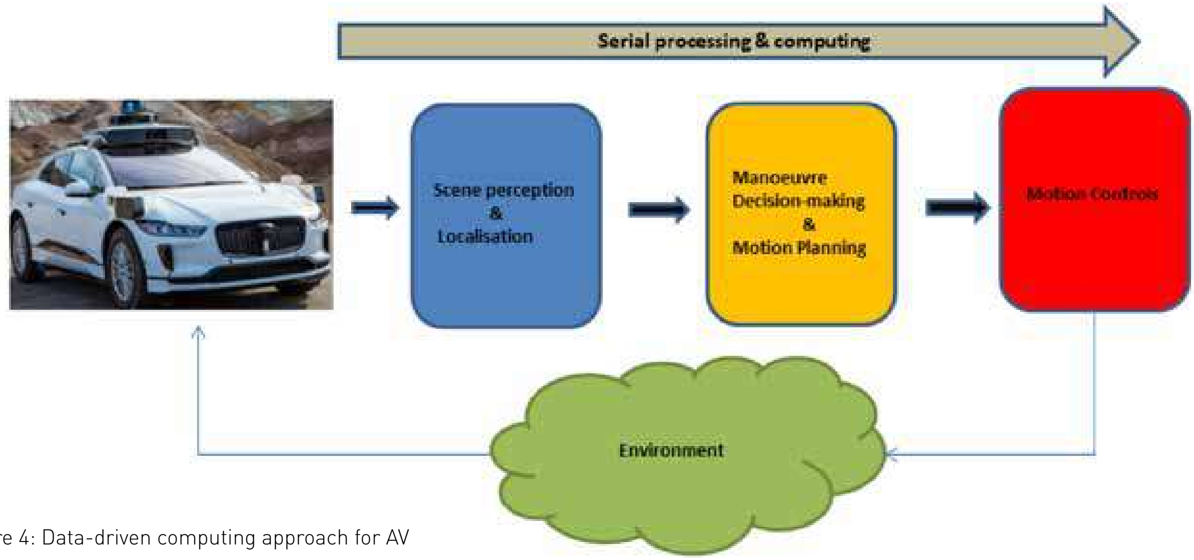

Figure 4: Data-driven computing approach for AV

Figure 5: AI based automatic object detection, classification and its localisation

to good performance and generalization on the benchmark datasets. Taking a cue from neuroscience development, few players investigating and building a robust lightweight platform based on signatures, bottom-up, fine grain, unsupervised learning enabling a comprehensive understanding of AV surroundings.

2. Episodic memory: To mitigate the challenges thrown by the real-world, Autonomous vehicle companies have started using the idea of world models and constructive episodic simulation hypothesis (CESH) in planning and imagination of future events remembering from past experience. AVs moving in complex and constrained noisy environments can leverage upon the idea of a hippocampal episodic memory controller that can guide decisions based on a single past episode that it remembers or even when it needs to transfer from one task to another as reflected in Rapid & Zero/Single-shot learning.

3. Cognitive model: A novel self-driving framework combined with an attention mechanism inspired by the human brain has been reported. The framework the brain-inspired cognitive model with attention (CMA) simulating the human visual cortex, LSTM, and cognitive map for attention mechanism. It can handle the spatial-temporal relationships, to implement the basic self-driving missions.

4. Metacognition: To deal with surprising events metacognitive learning has been used in AI agents to increase the level of autonomy and has the potential that would compensate for the weakness of model-based reinforcement learning (overconfident algorithm). Again it has roots in decision neuroscience. Metacognition refers to an ability to evaluate an agent's own thought process, such as perception, valuation, inference, and to report the level of confidence about choice leading to an outcome. This approach resolves exploration-exploitation tradeoffs and brings a performance boost to decision-making models in AV.

5. Virtual brain analytics: Self-driving vehicles implicating current ANN models are considered as 'black boxes' which makes it harder to detect the faults and where the impossibility of understanding leads to serious safety issues related to validating the computations of critical components.

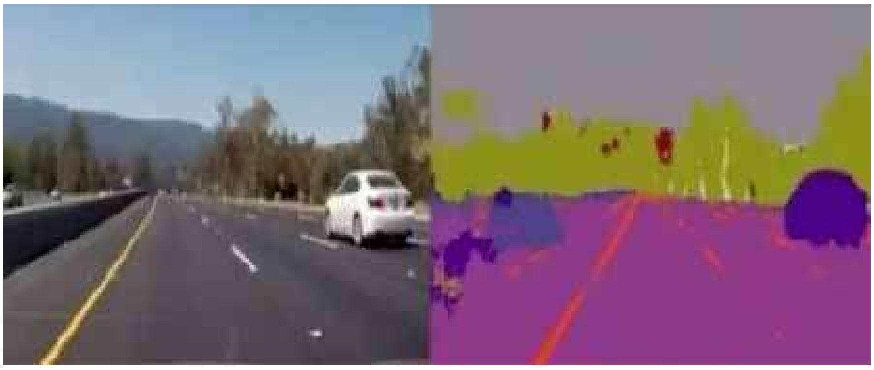

Figure 6: Colour segmentation enabling AI to learn to idenify driving environment

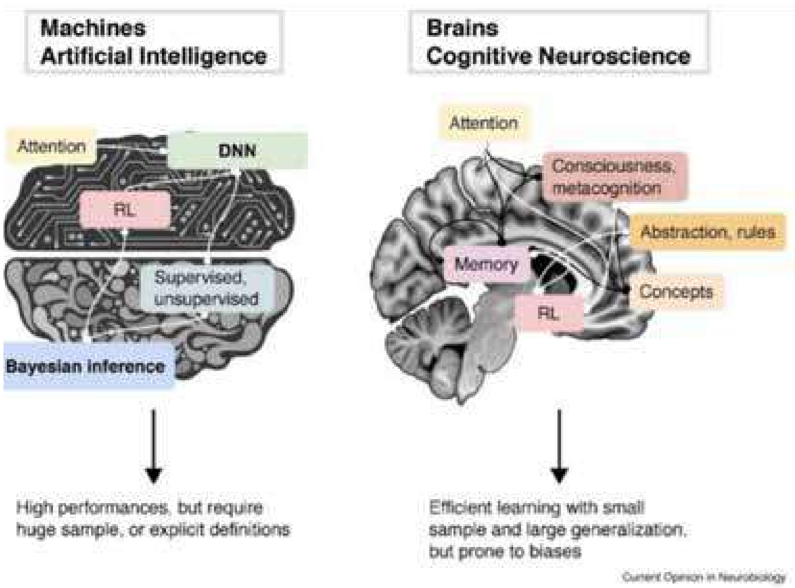

Figure 7: Comparison of artificial and natural intelligence

Efforts in the direction of decoding black box to grey box (if not white) are shown but proving the faithfulness of the automatically generated explanations on neural network models is the greatest challenge as of now. However, recent techniques like lesion and neuroimaging can be applied to get deeper insights to computation of AI systems. It also increases the interpretability of these systems so as to improve the safety issues.

6. Decision-making model: In a normative real-world, decision making in mammals is central to cognition and ubiquitous in our daily life. A decision is a process that weighs priors, evidence, and value to generate a commitment to a categorical proposition intended to achieve a particular goal. The recent development in neuroscience imaging proves the dynamism in the mammalian brain circuit during the decision process.

The brain is made up of more than 100 trillion neurons and synapses making a complex network to learn, but it takes just an image to extract the knowledge and builds a generalized conception about the overall environment quickly in an unsupervised way. The cortico-basal-ganglia-thalamo–cortical loop (CBGTC), a neural substrate, is involved collectively in the decision-making process and recent evidence in decision neuroscience has shown that multiple regions of the brain networks are associated with specific facets of decision making. The different neural circuit gets implicated with a decision made under-risk and uncertainty, probabilistic reasoning, value, and reward-based. Evidence accumulation based algorithm like multi-hypothesis test can be proposed for the arbitration process in case of a conflict between multiple decision-making systems in AV.

David Cox, MIT-IBM Watson chief, mention that days are not far when the brainpower of rat if properly applied is sufficient to drive a car. Live brain uploading or brain digitizing is the new frontier of research and going to squeeze the biological brain more to fill the gaps and upload in new AI.

To conclude, to be successful the system on its own has to perform well and meet the desired expectations of the goal in both normal and adverse situations. The above-highlighted areas of neuroscience have the potential to lend more real autonomy to make the autonomous car self-learned and be adaptive. Historically, the flow of information from neuroscience to AI is reciprocal. It's not a compulsion neither to apply biological plausible concepts or a mandatory requirement but a seeing through the lens from neuroscience springs new algorithms, architecture and validation of current AI techniques. The principles of neuroscience embody could inspire the development of comparable strategies that confer flexibility and efficiency in self-driving cars by filling the gaps that exist in ANN. The need of the hour is to have an inter-disciplinary approach from Computer science, Neuroscience, and Cognitive psychology as well as hardware support to convert the science-fiction theme to reality. ❏

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Autonomous Vehicles – A Waymo Perspective

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Autonomous driving technology is a promising, rapidly evolving, disruptive game-changer that will not just change our societal structure but earmark a radical evolutionary step beyond just commute. The introduction of autonomous vehicles (AVs) on public roads is perceived to be a futuristic change in the way human transportation is conceived and conducted. But what is more intriguing is the epoch of significant transition where a vehicle's control is with an onboard computer system while the occupants enjoy their travel time, sublimating to the technology's prowess of handling imperative artefacts like safety and seamless navigation on public roads. The nuanced concern about any technology, however, is building trust among the optimistic technology adopters through culture-changing technical innovation.

The primary conduit of human mobility has undoubtedly evolved and expanded its paradigm from being at the realm of the human right to resonating with the quality of life of the masses. Industry proponents believe that the world is ready to embrace autonomous vehicles in the foreseeable future with the reincarnation of AVs to solve the deep-seated problems of the general populace. Some of the proximal problems that we now face are with road-related safety, travel time efficiency, and repurposing transportation access for the disadvantaged social groups. Automation changes the fundamental nature of the remaining human work and to sculpt the coming forms of transportation right from attending an event or office without the hassles of driving, dropping kids to school, and providing mobility to those who cannot physically drive-such as the disabled, frail elderly, and children. Thus, AVs can relieve humans of all momentary tactical control and eventually strategic control over mundane tasks.

A lot of ink and ire has gone into campaigning AVs to mitigate the ongoing problem of road traffic injuries and deaths. In such circumstances, AVs could significantly be beneficial in cities grappling with high number of road-related fatalities and accidents, with concomitant reductions in human suffering and expenses for medical treatment and repairs, which is pegged to be around $500 billion every year in the US. If we put our attention to the number of accidents in the year 2016 worldwide, 1.35 million people died in car crashes. Statistics also show that around 2.4 million people were seriously injured in 2015 in car accidents. According to Waymo Report, most accidents happened due to human errors, and about 94% of crashes in the US were attributed to human choices and errors.

Google lead the charge on self-driving cars in 2009. Today, Waymo has taken the baton and is making ground-breaking advances in fully self-driven cars. Waymo's cars use varied technologies to understand the world around them and get the rider from the starting point to end destination. These cars are equipped with Lidar that sends out millions of laser beams every second to build a detailed impression of the 'perceptual' world around it. Additionally, radars are used to detect the distance and the speed of objects in the vicinity. With the high-resolution cameras deployed on the vehicle, it can get visual information such as color of the traffic signal, images of objects around it, etc. precisely up to 300 meters. The vehicle has an advanced onboard computers that imputes and computes the data to understand the world around them. In fraction of a millisecond, these cars perceives the surrounding and performs a predictive analysis to anticipate the movements of the nearby objects.

Constant assimilation of information tranches adds to our experience in life. Similarly, self-driven cars are undergo test-runs for millions of kilometres on complicated city streets or highways to continuously upgrade them with the nuances and subtleties of actual driving conditions and improvising on the safety aspects of pedestrians and vehicles around it. With the ingress of the huge influx of information, AVs pave the way for a safe, radically improved mobility medium.

While testing AVs on the road, information related to different driving patterns are captured and stored. The enormous amount of experience gained through driving across different conditions helps the car learn all the necessary lessons. AVs always look in all directions and spot moving objects approaching towards the car. The estimated position and velocity help the cars predict the next move of the object in fraction of a second. Night driving conditions are stressful for human drivers, but these cars can easily drive in night conditions. The lasers and the radars see where the obstructions are and even observe people not obeying traffic rules, for instance the red-light runner. In such situations, the car checks in all directions all at once and comes to a halt if it appears to be a red-light runner. Even in bad weather conditions, these cars can function optimally. These cars see things well in advance. If someone walks across the road, these cars can sense the movement using its lasers and radars, and slow down. All this happens in a millionth of a second. A usual person has a lot of built-in assumptions on how the world works.

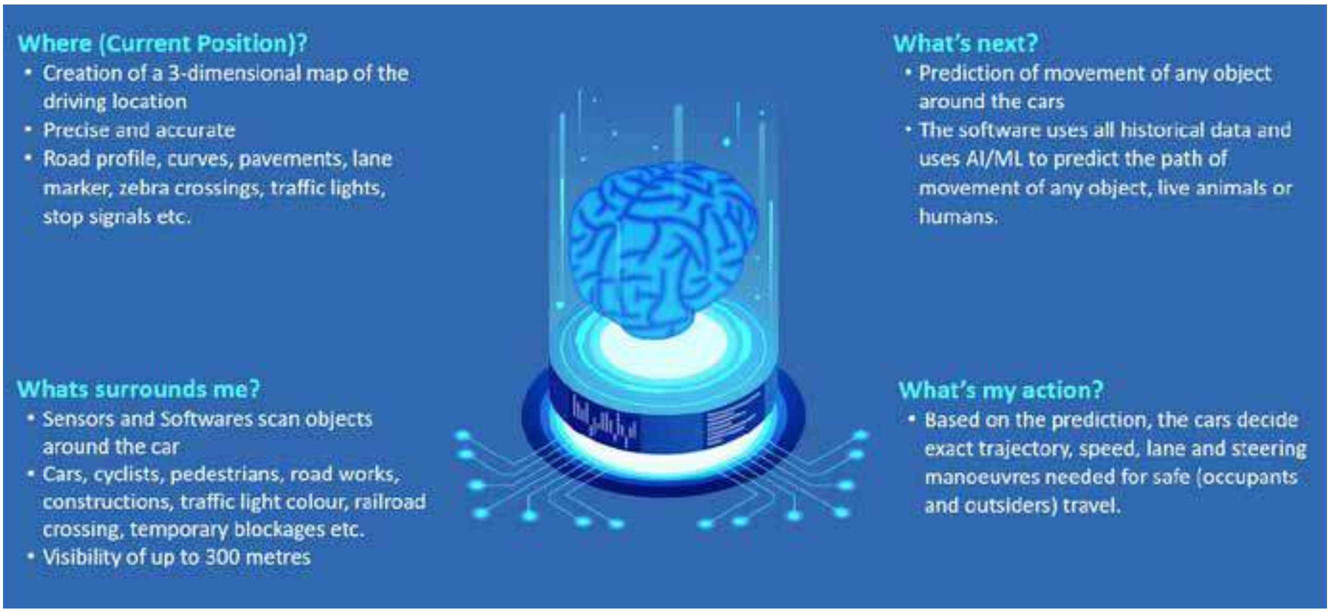


Figure 1 The four crucial logical and sequential questions in the brain of AVs

However, the car is always thinking and is designed to consider the worst. We might not be 100% alert while driving as you may get sleepy, drowsy, drunk, distracted by phone calls or by the children in the back seat. The car always pays attention to all of these factors and tries to think ahead. The cars do not just understand the world around but can make those predictions in the blink of an eye for you before you could really understand exactly what is going on.

Industry trends

Although technology heavyweights and early-stage start-ups are angling to get a slice of the self-driving pie, Google-Waymo, being the front-runners of this technology, is in the driver's seat with its largest collective experience garnered over the years. In July this year, AutoX, backed by Dongfeng, SAIC and Alibaba, became the second firm after Waymo to test autonomous cars on the California roads in the presence of a safety driver. WeRide and Baidu have been testing their autonomous vehicles in China but use a remote control to take control of their vehicles in adverse conditions. AutoX, however does not have a remote centre, as it believes that use of remote control would lead to safety issues due to stability and cyber treat issues linked to 5G signals. In China, Pony.ai, a Toyota-backed venture, and Didi Chuxing have been testing their autonomous cars with one or two safety personnel deployed in the vehicle to take control in case of unexpected situations. Keeping in view of the above, Waymo's AVs are completely autonomous, as it is built on Waymo's 3-layer technology, which is narrated in subsequent sections of the article.

Waymo's 3-layer technology as mentioned in their white paper Safety Methodologies and Safety Readiness Determinations, October 2020 has been elucidated below:

The Hardware Layer

The hardware layer of AVs comprises four major subsystems: base vehicle platform, motion control actuators, attached suite of sensors, and computational platform to run advanced software. Each of these subsystems is important from both safety and performance standpoints of AVs.

Base Vehicle

Waymo's base vehicle platform is in line with the physical safety of passengers. Its current fleet is comprised of Chrysler Pacifica Hybrid minivans from FCA, which have a 5-star safety rating from NHTSA.

Motion Control

As a pre-requisite for AVs, redundant braking and steering actuators are considered necessary for safety and complete control in case of a system malfunction. In human-driven vehicles, human drivers have the decision-making ability to physically steer or stop the vehicle in case of system failures with or without the help of driver assist features. However, in driverless operation, the Automated Driving System (ADS) is deployed to

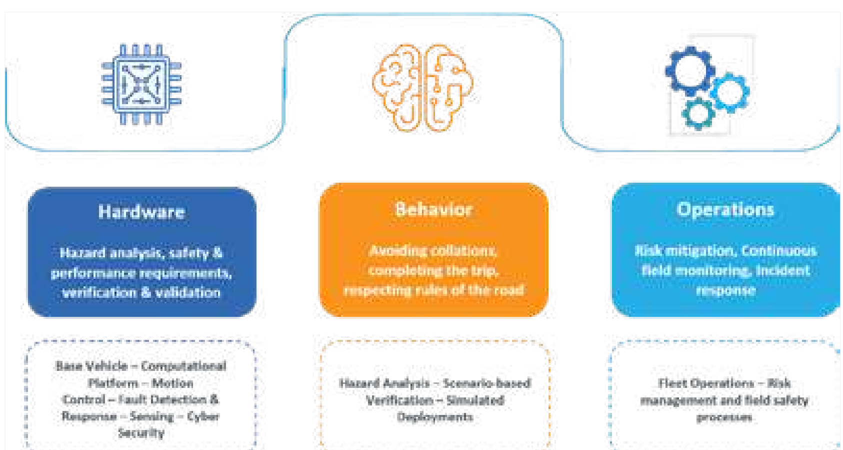


Figure 2 A brief and simple explanation of the three layers is demonstrated above.

detect faults in every component of the steering or braking system and also ensure control of the vehicle.

Sensing

Apart from the base vehicle and motion control systems, Waymo has added a host of sensing systems, including Lidar, Radar, cameras, inertial and audio units, which provide an expansive understanding of the driving environment as well as the precise location of the vehicle at any given point. Like the motion control system, these sensing systems are designed to meet the rigorous performance and safety norms.

Computational Platform

Waymo has developed a state-of-the-art computational platform that combines extreme performances with proven reliability and fault tolerance. Its advanced artificial intelligence in ADS can cater to the most critical computational demands of the driverless car. In addition to the advanced performance, they have equipped their computer system to execute the appropriate amount of redundancy. In case of the main computer malfunctions, an additional computer system is activated to control and stop the vehicle safely. In addition, Waymo has developed and tested multiple design choices such as redundant power systems to failproof the secondary computer system.

Fault Detection and Response

In the earlier part of the article, we briefly mentioned about the relevant fault tolerance requirements and the associated verification. In the subsequent sections, we have elaborated on the behavioural layer and the strategies to address detection and response to software faults. By definition, the Level 4 ADS should achieve a minimal risk condition without human intervention in the event of a failure of either the ADS or another vehicle system that interferes with the ADS to perform the dynamic driving task or while encountering conditions beyond the scope of the approved Operational Design Domains (ODD)'s specifications. In addition to the fault detection and fault tolerance mentioned in the sections above, the system has a predefined portfolio of appropriate fault responses to any failure. The proper response will vary according to the type and extent of the system failure and the surrounding traffic situation.

Cybersecurity

While fault tolerance is a critical indicator to gauge the robustness of a system against internal failures, cybersecurity is the other aspect of the system's resilience to avoid, detect, and respond to external attacks. It is evident in the modern world that attractive targets are frequently attacked; hence, sound security engineering practices are required to ensure robustness of the system and significantly mitigate cybersecurity risks. Although stated in the hardware section, the process extends beyond the software and operations layers. Waymo has built its security framework based on the NHTSA cybersecurity guidelines.

The Behavioural Layer

The behavioural layer ensures that the software is capable of executing safe, driverless manoeuvring of AVs on public roads. Unlike the hardware layer, where more traditional, deterministic safety methodologies can be readily used to measure safety, the behavioural layer requires solving for an infinitely variable set of inputs like actions of other objects on the road and roadway conditions. The complexity of the challenge requires the use of sophisticated algorithms and specialized evaluation methodologies to determine the performance of these algorithms. There are three primary capabilities for evaluating the performance of the ADS' behavioural layer; viz. avoidance of crashes, completion of trips in driverless mode, and adherence to applicable driving rules.

Hazard Analysis

Waymo leverages hazard analysis techniques to develop and test safety-critical software that adheres to the established industry best practices. Hazard analysis is a prominent methodology used to identify potential causes of safety risks and ways to either eliminate or mitigate these hazards early in the development phases. In the last few decades, reliability and safety professionals were considered as the hazard analysis techniques using deductive methods such as Fault Tree Analysis (FTA) and System-theoretic Process Analysis (STPA), and inductive methods such as Failure Mode and Effects Analysis (FMEA).

Scenario-based Verification Programs

Waymo uses a plethora of scenario-based testing approaches to ensure ADS' capability of basic behavioural competencies as well as advanced functionalities. The competencies and functionalities that require evaluation in these test programs are derived from systematic methods of describing competencies needed for naturalistic driving research data and public road testing (real world conditions). The virtual test scenarios are either mined from public road driving logs, procured from closed course driving logs, or developed from scratch in simulation-only workspaces. Additionally, Waymo selectively conducts physical tests on candidate software on a closed course. These scenario-based test sets are used to evaluate ADS' performance across broad spectrum of conditions. One such example of a testing program is the 'Collision Avoidance Testing Program'. In addition to demonstrating an AV's capabilities in "normal" driving situations as well as in system failure conditions, an ADS, within reason, should have some capability to avoid or mitigate crashes in urgent situations relevant to the ODD and caused by the behaviour of other road users. It has seeded this test program with scenarios based on the naturalistic driving data and crash databases.

Simulated Deployments

With test processes and structured development, one can effectively establish the evidence for a performant system. It is crucial to undertake additional measures to validate the methods used to this point as well as objectively evaluate the ADS against critical performance indicators. To achieve these goals, Wayno consistently put its system through simulated deployments, wherein its strives to answer the fundamental question, "if this system was deployed in driverless mode, how would it perform?"

These simulated deployments can occur in two main methodological variants. The first variant is one that is executed by re-simulating a certain software version and system configuration against historical

Levels of Autonomous Vehicles

SAE Automation Category	Vehicle Function
Level 0	Human driver does everything.
Level 1	An automated system in the vehicle can sometimes assist the human driver conduct some parts of driving.
Level 2	An automated system can conduct some parts of driving, while the human driver continues to monitor the driving environment and performs most of the driving.
Level 3	An automated system can conduct some of the driving and monitor the driving environment in some instances, but the human driver must be ready to take back control if necessary.
Level 4	An automated system conducts the driving and monitors the driving environment, without human interference, but this level operates only in certain environments and conditions.
Level 5	The automated system performs all driving tasks, under all conditions that a human driver could.

Figure 3 SAE automation categories

logs. This method has its own advantage of being highly scalable, allowing for extreme acceleration of results, and allows individual developers to execute the evaluation themselves. To ensure the credibility of simulations, Waymo has an ongoing simulation credibility process.

The second variant involves driving on public roads with the added supervision of a vehicle operator, and only simulating the points in time where the operator took control of the vehicle, and is usually known as public roads driving with counterfactual simulations. This approach has the advantage of having extreme credibility, since the software version under evaluation was controlling the vehicle in real time for most of the time.

By leveraging both simulation and real-world driving scenarios, Waymo can achieve a level of scale not possible in real driving alone as well as a level of credibility not possible in simulation alone. In both methods, three critical parameters such as avoidance of crashes, completion of driverless trips, and adherence to rules of the road are critically analyzed.

The Operations Layer

Fleet Operations

The application of Waymo's safety methodologies at the hardware and behavioural layers produces highly capable AVs. Operating the a fleet of Waymo's AVs on public roads requires additional methodologies to manage risks that may arise during these operations as well as derive data that can be fed into the hardware and behavioural layers to ensure continuous improvement. In numerous ways, these final processes serve as the final layer of validation, ensuring that the product and the requirements adhere to the needs of the customers.

Waymo's safety program ensures application of industry-leading safety practices for operating AVs, which include fatigue management program for our trained vehicle operators and coordination with law enforcement agencies and emergency responders to deal safely with driverless vehicles. Emergency responders plan and prepare extensively to ensure that incident response capabilities are ready to be addressed for a range of events. Moreover, passengers have immediate voice access to the support team for ready assistance seamlessly. Waymo has a fleet response team that can provides remote assistance to the ADS in adverse scenarios. Waymo's ADS is designed to recognize unexpected situations and contact its fleet response team for additional data on ADS' visual feed and provide additional contextual information.

Risk Management and the Field Safety Process

Despite the thoroughness of Waymo's safety methodologies discussed above, a complete safety program must address the residual risks that may remain from these processes and new risks revealed during actual operations. Waymo's safety program encompasses a full life cycle of AVs. Waymo's Risk Management Program ("RMP") identifies, prioritizes, and drives the resolution of potential safety issues before the new or updated features or software are used on public roads or tested at the structured test facility. Issues are prioritized based on a consistent framework for categorizing the residual risk and escalated according to the category, ensuring priority resolution to highest risks and appropriate level of review.

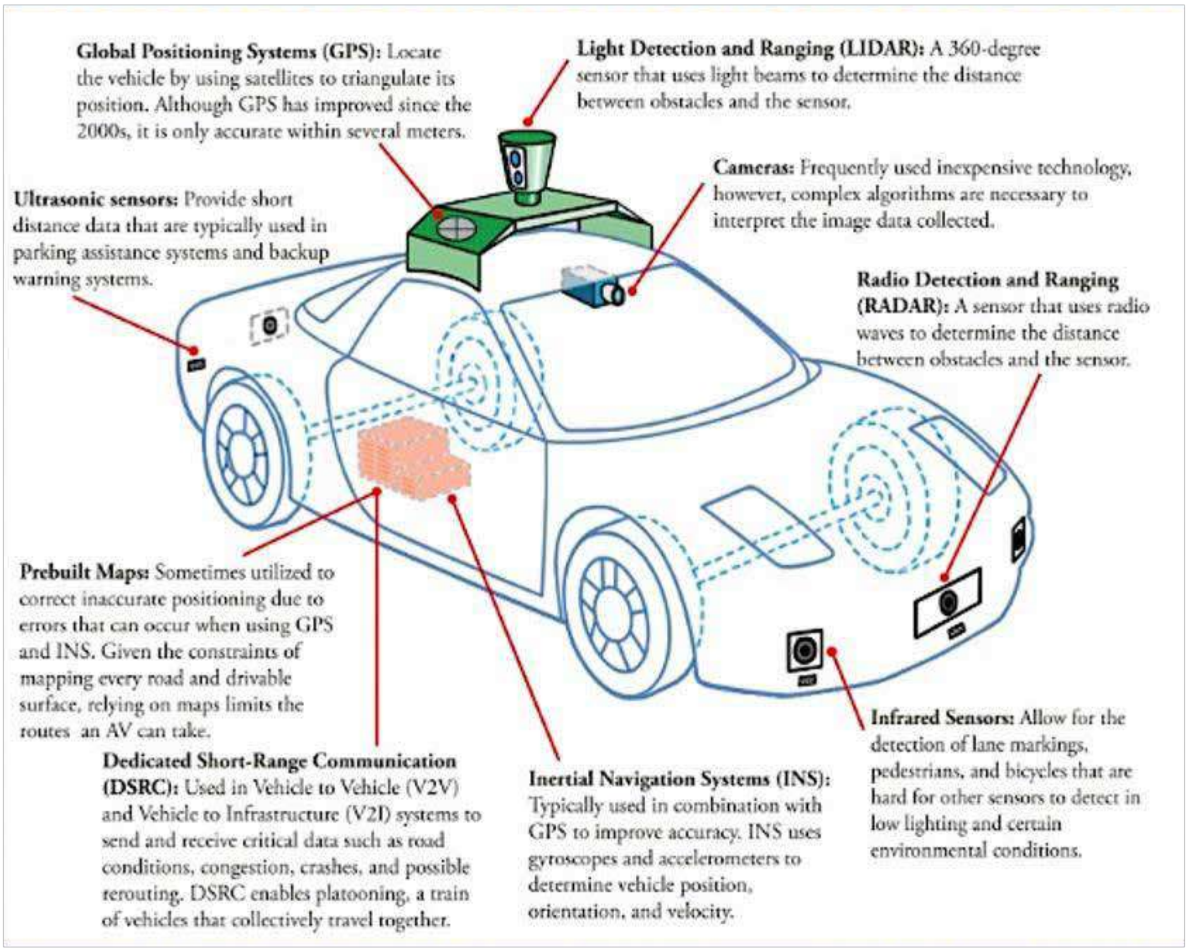
Safety Governance

An effective safety program should include a governance process for making important safety decisions based on the outputs of various safety methodologies. Waymo's governance process includes a tiered system of analyzing safety issues that arise from field safety.

Autonomous Vehicle Technologies

A schematic illustration of the hardware components of an autonomous car is given below for a complete understanding of such vehicles. This was released by University of Michigan.

Figure 4 A schematic illustration of the hardware components of an autonomous car. Source: CRS, based on "Autonomous Vehicles" fact sheet, Center for Sustainable Systems, University of Michigan.



Although AV technology is at a progressive stage, it represents a fast-paced field of modern technology, as companies compete for dominance in this important field of emerging transportation capacity. AVs will extend its profound effects within the automotive sector to not just cars but also trucks, long distance trailers, tractors and two wheelers. AVs possess much more intelligence and operational capacity than yesteryears and will lead to the emergence of an integrated transportation infrastructure.

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Source:

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CHANGING FACE OF TELEMATICS WITH AUTONOMOUS VEHICLES TECHNOLOGY STACK

NISARG PANDYA
drivebuddyAI

Telematics - the technology of sending, receiving and storing information using telecommunication devices to control remote objects, the integrated use of telecommunications and informatics for application in vehicles and to control vehicles on the move, global navigation satellite system technology integrated with computers and mobile communications technology in automotive navigation systems. These are all typical definitions from Wikipedia. The industry of telematics emerged with the emergence of the telecommunication systems with 2G and GPS based positioning to share location details of a vehicle. The world today in 2021, has seen Google Waymo, Tesla Autopilot, Cruise, Comma.ai, Voyage like companies putting the whole GPU systems in the vehicle where the vehicle is taking all the decisions all by itself. The GPS based location tracking and Autonomous Vehicles, are two extremes of vehicular technologies. And this is a very strange situation and opportunistic in a way, where 90% of the commercial trucks are not even using Telematics and the world has reached to Level-5 Autonomy. The interesting thing to consider here is, how do we bridge the gap and how do we emerge in the age of advanced technology and communication.

The road to Autonomy and Level – 5 like autonomous systems are not going to come suddenly, it'll be a journey, a long journey of transformation of technological adoption for commercial vehicles. The journey of vehicular telematics has started from GPS based navigation systems which is now a mandate in India for commercial vehicles and many other countries globally. The next improvement which was introduced was OBD – II based engine diagnosis along with location-based settings. With OBD-II based devices, the visibility of the vehicle being monitored improved a lot and it led to predictive maintenance which involves lots of data science and machine learning technologies. This led to requirement of high computing over the cloud/local servers for running heavy learning algorithms to derive predictions. This was achieved around 2006-2008 in US and around 2010 in India where Indian vehicles started coming with OBD-II port in the vehicles which supported J1939 and other related software stack for reading the data from the engine of the vehicle. With the OBD-II based devices which were able to get a picture of driving behavior and resulted in better fleet management systems.

The new era started in vehicular telematics when cameras joined the race as contextual information started with dashboard camera systems, which were able to record videos and store it in the device itself. Lot's of people started using CCTV solutions in heavy vehicles for surveillance purpose. The need of the visual information started making a space in the market but there were not many of the solutions/products available in the market and those available were not affordable in the Indian context. The other most important aspect in the telematics industry is the communication medium, starting with 2G enabled devices started throwing data for OBD-II & GPS based systems. For the telematics industry to grow, there has always been a trade-off between the performance & price. If you want more features, there's a cost to pay per vehicle, but there's very little room available for high-end technical products to outshine old ones as they are little more expensive and so becomes luxury where older technology is easily available for lower cost. The real challenge for newer technologies to pre-empt the GPS based systems and speed-based analytics which is going on since years now.

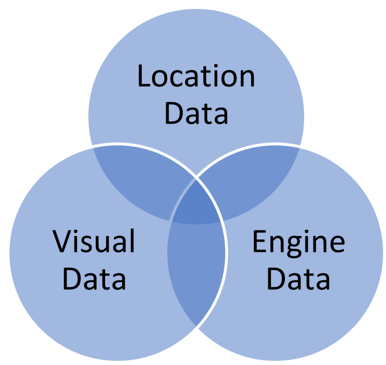

Figure 1 Types of Telematics Data from Vehicle

With emerging and growing powers of AI/ML & Vision technologies, the face of the telematics is also changing. The biggest backbone of this is growth of autonomous vehicles of L2/3/4/5. Many companies in the USA, China, Germany & Singapore have developed full stack software for autonomous vehicles. A typical autonomous vehicle works on a very simple principle made by three questions:

The first question talks about the localization and the localization can be achieved with GNSS (Global Navigation Satellite System), IMU (Inertial Measurement Unit) & Camera (Lane Position). The second question talks about perception which could be achieved through LIDAR, RADAR

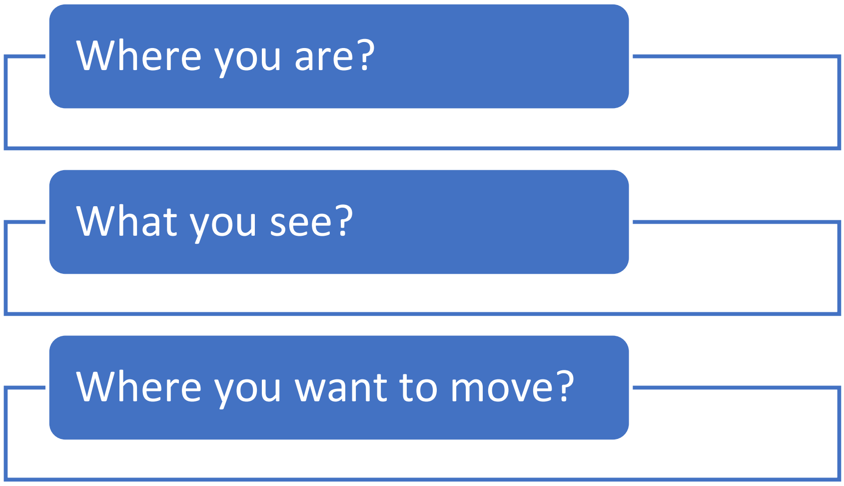

Figure 2 Fundamental question for Autonomous Vehicle

& Camera. What kinds of objects do you see, how far are they, what is the criticality if the vehicle moves in a certain direction? The answers to these questions are derived with the help of AI/ML & Computer Vision based algorithms. The third question talks about the decision making and movement. Once you know where you're, what do you see, and perceive that according to the current situation/location what is the best way to move ahead, what could be the best speed or do I need to brake and stop. The answers to all these questions are then actuated by vehicle central machine and takes the according decision.

The typical technology stack for AVs is as shown below.

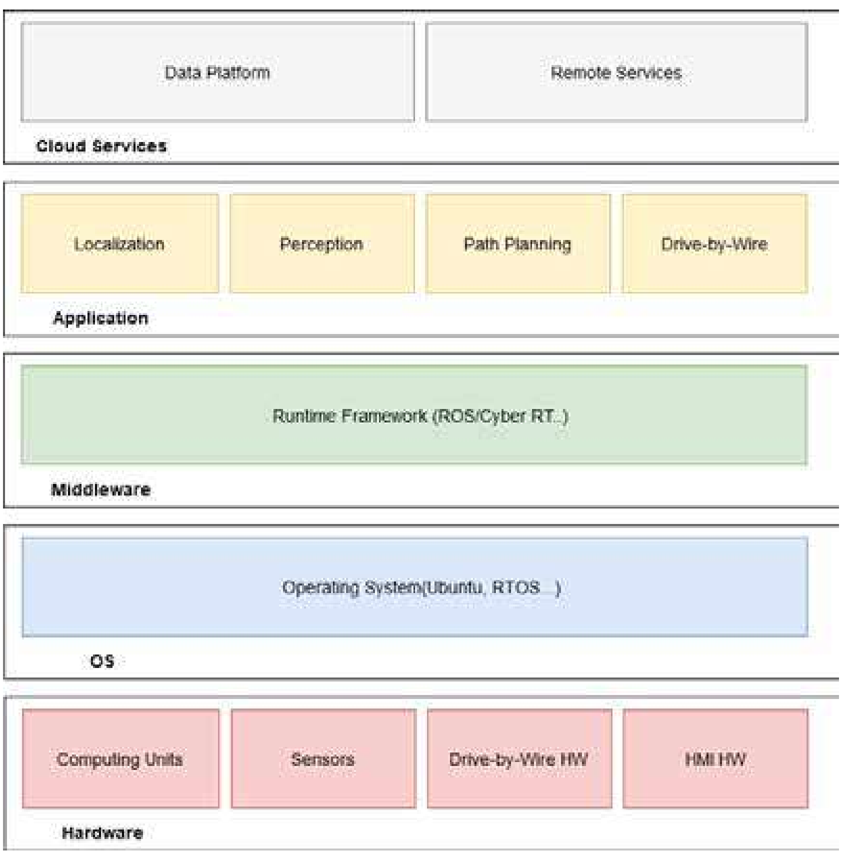

Figure 3 AVs Technology Stack

All the layers on the stack, starting from cloud service includes the data management for AI/ML & CV algorithms. The application stack covers the questions of above section, the middleware is ROS like framework for building applications on top of OS layer and then comes the hardware layer which the most critical and deciding factor. Hardware layers is the one deciding measure of how the conjunction of AV technology stack and telematics system happens. AVs are typically highly expensive systems including LIDARs, RADARs, Camera, IMU & storage on board. The decision making for actuating the vehicle happens on the vehicle itself, which requires lighting fast computing and that could be achieved with high performing GPU systems. These systems run AI/ML & Vision based algorithms and take a decision to drive a vehicle.

Interestingly, there are few car makers in the luxury segment of cars, do provide driving assistance systems in the vehicle which is of the kind cruise control, auto braking & traffic jam assist. These systems are called ADAS i.e., Advanced Driving Assistance Systems. These systems are kind of pre-stage of AVs where the drivers will be there always and they are considered as Level 2 autonomy.

Commercial Vehicles in India specifically MCVs & HCVs do not come with any kind of assistive mechanism and while the majority of logistics & fleet industry rely on them. Majority of them are now equipped with GPS based location tracking systems for better fleet management. The high rate of accidents in India & globally when the freight movement has increased the risk has also increased for loss of lives and assets. It's time for the world to see full autonomy at every corner and it's a far-fetched goal for the transportation sector where the global ecosystem of driving will be made safer and secure by technology and autonomous vehicles. It is being said that, with the AVs & connected vehicle eco-system, the vehicles will be able to follow one another, would not require any traffic signals & will also upgrade their insurance premiums automatically. These are all good fantasies to watch for in the coming future. The need of the time is

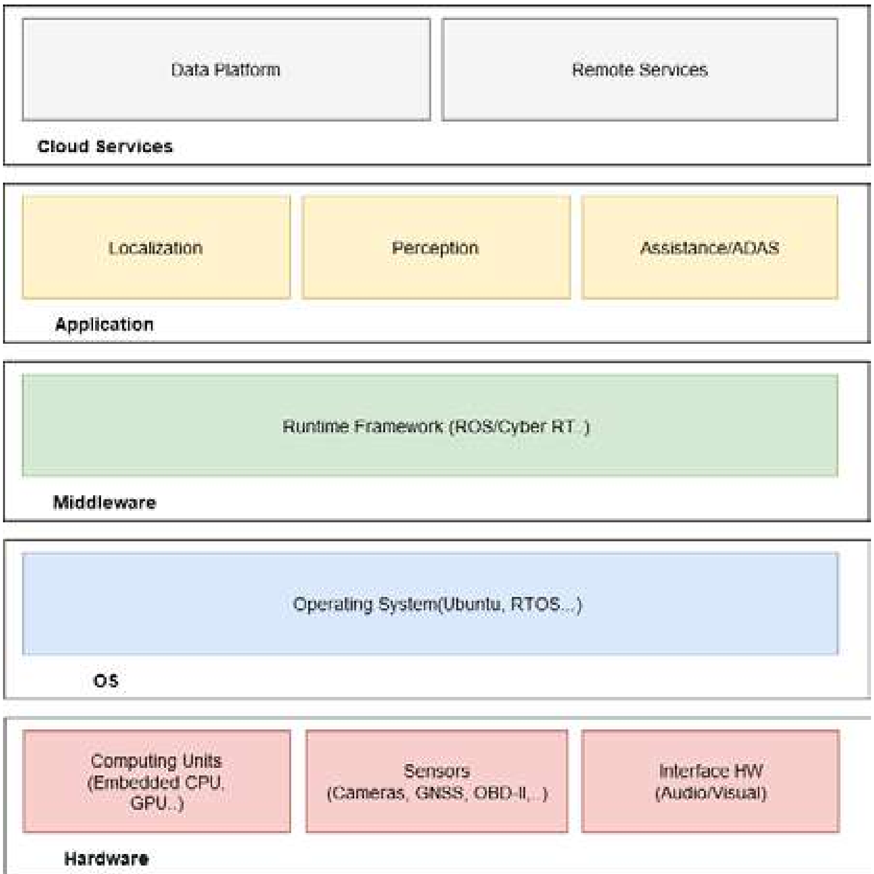

Figure 4 Adoption of AV Full Stack for Telematics

to use the software stack of autonomous vehicles which provides/ensure more safer journeys with intelligence and insightful decision making. The systems are comparable with ADAS in luxury vehicles but retrofit, more than typical GPS/OBD/Dashcam based telematics systems. Interesting thing to note is many AV companies have taken all different routes to build AVs and it has been proven that the incremental approach has gain lots of success in achieving self-driving compared to the one which has taken the direct route. The reason behind that is human drivers. The fundamental of AI is to augment the human and help in the decision making process, be it vehicle driving is also about learning from humans and help humans from their driving only. In 2018-19 lots of AV companies which were funded heavily had to shut shop because of no revenue plans in future and it's all about the technology stack which turned out to be impractical/not so feasible. Many of these companies either got acquired by tech majors to earn valuations or took a step back to use the technologies developed in AVs for ADAS & Telematics products. There are few AV companies who have taken an incremental path towards AV & they are still surviving in the tough market by making money from telematics & ADAS services.

"THE JOURNEY OF SELF-DRIVING WILL COME VIA COMMERCIAL VEHICLES AND FOR THAT TO HAPPEN, THE OEMS WILL HAVE TO ADOPT SUCH TECHNOLOGIES AS RETRO FITMENT FIRST AND THEN AS OEM FITMENT"

The real path to building AVs is going through the mass adoption of telematics and ADAS in commercial vehicles and then to passenger vehicles. The larger the adoption leads to more data and fine learning for algorithms to make better decisions in unstructured & uncertain environments in future. The key to this is to adopting technology stack of AVs & removing the controlling section from it. And this is how it looks practically,

The removal of Planning & Drive by Wire sections from the application layer & drive by wire HW from the hardware layer makes it a complete advanced technology solution for telematics.

With the time, telematics has also improved with data analytics and machine learning. Location & OBD based systems have started coming up with data dashboards & insights about the fleet & driver performance, route optimization & many more applications and useful insights. Another vertical which gets the benefit out of the data driven fleet and telematics is the Insurance industry. Insurers have always been the evangelists for new technologies and in the case of telematics also it'd be the case in coming times.

Telematics systems today have reached a stage where they can fetch data from OBD-II, GPS, tyre pressure & driver face images. Collecting all these data and applying AI/ML algorithms are used for data dashboards for preventive maintenance, driver incentivization & monitoring. The next advancement in this will be telematics devices with ADAS capability in it. They'll also possess AI processing power in the devices themselves. These kinds of devices will be retrofitted in any kinds of vehicles. The crucial aspect for this is computing power i.e., GPUs and 2019 was the year which was expected to bring lots of edge computing hardware to the market but due to pandemic, the progress is slow. The edge compute device clubbed with high-speed communication that is 4G for the current time and 5G for the future, will change the face of telematics completely.

The advanced telematics technologies will not only track or monitor vehicle, but it'll observe the driver, learn from it

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Refining & Redefining Vehicle Telmatics

GENUINELY !! MADE IN INDIA

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TS101 Basic

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- IP65 rating
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AIS 140 Certified

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- Serial Port with multiple I/Os
- Optional CAN & RS485

OBD II

- Track Trace and Driving Behaviour
- Advanced Diagnostics through CAN & K-Line
- Plug and Play
- Accelerometer
- J1939

TS101 Advance

- Track Trace and Driving Behaviour
- Serial Port
- IP65
- 8 I/Os
- Accelerometer

Advanced Telematics Devices

DriveAssist - 4G LTE

- Track Trace and Driving Behaviour
- Android-based smart telematics device
- 5” touch screen
- P2P Live Streaming
- Advanced Diagnostics through CAN
- ADAS through dual cameras and Dash CAM

AIS 140 Certified

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- Video Telematics
- Advanced Diagnostics with 3 Channel CAN
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as well as train them. The data collected from camera systems will help to create context of the situation at any point of time in the driving along with the decision made by driver. The systems will come with active assistance mechanism for drivers to avoid such collision prone situations in case if any arrives and assistance is provided. This will enhance the asset life for any fleet in terms of drivers as well as vehicles. The challenge to make this successful depends on how interactive these devices are, as they'll interact with the humans who have never interacted while driving with technology and it'll be a huge psychological shift for commercial truckers to live with the upcoming new technologies. The previous versions of telematics have always seen the hindrance from the drivers as they believe them to be spying vehicles and that is also the resistance from the fleet fraternity for adoption as losses are high in case drivers do not adopt it.

Developing technology and product is easier than making it adaptable by user and for such advanced technology which is meant to assist and coach their users will have to go through the mindset shift. Once the adoption is there, taking the technology to the advanced level where vehicles can take decisions on-behalf of the drivers become possible. The journey of self-driving will come via commercial vehicles and for that to happen, the OEMs will have to adopt such technologies as retro fitment first and then as OEM fitment. The journey will look like this for context like India looking at current activities and fleet management industry with telematics as below:

"THE JOURNEY OF SELF-DRIVING WILL COME VIA COMMERCIAL VEHICLES AND FOR THAT TO HAPPEN, THE OEMS WILL HAVE TO ADOPT SUCH TECHNOLOGIES AS RETRO FITMENT FIRST AND THEN AS OEM FITMENT"

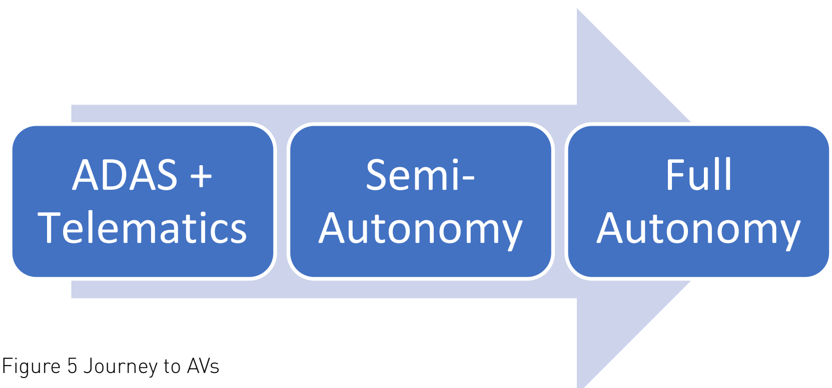

Figure 5 Journey to AVs

on them. Though all the telematics device enhances the visibility for fleet companies and managers but most of the drivers want to get rid of it and there have been cases where drivers have removed and thrown these devices away from the

To bring AVs on the road and to make machines drive vehicles in difficult uncertain scenarios with existing infrastructure, there will be a need to learn how humans are driving, what challenges they are facing and how they overcome such incidents to avoid accidents or vice versa. This kind of learning will be achieved only through continuous learning from the human drivers and that will come from advanced telematics devices with ADAS capabilities.

The development of the brain to drive vehicles on the road, the journey is not only for engineers but for all the stakeholders and the most important are drivers who'll bring the change and adoption. The engineering marvel which will make it possible in coming times will be only learnt from human drivers and continuous feedback loop back to the active safety in vehicle which will adapt according to how drivers will drive and this process will continue for a long time considering the infinite numbers of uncertain scenarios to drive and fight of human drivers to swim out of it or sink into it.

Though the world will see autonomous vehicles in coming decades or not, the technology which has been implemented are surely going to open avenues for fleet management, driver management, driver coaching, insurance risk assessment and semi-autonomy with the help of changing telematics. ❑

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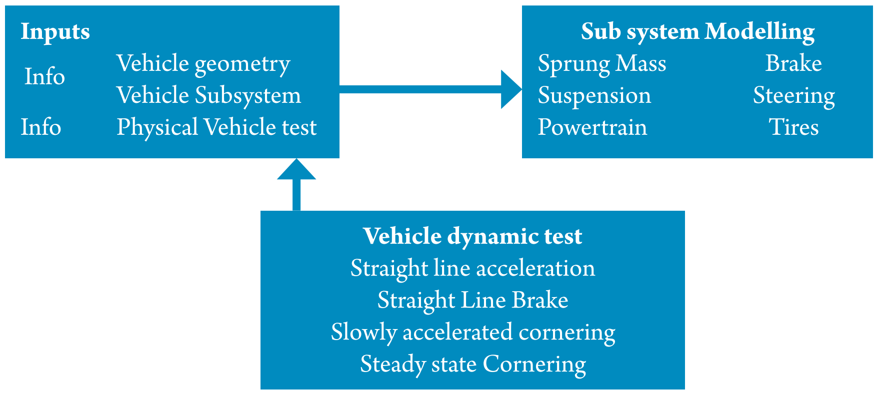
Importance of Vehicle Dynamics and Vehicle Modelling in Virtual Closed Loop Testing for Autonomous Driving Feature Development

DHANRAJ DOMALA
ZF GROUP (TECHNICAL CENTER INDIA)



Autonomous driving features for Level 2+ functionalities are gaining traction in most of the countries. It is mainly driven from regulatory bodies to improve the safety and customer interest on comfort features while driving. These features mainly improve the safety of vehicles by actively or passively assisting the driver.

Validating these features on public roads and proving ground needs a lot of time and effort. OEM's in general would be interested in looking at at least more than 1 million km of test data to gain confidence, rectify bugs and roll out these features in production cars. Physically testing vehicles with developmental AD features for such high mileage is not an ideal approach as it takes Longer time to validate them. Such high lead time is risky for OEM's in the current competitive market.

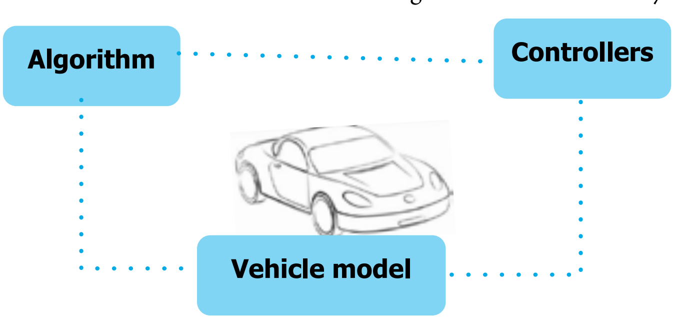
Virtual closed loop simulations for AD feature testing would be of great benefit in reducing physical testing as most of the testing would be done in the virtual simulations. Environment creation for such simulation is a challenging task as it has to mimic the real-world situations in a virtual framework.

Virtual Closed Loop Simulation

In a very broad sense, it is a framework involving algorithm which is like the brain for the AD feature/s, a controller which is like a virtual driver which drives the car adhering to decisions taken at the algorithm end and vehicle model. All these three components work in a closed loop intended to mimic the real-world case with the vehicle, and different control units.

Here the Algorithm includes all the perception components which include inputs from camera, radars. It also includes the behavioral logics which are intended to take decisions. The controllers are expected to control the vehicle based on the logic implemented in the algorithm.

It is very important to note that the behavior of the vehicle used in the virtual simulation has to be close to that of the physical vehicle under test. Else it is difficult to predict the AD feature functionality using the virtual simulation framework. Vehicle modelling in virtual framework is key to test and validate AD feature functionality



Vehicle modelling

Vehicle modelling is done in various simulation platforms with Math-models from third party tools or completely developed inhouse. Most companies use commercially available platforms to model their vehicle and validate it against the physical vehicle. In these platforms, the vehicle is modelled subsystem wise.

The above blocks indicate the input data required for vehicle modelling and various vehicle dynamic tests

Vehicle modelling usually requires information from OEM's or derives them from the available data. In many cases OEM's do not provide relevant information for virtually modelling the vehicle due to their confidentiality. In such cases an approach of physically testing the vehicle for standard vehicle dynamic tests is adopted and the subsystem level information is modelled making sure the performance of the virtual model is close to that of a physical vehicle. There is always a trade-off while modelling the vehicle and a model validated upto >70% with physical data is considered good and is used in various closed loop environments. To summarize, a vehicle model's maturity is of great importance for virtual closed loop testing of Autonomous driving features which eventually helps in reducing physical testing and saves time. ❑

MEETING THE CHALLENGES OF OVER DIMENSION CARGO WITH ACCURATE FUEL AND FLEET MONITORING SOLUTIONS

MOHIT MEHROTRA
OMNICOMM INDIA

Over Dimension Cargo (ODC) is a specialised transportation industry for carrying ultra-heavy and extremely large cargo such as nuclear chambers, wind turbine blades, ultra-high-tension transformers and sheet steel coils. Typical trailer trucks carrying such 90-tonne and above cargo have 20-22 axles and over 100 wheels.

Each round trip is a specialised transportation project. Pilot cars and rear guard vehicles often form part of the convoy, measuring road widths, road shoulders, culvert capacities, and the height of overhead barriers. Since even a small damaged road section may require a significant diversion (often adding a 100km journey), seldom do two round trips cover the same distance.

Specialized drivers guide these massive trailers with engineering precision that is difficult to achieve on chaotic Indian roads. Tracking each trailer's progress, ETA and route deviation planning and tracking is an ongoing daily task for the project office.

The trailers are high fuel consumers, consuming between 1.25 km / litre (on an empty trailer) to 0.6 km / litre on full load. A single trip may require nearly 3,000 litres of fuel, and fuel constitutes significantly more than 50% of the operational cost of each trip.

A 2200km round trip may need 9-12 refuelling stops. Since many of these trailers can't negotiate the constrained space of highway gas stations, the assistance vehicles often bring diesel in containers. Therefore, refuelling is unmetered and runs the risk of pilferage.

Save on fuel costs with reliable fuel monitoring

An accurate and reliable fuel monitoring system brings greater transparency and accountability to each refuelling event, making it possible to measure each refuelling incident and generate instant alerts to transportation control towers. Validating refuelling in real-time results in better incident investigation, as bundled and historical refuelling data is simply not actionable.

Combined with geofences, the control tower can be alerted when trailers try to refuel at blacklisted gas stations.

When integrated with the transportation company's ERP system, a reliable fuel monitoring solution can generate dynamic trip costing, allowing better assessment of trip profitability. Daily money transfers to fleet cards are now based on actual stock-in trade, which allows daily fuel stock accounting for in-transit trucks to enable better fuel inventory management.

OMNICOMM's fuel monitoring solution uses fuel-level sensors with an unbeaten 99.2% accuracy, enabling customers to measure fuel consumption to plan refuelling and forecast costs with confidence, track vehicles in real time, plan technical maintenance and detect expensive and damaging behaviours such as engine idling, dangerous driving, fuel wastage and theft.

Logging real-time fuel consumption for each lap of the trip under specific load, traffic and driver combinations facilitates better route analytics using detailed reports on the OMNICOMM Online fleet management platform. Correlating mileage with CAN bus data from compatible on-board vehicle terminals on clutch-pedal positions, acceleration, braking and speeding enables better driver analytics and opportunities to optimize safety and working culture.

Case study: Pan-India ODC boosts bottom line by 4%

While working with a Mumbai-based pan-India ODC cargo logistics company, OMNICOMM discovered that for a 90T trailer which covers 2200km round trips, the actual fuel consumption was about 2,600 litres. The trailer crew was claiming that consumption was 3,200 litres. With the potential to optimise 600 litres of excess fuel being claimed on each trip, the ROI was obvious.

Armed with detailed data from OMNICOMM's industry-leading 99.2% accurate fuel sensors and sophisticated analytics, the client identified fuel pilferage incidents. In response, they took disciplinary action against errant drivers and devised an incentive scheme for others that paid the drivers 50% of the total fuel savings. The client was able to derive significant savings that ensured a payback for investment in less than 3 months on 50 vehicles equipped with Omnicomm fleet management and monitoring solution.

12 months later, the fuel monitoring system has resulted in an improved bottom line of 4%. The driver salaries and extra incentives are the ODC carrier's best driver retention strategy. There is greater transparency of the actual cost of route operations, which has resulted in sharper route-wise price quotes, based on actual historical costs. The company's management sees the system as a digital trail of all transactions, reducing manual operations and accounting irregularities to result in better sleep at night. ❑

Secret Ingredients of Autonomous Vehicles

SUDHANVA S
GREAT WALL INDIA RESEARCH AND DEVELOPMENT PVT LTD

A hot topic these days in automotive research is autonomous vehicles. Almost all automotive companies are racing either jointly or independently with each other to dominate the market by producing them. Nevertheless, winning the race is not as much easy as anybody thinks due to many challenges to overcome from research to market.

Challenges

Investment

The companies have to invest considerably high amount of research since the ratio of resource to final product is higher unlike in production which forces the companies for long-term investment planning which is very unlikely to get back the investment soon in return with margin of profit.

Patience and perseverance

The teams working on it require a lot of patience and perseverance as there will be times when some of the researches are successful, some take longer than usual and sometimes do not succeed. The companies have to stand with the teams and encourage which otherwise may lose all the efforts of research carried out so far. Nevertheless, at the time of a crisis, it would be difficult for the companies to get the research going.

Market Readiness

The market has to be ready to accept the latest technology in vogue and put it to use. May it be MaaS (mobility as a service), or ownership, how do we convince the customer to take a ride assuring that it is safe? How do ride-hailing companies assure the same to the customer? How do we convince the owner who enjoys the ride who is very much passionate about driving the car? However, FaaS (freight as a service) might not face much difficulties as it might not pose a threat to human lives riding within the vehicle.

Lack of general intelligence

The trolley problem that arises in most of the common people's mind, the answers are dependent on each individual's psychology. With such a scenario, it is difficult to train and derive an expert system to make decisions at a sickle of time that is morally correct. For example, think of an ambulance shifting a critical patient to a hospital downhill on a hilly terrain. Suppose a pedestrian is crossing the road, avoiding pedestrians might plunge the ambulance down the cliff. On the other hand, hitting pedestrians may cause death on the spot. Should the ambulance driver kill the patient or the pedestrian?

Liability

In case of any accidents, if the vehicle driver is said to be liable, the vehicle was never driven by a human. If the service provider is said to be liable, who never developed the system. If the manufacturer is said to be liable, who would have not had the data of scenario for which the vehicle was not developed/tested. Same goes with traffic rule violations as well.

Infrastructure

Infrastructure has to be geared up to handle mechanical breakdowns like towing services or nearby repair stations to where the vehicle can drive itself. Nonetheless, software updates can be pushed over the air with the help of recent technologies.

Dilemma

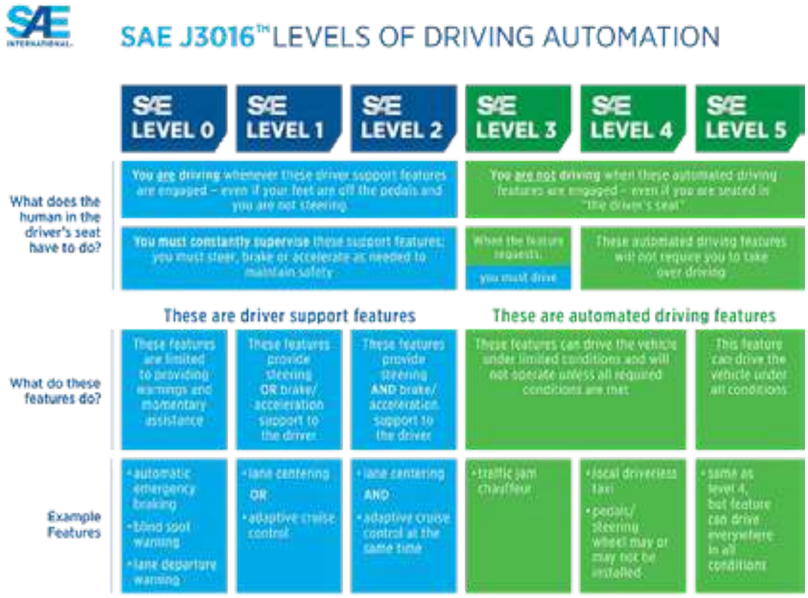
The society may be in a dilemma for accepting the advanced developments in technology with their implications. One such example is the doubt of loss of jobs for taxi drivers.

Security and safety

There are many possibilities when the security of the autonomous driving system can be compromised. One of the good examples is hacking as shown in "Fate of the furious" and other movies thereby putting the lives of riders at risk. There is also a possibility that the autonomous vehicle can get stolen or crashed somewhere making it nearly impossible to track. A nightmare would be holding the vehicles hostage and demanding ransom, unauthorized collection of customers' pickup and drop off points to list a few. With the above facts said, a good Intrusion Detection and Mitigation System, in-vehicle SoS, along with a BlackBox like the aeroplanes have, and other safety and security systems have to be designed.

With all these challenges, some automotive companies are researching on SAE Level 4 Autonomous Vehicles which are developed robustly, tested rigorously and deployed to run within a geographically fenced area under controlled environments and concentrate on plunging into the market through ride hailing as a first step on deploying their vehicles on roads. While some others are working on Adasis V3 which enables the concept of Mapping and Localization for SAE Level 3 Autonomous Vehicles where the vision of sensors are extended through the help of a map and the vehicle's position thereby making their selling products more robust and safer.

on the environment perceived. This requires the vehicle to be aware of the environment in which it operates and its current position in the environment so



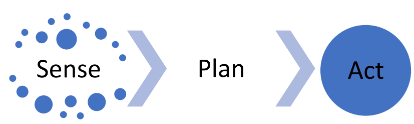
The above table shows different levels of autonomy [1]

SAE Level 3 Autonomous Vehicles are an application of Braitenberg vehicles which exhibit reactive behaviours. These vehicles are incapable of making decisions on their own as they lack the ability of "planning" (as shown in the figure below). A good example of this is a line follower robot that students start their robotics learning with. SAE Level 3 Autonomous Vehicles take actions based on what is perceived from lane keeping to emergency braking. Driver has to take the vehicle into control when the system is requests.

The figure above shows steps taken up by SAE Level 3 Autonomous Vehicles.

SAE Level 4 Autonomous Vehicles are an application of Mobile Robotics which sense, plan and act (as shown in the figure below). These vehicles will have a dedicated planning module to command stop, steer and throttle the vehicle based

that it can think where and how it should navigate and drive to reach the destination safe and cost effective. This means the vehicle can be driven only within a geographically fenced area. This can be compared to robotic technology where, robots work in hostile and dangerous known environments lessening the burden and risk of human beings.



The figure above shows steps taken up by SAE Level 4 Autonomous vehicles.

Adasis V3 makes the SAE Level 3 Autonomous Vehicle prepared via HDMaps for taking actions ahead of the detection through vision sensors. Also, in case of other vehicles covering signs or the glare on cameras from Sun during morning or evening, the map can also act as a complimentary sensor for taking action, provided the sign is tagged geographically in the map and validated. However, there comes another challenge of validating the map as there could be environmental changes since when the environment was mapped.

Mapping and Localization is a concept borrowed from Robotics where the vehicle first learns about its surroundings to plan "How should I reach the destination?" the next question to be answered will be "Where am I now?". In addition to this, maps can also make the vehicle turn on specific vision algorithms to search for landmarks and sign boards based on data from the map when the vehicle enters the vicinity.

Mapping and Localization is a chicken and egg problem because, in order to answer "Where am I?" vehicle needs to know its environment which is on a map. In order to create a map based on the sensor measurements perceived from the environment, vehicle needs to know how far it has travelled from a landmark that it perceived before. During this course, there could be errors from the sensors due to various reasons. For example, the environment does not have a good illumination which makes the data from the camera erroneous. Thus, the system has to rely on wheel rotation and magnetometers which gives birth to another set of errors when robot skids. The problem starts when the system has to choose between sensors to trust more so that the data perceived is more accurate without the intervention of a human. This will be solved using the probabilistic estimation and data assimilation.

This necessarily should not mean that each and every vehicle has to have a local copy of maps of the geographical area where it drives. With the recent technology advancements, the AVs have to be able to swiftly pull a part of a map covering a couple square kilometres of area from its dedicated server which should suffice to work in the advent of network connectivity issues.

Updating the map information in case of environmental changes can also be crowdsourced like how Google has made the information of nearby places available on our fingertips. Nevertheless, this whirls a question in mind to validate the crowdsourced data based on which the AV has to be driven.

Having the environment and position of vehicle through sensing, the plan has to be developed during the mission which happens in two stages. First will be the global path planning which plans the route to destination choosing which roads to travel on. The next comes the local path planning with obstacle avoidance, over taking, etc while following the traffic rules which are achieved using many ways. Some of the indoor mobile robots which operate at slow speeds having the luxury of on axis rotation implement carrot planner, where the goal point is placed dynamically in front of the robot like it happens with carrot and donkey which keeps the robot self-motivated to catch-up to goal till it reaches the destination. However, this does not suffice for autonomous vehicles which require implementations like curve fitting and parabolic blend because of the fact that an object cannot attain a set velocity instantly but achieve a smooth increase in the same through acceleration and cars cannot perform an on-axis rotation.

Once the planning is complete, then comes bringing the plan to action. The vehicle has to take actions to rotate the steering and increase or decrease brake and throttle based on the Ackermann kinematic model which is generally used in all cars in the automotive industry irrespective of FWD (front wheel drive) or RWD (rear wheel drive).

The entire pipeline of making an autonomous vehicle function is an majorly an application of engineering mathematics that students study during their course like linear vector transformation, vector decomposition, coordinate geometry, trigonometry, fourier transforms, differential equations, integral equations, probability, euler angles, model fitting, polynomial fitting, parabolic blend, real numbers, eigen vector and eigen values to name a few. All these concepts when implemented together using programming languages, gives birth to a new startling product like these.

Safety is an utmost concern in autonomous vehicles which has to be borrowed from aerospace. For example, an engine failure during the flight of an aircraft is never acceptable. Similarly, the software that runs the autonomous vehicle must never fail/crash; in fact, even a couple of milliseconds of lag could be fatal. Designing a safety system in such a way that the software malfunction/crash is detected and the vehicle at least pulls over to a side of the road and stops safely in degraded mode is still a big challenge.

Open-source platform

It so happened in the field of robotics, the ideas used to originate from colleges/ universities. The young student minds with a strong desire to implement something new, start to develop a robot with the available resources which I too experienced back in my student days. Just as the fact is known, student(s) can work very less alongside their studies in spite of many trial and error. As the saying goes, "no two clocks agree", the next student who would like to continue had hitches in accepting the software/hardware developed previously and integrating to build further. Also, the non-standard documentation procedures make it difficult to understand the intent of the implementations in a program. Due to the facts said, self-motivated and highly ambitious student now starts everything from scratch discarding the previous review of research and development underestimating the problems that transpire and end up at the same state which may not improve further. This was inhibiting the research on robotics since the platform could never be developed further.

When Robot Operating System (ROS) was made open-source with standard well-defined procedures, the research and development using ROS started and now almost all the robots in the world are powered by ROS. Many companies started using ROS as a platform to develop their Level 4 Autonomous Driving platform. Nevertheless, ROS has a single point of failure in the system which is dangerous to be deployed on an Autonomous Vehicle. Also, each ROS distribution reaches EoL (end of life) which require retesting of all the features whenever there is a distribution upgrade. Some companies built their own "ROS like" platforms while some others have started using ROS2 which is decentralized. Nevertheless, ROS2 itself has not been certified compliant with ISO26262 but some of the applications on it are built to be certified to the highest level of the automotive safety norm ISO 26262 (ASIL-D).

Making Level 4 Autonomous Driving software development platforms open-source has enabled the companies to collaborate in leveraging the technology in industry. This has also given access to industry standard platform on which the algorithms can be developed and benchmarked from academia encouraging the participation and contribution that industry can constantly influence towards betterment. Although autonomous driving technology seems to be smaller in dimensions, when applied it can handle large scale miracles. Just like Android, after it was made open-source; which now powers from coffee vending machine through TVs to smartphones.

Thus, the path taken by automotive companies will have lot of uncertainties and challenges with business as well as the technology platform while developing autonomous vehicles as a product that would not be seen to the world. The last hit hammered to a nail is not the only successful hit. Twenty years ago, most of us had never thought we would have smartphones but, everyone has one today. Autonomous vehicle technology needs constant and continuous participation in research and development from academia as well as the collaboration between automotive and non-automotive industries together to make the vehicle run autonomously in all scenarios and conditions i.e., SAE Level 5 Autonomous Vehicles.

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CONNECTED AUTONOMY

DR. GOPINATH SELVARAJ
TATA ELXSI

High (L4) and Full (L5) autonomous features aim to transfer the entire responsibility of driving from humans to vehicles. Fully Autonomous Vehicles (AVs) are expected to react appropriately safely to the complicated and extremely diverse driving situations that it has to encounter on road , be it driving at intersections, tackling vulnerable road users (VRUs) such as motorcycles, bicycles, pedestrians, animals and what not. Autonomous vehicles equipped with only in-vehicle perception suffer with limited range and line of sight constraints. This leaves the AVs to sacrifice with un-addressed features of (L4 – L5) level of autonomy.

On a parallel track, V2X (vehicle-to-everything) technology improves road-traffic safety, fuel efficiency and driving comfort by connecting transportation infrastructure to vehicles and vice versa. This makes the V2X system a lot cooperative in nature, and thus Tata Elxsi believes V2X and autonomous vehicles could complement each other.

Marrying the V2X features with AVs can enhance two key features of autonomous driving: Sensing and Maneuvering. Cooperative Sensing allows vehicles to exchange information gathered from local sensors, and Cooperative Maneuvering permits inter-vehicle coordination of maneuvers. It enables the creation of cooperative AVs, which may significantly improve traffic safety, efficiency, and driver comfort along with improved decision making in maneuvering complex driving scenarios such as intersection & handling VRUs. V2X communication provides 360-degree non-line-of-sight (NLOS) awareness and increases the capabilities of the existing line of sight sensors viz. Camera, LIDAR, and RADAR in AV perception system, thus extending the AV's ability.

Easier said than done, this is an expensive solution to try out as the implementation and testing would require infrastructure refinements, addition of new sensors and other hardware that makes these features viable for testing the Connected AVs (CAV).

This whitepaper talks about the necessity of CAVs, aligned to Intelligent Transport Systems for communicating with roadside Infrastructures and Non-Line of Sight (NLOS) neighboring vehicles. End result being, coordinated driving decisions (eg. Cooperative Adaptive Cruise Control for Green Light Optimized Speed Advisory - GLOSA), for improved safety, expediency, and L4-L5 level of mobility. To tackle the implementation part is Tata Elxsi's modular Autonomous Driving (AD) software Autonomai & cost- effective V2X Emulator based solutions for CAVs ecosystem are detailed along with use cases.

Technology Introduction:

AUTONOMAI – Tata Elxsi's Autonomous Vehicle end-to-end software platform, autonomai, is designed to help OEMs and Tier1s to build, test and deploy Autonomous Driving applications rapidly. The multi-model sensor-based perception system perceives the environment surrounding the vehicle and builds a detailed environment map. Both, on-road objects such as vehicles, pedestrians and road infrastructure details such as lane markings, traffic signs, and signals are detected and classified. The GNC system extracts the drivable region and performs localization, path & motion planning based on the perceived environmental map and issue the necessary high-level control commands to the drive-by-wire system. Tata Elxsi has licensed this software to one of the top OEMs in Germany to test autonomous driving features such as Stop and Go, Distance Keep, Lane Keep and Lane Change etc. on their driverless test vehicle. Autonomai software stack is modular in its architecture and easily customizable for the AD & L3-L5 ADAS features development.

V2X Emulator – V2X - Vehicle to everything (X) refers to an intelligent vehicular communication system, where all the vehicles and infrastructures are interconnected with each other. V2X incorporates more specific types of communication, such as Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I), Vehicle to Pedestrian (V2P) and Vehicle to Network (V2N) communications as seen in Figure 2. By complementing other sensors, this technology provides a higher level of predictability and determinism by conveying location, speed, direction.

V2X can be essential for autonomous driving with the following features:

Accurate vehicle information: V2X

Figure 1 Tata Elxsi's Autonomous Driving Software Stack – 'autonomai'

Figure 2 V2X communication systems explained

can provide accurate speed, heading, and more while other sensors give estimated vehicle data.

Obstruction sensing: V2X communication alerts the autonomai about the non-line-of-sight objects and facilitates better decisions by the ego vehicles.

Works in all environmental conditions: V2X is a highly reliable sensor in any weather or lighting conditions.

Usually, V2X uses Dedicated Short Range Communication (DSRC) which is wireless communication technology. It uses a radio frequency spectrum band of 5.9 GHz. DSRC has low latency and is useful over short to medium distances with high reliability. V2X communication uses the DSRC technology and communicates using transponders known as On-Board Units (OBUs) used in V2V communication and Road Side Units (RSUs) used in V2I communication. The DSRC includes five main messages viz. Basic Safety Message (BSM), Road Side Alert message (RSA), Map Data, Traveler Information Message (TIM), and Signal Phase and Timing message (SPAT).

Tata Elxsi's patented V2X Emulator is an equipment based platform which reproduces real world conditions in the lab and facilitates testing of V2X ECUs employed in AVs. With the help of augmented reality, field testing can be carried out of real roads by creating a virtual V2X environment. Tata Elxsi's AR-V2X has been awarded AutoSens 2019 silver award for best validation tool.

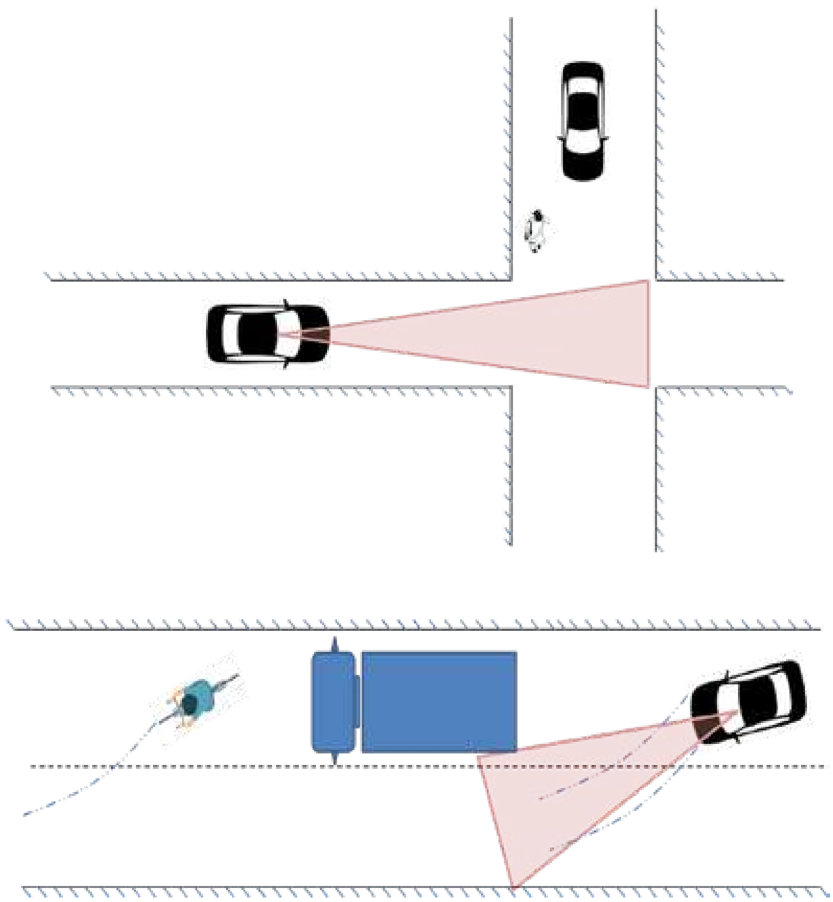
Problem Statement:

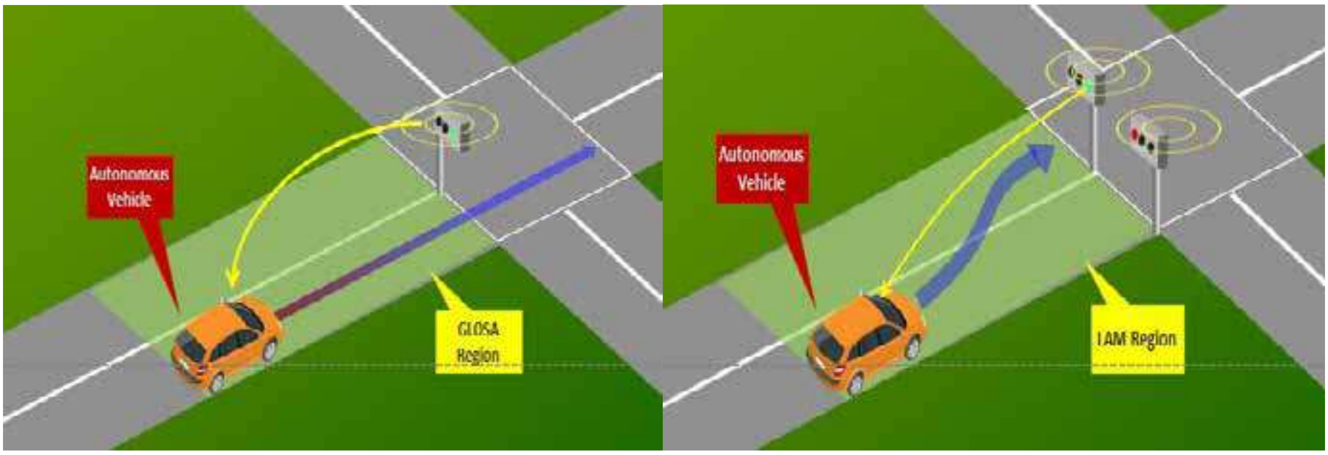
Autonomous vehicles (AVs) majorly depend on their on-board sensors such as cameras, LIDARs, and RADARs to perceive on-road objects. These perception sensors have limited range and field of visibility, which constraints the AVs' maneuvering ability & decision making capabilities to cover the entire L4/L5 driving scenarios.

On-road scenarios such as complex intersections, handling Vulnerable Road Users (VRUs) are typical examples as shown in above figure, where the on-road objects/obstacles are obstructed/ not in the purview of the AVs' on-board sensors. In such complex situations, AVs are expected to take safe & feasible maneuvering decisions. Wrong maneuvering decisions may lead to accidents causing injuries, fatalities and this may further bring down the already low trust factors on AVs among masses. Hence, relying totally on the on-board sensors under complex driving scenarios, harsh weather conditions make the AV's L4-L5 mobility worse more.

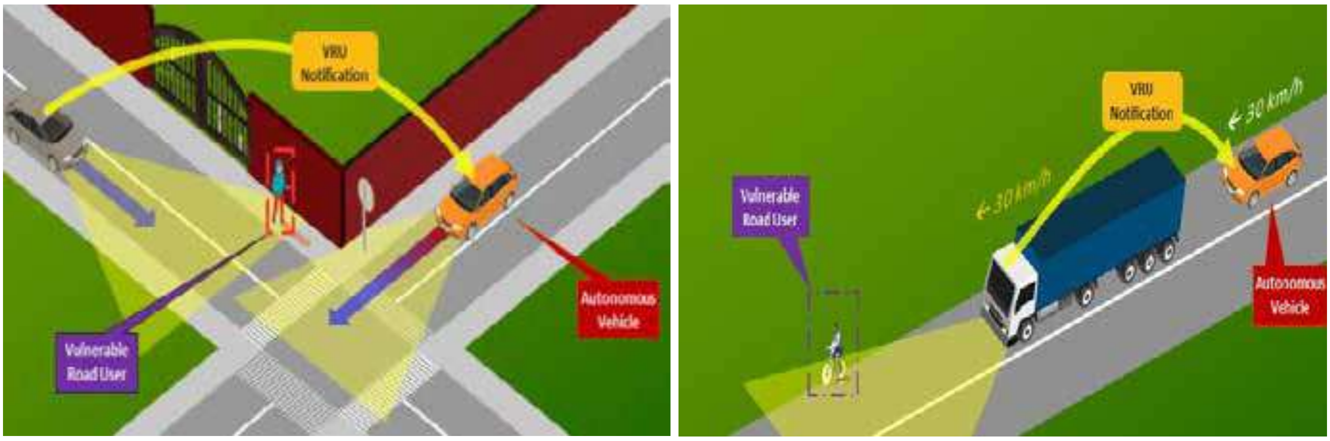
Approach/Solution Alternatives:

Vehicle to Everything (V2X) Communication facilitates vehicles to communicate with other vehicles and the Road Side Units (RSUs)/infrastructures. It can alert the Autonomous Vehicles (AVs) about traffic jams ahead, bad weather, road works, and broken vehicles. Using this data, AVs can make better maneuvering decisions for safe and efficient journeys. Significant efforts are put in place by OEMs and Tier-1s


Road scenarios (intersections, blind spots with VRUs) shows the necessity of Connected Autonomy



Handling Green Light Optimized Speed Advisory (GLOSA) and Lane Change Advisory



Handling Intersection and Vulnerable Road Users (VRUs)

to establish the vehicle connectivity in multiple ways such as,

- Use the network of vehicles to inform each other of situations ahead about the traffic jams, road hazards
- Usage of infrastructures equipped with intelligent sensors to predict the vehicles, VRUs behavior in blind zones for AVs and communicate to avoid the possible collisions
- Usage of smartphones & network providers for updated traffic flows

The challenge, however, will be to ensure the connectivity and compatibility of these systems working in multiple platforms and their seamless integration. Rigorous testing would help us to provide the efficacy of connected autonomous vehicles and their corresponding V2X feature handling capabilities.

V2X technology allows autonomous vehicles to communicate with other vehicles, infrastructure, and VRUs. This helps in making autonomous vehicles drive safer and make efficient driving maneuvers such as lane change, intersection handling etc. By providing the information about the Non-Line of Sight Objects through V2X, the Connected Autonomous Vehicles (CAVs) can take feasible maneuver decisions towards road hazards, VRUs, and thus helping avoid traffic injuries and fatalities.

In all the above scenarios the infrastructures and/or vehicles need to have the implementation of V2X solutions, which involve expensive infrastructure refinements, additional sensors, necessary hardware, and ensures secured communications of the information among infrastructure to vehicle and vice versa.

One efficient and cost-effective way is to use Tata Elxsi's V2X Emulator which can be the most optimum choice of OEMs and Tier-1s to perform testing on simulator than on a real vehicle. V2X emulator is a test bed solution to test the V2X capability of a device under test. The device under test here is the ego vehicle. The V2X GUI software operates in a Windows environment. According to the scenario configured in the GUI, the V2X emulator software sends the DSRC messages. These DSRC messages are encapsulated for secure communication, as shown in Figure-2. Once the autonomai platform receives these messages, the data collected is decoded into the format as required by the autonomai modules such as Sensor Fusion, Decision making, and Motion planning for cooperative sensing and maneuvering, as shown in Figure-3.

For the establishment of the connection between windows OS and Linux environment, a socket communication approach is used where the encoded DSRC messages are sent through the sockets. Once the sockets are received by the Tata Elxis's autonomous driving software (autonomai), a wrapper code developed transforms the DSRC messages in the format as required by the autonomai and is sent to the corresponding modules.

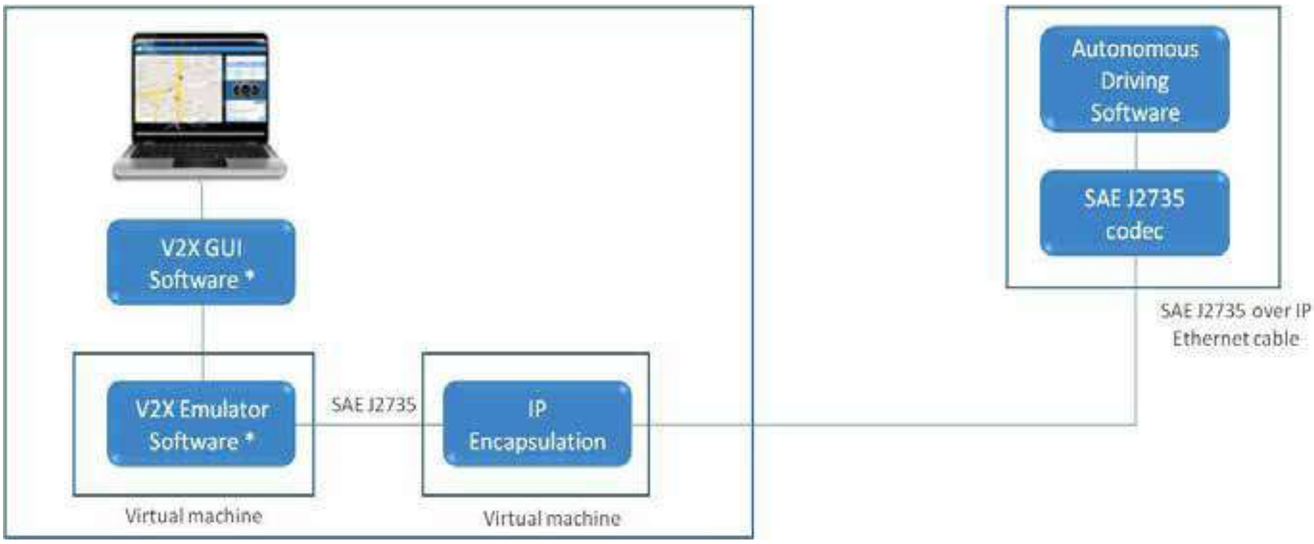


Figure-3 Testing V2X features of Autonomous Driving Software (Autonomai)

Case Studies:

To showcase the connected Autonomai with the V2X features, the following two scenarios are considered for Autonomous Vehicles applications:

- Yielding to Emergency Vehicles
- Speed Adaptation in Speed Limit Zones

Yielding to Emergency Vehicles: The scenario considered here involves an emergency vehicle, which follows the ego vehicle by traversing the lane as same as the ego vehicle. The vehicle information of the emergency vehicle is sent through a specific DSRC message viz. Basic Safety Message (BSM). BSM mainly carries the positional information of the emergency vehicle viz. latitude and longitude, vehicle dimensions, vehicle speed, acceleration, and heading. It also carries a special flag, which indicates whether it is an emergency vehicle or not. On receiving this information, the autonomai checks if the emergency vehicle is within the defined range, and then the ego vehicle is configured to react by triggering a lane

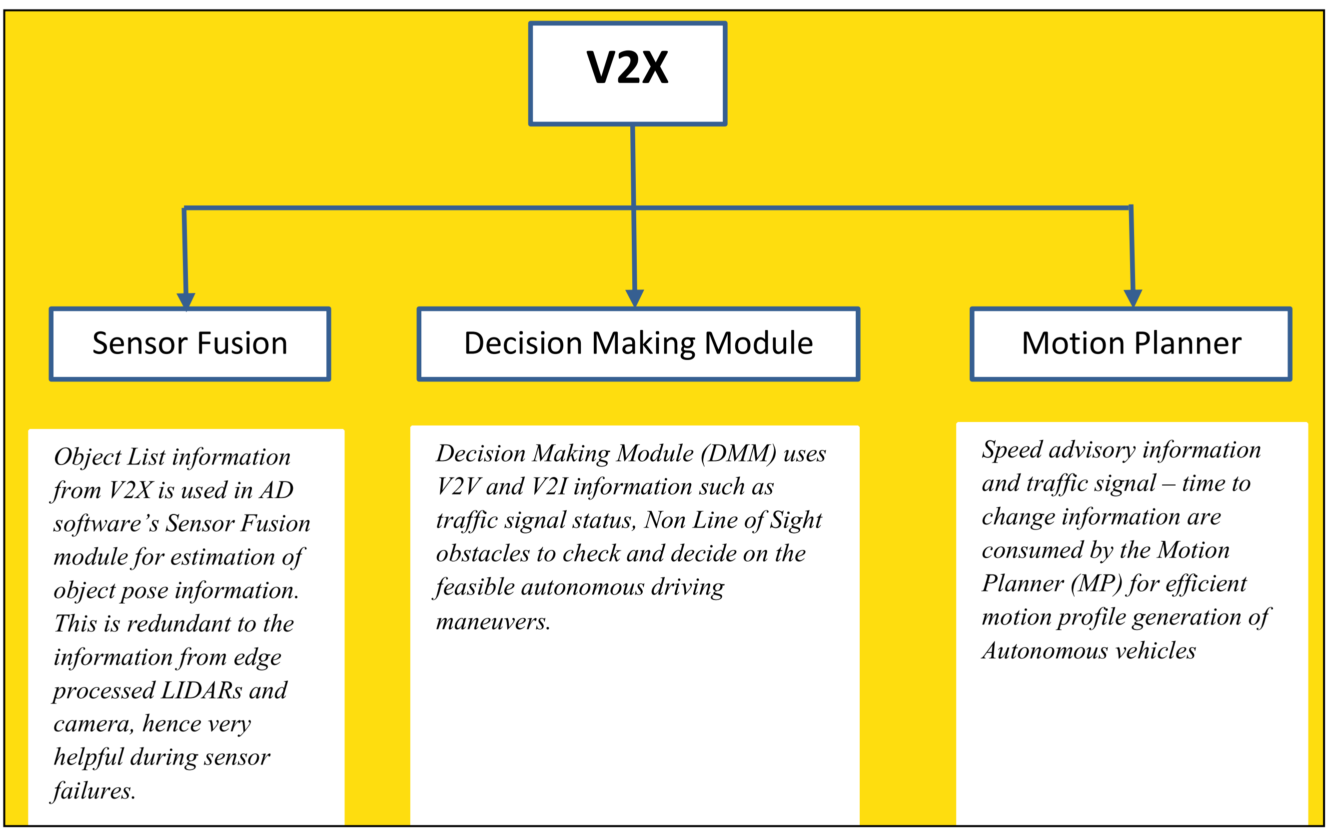


Figure 4 Connected Autonomai- Cooperative Sensing and Maneuvering

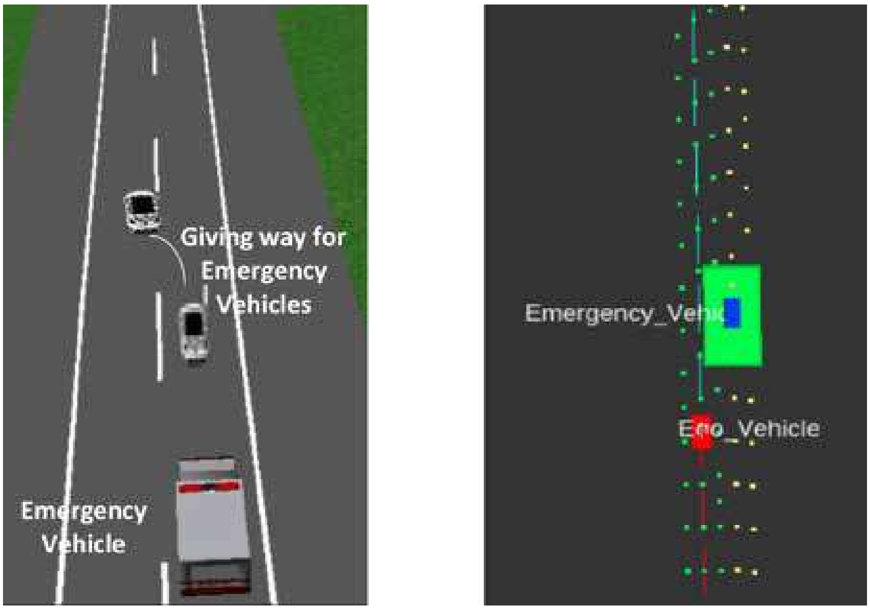


Figure-5 Yielding to Emergency Vehicle by a Lane Change in AD

change/giving way by the ego vehicle, as seen in Figure 5. The emergency vehicle traveling ahead of the ego vehicle can also be seen.

Speed Limit Adaptation in Speed Limit Zones: This scenario involves a Road Side Unit (RSU), which gives a speed limit value which has to be maintained over the defined region. The information corresponding to the Road Side Unit is sent through a specific DSRC message called Road Side Alert (RSA) message. RSA message mainly carries the positional information of the Road Side Unit viz. latitude and longitude and speed limit. On receiving this information, the ego vehicle makes the corresponding changes and hence ramps speed to the specified limit, as seen in Figure 6. The variation in the speed of the ego vehicle can be seen in the figure. The figure also shows that the ego vehicle speed, which was initially 50kmph ramps down to 20kmph as specified by the RSU. It can be observed that the ego vehicle's speed ramps up to the desired/set speed value, once it gets out of the speed limit zone. RVIZ plot of speed limit zone and the ego vehicle traversing is also shown in the Figure 5.

The two case studies mentioned above provides a brief on how the Connected Autonomous Vehicle systems could be enabled, tested and their features are benchmarked in a virtual environment using V2X Emulator. AVs coupled with the V2X is one such a possibility that bring more enabled L4/L5 mobility features.

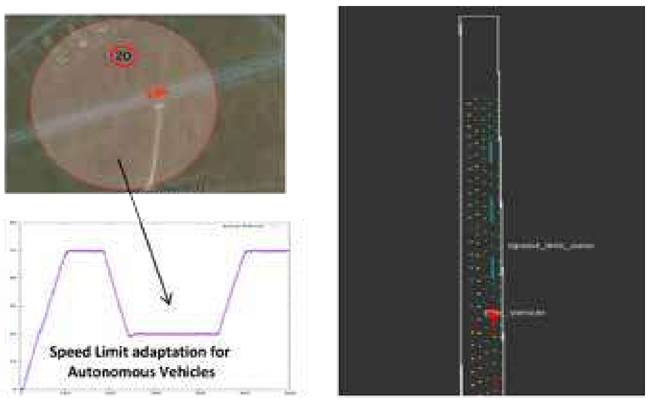


Figure-6 Speed limit adaptation in speed limit zones

Conclusion:

For a driver to give up on the responsibility of driving the vehicle, it is recommended to enable Autonomous vehicles with Connectivity. This also brings about a distribution of responsibilities for Sensing and maneuvering on the entire ecosystem, rather than being over an Autonomous vehicle alone. And, with Continuous development and improvements in vehicle-infrastructure connectivity (ex. DSRC, 5G etc.) with improving AVs processing power will significantly promotes L4-L5 level of mobility. Lastly, the road to implementation can start off with V2X Emulator approach for significant cost and time saving.

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Autonomous Vehicles – Insights into Development and Challenges

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How would you like it if your favorite car can drive you to your office daily without your intervention? Or if your car can drive you to your favorite restaurant while you spend leisure time with your family in the car? Have you ever thought about how we can make driving safer?

If this excites you then there is some good news! The automotive world is in a race against time to make Autonomous Vehicles (AV) a reality. These vehicles are expected to make mobility more convenient and safe. However today only partially autonomous cars and trucks with varying amounts of self-automation exist.

Movement of people and goods have always been a fundamental part of our lives since ages. Due to this, mobility has been a very important aspect to mankind and there have been numerous efforts to enhance the same. Since the time the wheels were invented, the way we move around has drastically changed. Today we are in a pursuit to enable mobility with more independence and intelligence in order to make it smart, convenient, safe and green.

So what is Autonomous Driving?

Autonomous driving can be understood as handing over the vehicle guidance function and authority to a vehicle.The transfer of the guidance function may be for a limited location or a limited time and can potentially be interrupted by the driver. Basically, the autonomous vehicle is capable, without human assistance, of deciding the route, lane, and interventions in the driving dynamics like braking or steering. Such a function is subject to both technical and social requirements. Implicitly an autonomous vehicle must pose no greater danger than a vehicle controlled by a person!

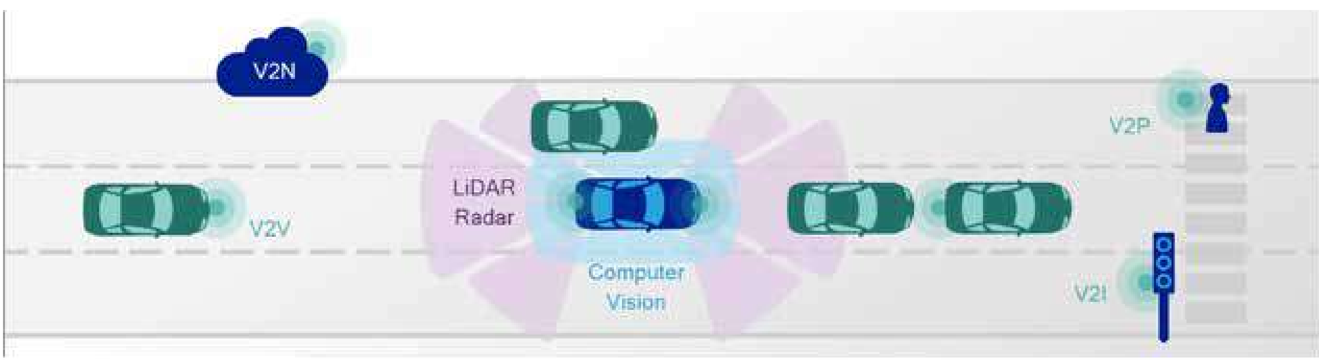
The level of autonomy of a self-driving car refers to how much of the driving is done by a computer versus a human. The higher the level, the more of the driving that is done by a computer. SAE International (Society of Automotive Engineers) provides taxonomy and definitions for different levels of Driving Automation. Six levels are defined starting with Level 0 (No driving automation) up to Level 5 (Full driving automation).

Self-driving cars can be further distinguished as being connected or not, indicating whether they can communicate with other vehicles and/or infrastructure, such as next generation traffic lights. Most prototypes do not currently have this capability.

Design considerations for development of AVs

Though the design details for autonomous vehicles widely vary, one way to equip the vehicles with intelligence is to mimic the capabilities of human information processing itself on the vehicle through reliable models. This involves capturing the real world data through sensors (Sensing), transforming the data into a cognitive representation (Perceive) and Interpretation of the information through which decisions can be taken on the reaction (Stimulus). It is necessary to perform this cycle continuously with the highest precision by overcoming the timing and hardware resource constraints. In addition interior or driver monitoring further enhances safety by detecting driver drowsiness or distraction.

Capturing of real world data includes all processes relating to the discovery and recognition of relevant information. During driving the most significant inputs are the visual, acoustic and tactile information that are realized through sensory organs of eyes, ears and skin receptors respectively. This cooperative sensing is realized with use of environmental sensors and technologies like RADAR, Video, Lidar, GPS and V2X (Vehicle to Everything. See picture below). Equally important is to capture the information of the vehicle under test. This is accomplished by continuously reading information from vehicle sensors like wheel speed, yaw-rate or steering wheel angles sensors.



So far, the Internet has played an only marginal role in vehicles. Up until now, the use of data links has been restricted mainly to infotainment and navigation support. For the development of autonomous vehicles, the internet is believed to bring in more capabilities. For example the Vehicles equipped with sensors and V2V communication devices could expand their horizon via cooperative sensing using internet and data cloud. But for this a reliable network with high quality of service and data integrity becomes necessary.

Though the environmental sensors like Radar, Video or Lidar are capable to an large extent in collecting detailed data of a car's surrounding environment, there is lot of room for enhancing system cognition and situational awareness. Transforming the sensor data into a meaningful representation of a real world involves exhaustive cognitive processing. Artificial Intelligence related techniques have made it possible to push the boundaries that were imperative in the conventional models. Large neural networks are trained for tasks like Image Classification, Object Detection and Classification, Road Sign and Lane Recognition to name a few.

So instead of manually writing a software function for an autonomous vehicle to follow, such as , "stop when you see red light", deep neural networks enable autonomous vehicles to learn how to navigate the world on their own using sensor data. These algorithms are inspired by human brain, implying they learn by experience. However the Deep Learning based techniques for computer vision are dependent on training data, a lot of which is being already collected and processed. Hence through deep learning, vehicles will "learn" to understand its environment.

One of the foremost tasks involves synchronizing the data from various sensors since it is likely the data is captured at different time instances. The primary scope of the perception would be to provide answers to questions like what do we see or how do the objects look like. To get a complete and accurate perception of the surroundings it would be necessary to fuse the data from multiple sensors. Combining the information from different sensors helps to leverage the benefits of different sensor technologies. The primary objective of data fusion is to merge the data from individual sensors so as to combine their strengths in a beneficial way and reduce individual weaknesses. For example, RADAR provides reasonably accurate measurements of object longitudinal distance and velocity in various weather conditions. However these sensors have limitations in measuring lateral distances, reading road signs and lanes. Such gaps can be offset by utilizing information provided by the Video. This makes it possible to reduce false interpretations and improve accuracy and improve the system's ability to detect objects more robustly.

The ability to interpret and predict the current traffic situation is essential for being able to automatically derive reasonable decisions. Though several models exist which satisfy the requirements for lower levels of autonomous driving, more needs to be done for development of methods and algorithms to acquire better situational awareness at a safety-relevant integrity level. These involve Intention and Behavior models to predict behavior of driver and other traffic participants.

For higher levels of autonomous driving Path Planning plays a key role in navigating the vehicle safely to its target destination by avoiding obstacles. Simultaneous Localization and Mapping (SLAM) is a common technique used in autonomous navigation where a vehicle builds a global map of current environment and uses this map to navigate or know its location at any point of time.

Next the decision on reaction is conveyed to vehicle motion control modules that drive the necessary actuators to realize required maneuvers like lane change or acceleration or braking.

Challenges and Conclusion

Nevertheless autonomous vehicles encounter several challenges. If autonomous driving is intended to improve road safety by the widespread use of vehicles with such capabilities, the safety objective must be measured against the status quo of road safety. The available testing methods needs to be improved to validate such complex systems. Concepts for the assessment of human and machine driving performance are required. Hence newer metrics may have to be defined to assess the performance. This could be a greater challenge than the development of artificial intelligence for autonomous driving itself.

Secondly, technological development requires large investments that can only be redeemed by an appropriate market demand. If the market does not accept the developed product, financing further developmental steps may prove difficult.

Next the autonomous vehicles would need a strong infrastructural support. For example in terms of road topology or lane markings. Collective traffic control is dependent on technologies like V2X which needs further development towards a level of maturity that allows usage in on road vehicles.

Finally introduction of such cars in the market needs to satisfy legislation requirements of various markets as well as legal requirements (Who's liable in the case of an accident?). Though it is clear that the automated systems on one hand can increase convenience and road safety it is likely to bring in some automation related risks to road traffic that is not fully known. The question of acceptance in future therefore remains significant.

Disclaimer

The views expressed in this article are my own and do not necessarily represent the views of the organization I work with. ❑

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Prospects of Autonomous Driving with Enhanced Driver Monitoring System to perform Breathe Alcohol Content Test – To ensure safeness of everyone

SAM RICHARDSON AMALRAJ
RENAULT NISSAN

It gives me great excitement to watch the revolution that autonomous driving is going to create in people's lives, not just within the automotive industry but also in multiple fields of engineering, ranging from the health-care industry and eBooks to the entertainment industry, and that is just the cherry on top. The ocean of opportunities goes deeper on the hunt to mine down the various business possibilities in the field autonomous drive.

It seems that the race to build the first fully-autonomous vehicle has only just begun. However, with the theme "The World of Tomorrow," GM presented an audacious vision of America two decades early. Futurama, revealing an automated highway system complete with self-driving cars.

The success of autonomous driving purely depends on bridging the existing driving challenges within the vehicle components, its robust behaviour in the environment and the homologation that varies from country to country, in order to provide a safer and more comfortable driving experience to the driver.

In present-day high-end cars, the number of electronic component units (ECU) that are embedded into cars varies between 80 to 120 nos. In the days to come, this number will go higher. Keeping this in mind, some of the leading chip processor manufacturers like Qualcomm and Intel already have research in place to develop the advanced processing units required for autonomous driving.

With growing volume of big data around us and increased IoT infrastructure scaling, analysis of any kind descriptive, diagnostic, prescriptive and predictive levels have been made highly viable. In recent years, investors in Silicon Valley and across the globe have been pumping in more revenue into research for self-driving cars. The autonomous vehicle manufacturing vertical raked in $10.3 billion worldwide in Venture Capital financing across 146 deals in 2018 according to PitchBook

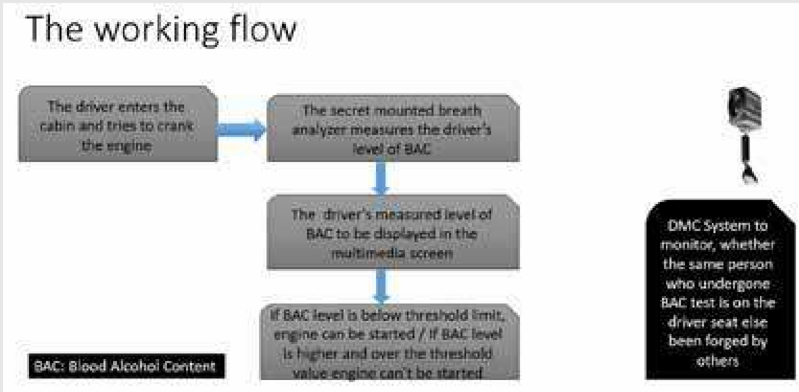
The Futuristic Medical Benefits off Self-Driving Cars:

In 2015, more than 38,000 people died in motor vehicle accidents as per the National Safety Council. 26 percent of these accidents led to deaths that were caused by distracted driving.

Every day in the United States 4,110 heart attacks and strokes occur. This amounts to roughly 1.5 million every year. Drivers in the United States on average make 1.1 billion trips per day. This means that for roughly every 733 trips taken, one driver could experience a heart attack or stroke while behind the wheel.

This presents a real risk for everyone who gets into a car. If a driver does have a heart attack or a stroke, the chances of them losing consciousness and endangering themselves, passengers, other drivers or pedestrians is highly likely.

These risks will greatly be reduced, if not eliminated, through the introduction and widespread adoption of level 5 autonomous vehicles.



Picture depicting the flow of BAC test implementation for Autonomous Vehicle

In the future, self-driving cars won't just prevent deaths from human error. An autonomous vehicle will reroute to a hospital if a driver is found to be sick in any way, ranging from persistent coughing to a high-risk disease like heart attack or stroke.

This year, an individual driving on a highway in Missouri suffered a pulmonary embolism and manually rerouted the vehicle with autopilot to the hospital. The semi-autonomous autopilot feature saved the individual's life, and in the future, fully autonomous vehicles will save a tremendous amount of lives.

This is just the first step. In the future, autonomous vehicles will be able to sense driver behaviour such as body movement, temperature or even increase in respiration.

If a passenger is feeling chest pain or numbness, they will be able to communicate with their autonomous vehicle through an intelligent voice assistant by simply saying an easy word or phrase such as "help."

Through artificial intelligence, the autonomous vehicle would understand the problem (partly due to the driver's tone and body movements) and could then send a message to the nearest hospital that a patient in distress is arriving soon.

The medical staff at the hospital would be able to track the location of the autonomous vehicle and communicate with the passenger. Upon the vehicle's arrival at a dedicated emergency autonomous vehicle drop off-and-pickup zone, medical staff were present to take care of the passenger. Furthermore, since the autonomous vehicle took control of the wheel, other drivers and pedestrians on the road were not put at risk

A future with autonomous vehicles will undoubtedly save time and lives, improve mobility and lower risk of casualties during medical emergencies. A promising future indeed!

Citations: according to GE news: Grayson Brulte, January 13, 2017

BAC test (Breath Alcohol Content) under the surveillance of Driver Monitoring Camera system:

Life is the most precious aspect to be considered in any aspect of research and autonomous driving research has left no stone unturned in the preservation of human life at all costs.

To monitor health conditions of passengers, particularly drivers, inside an autonomous driving unit in real-time, an advanced ensemble of high-performing hardware to generate accurate and precise results through which decisions can be taken by the autonomous driving unit instantaneously. A Driver Monitoring Camera is one such system that facilitates in the monitoring of health functions of passengers. A DMC monitors the finer aspects of a driver's motor functions like pupil dilation, drowsiness, stability, posture and extending to breath alcohol content.

When a driver boards an autonomous driving unit, the DMC kicks into action. The alcohol content in the breath of the driver is detected by the BAC tester mounted in the steering wheel. The whole test is done under the surveillance of DMC system to avoid manipulation by drivers or external agencies since a DMC cannot be tampered.

A DMC system can be further linked to a Traffic Control Room where analytics can be performed on the recorded data. This includes any history of violations like driving without seat belt or under the influence of alcohol.

Conclusion:

It's high-time to ensure autonomous drive machines are equipped to handle real-time scenarios on-road and added with a wide range of advanced driving features to be declared as safe for human use. ❏

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AUTOMAKERS AND STARTUPS IN AUTONOMOUS VEHICLE

RICHA TYAGI
TELEMATICS WIRE

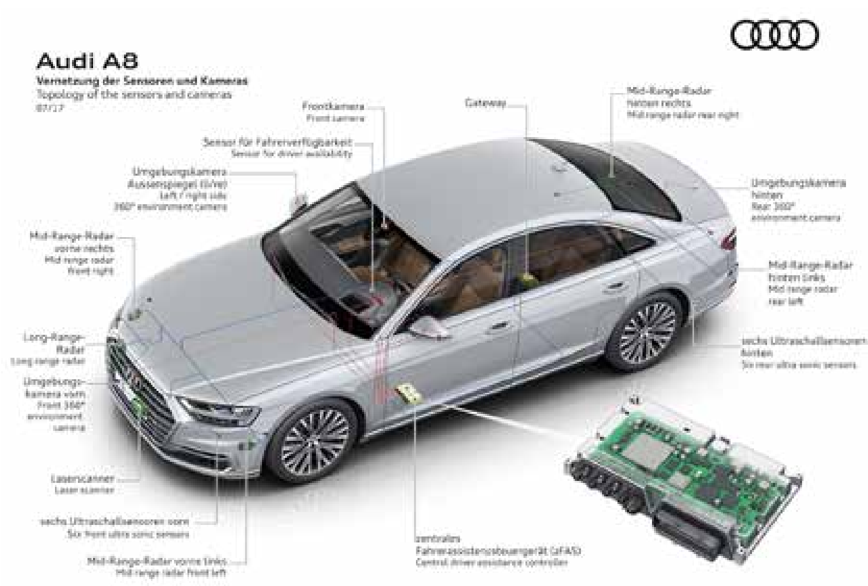
Vehicle autonomy is the way forward for automotive industry. Though how much time it takes for the industry to cover the journey from L1/L2 to L4 is domain of research for industry consultants and market research firms. But, irrespective of all these there are various automakers and startups who are on their way to pinnacle of self-driving. In fray are many automakers working on self-driving initiative. Below is compilation of some of the initiative in self driving domain by the automakers and startups.

Audi AG

Audi ventured into autonomous driving with budget close to $16B to spend by 2023. It is said to deploy hands-free driving in its A8. The 2019 A8 model included suite of semi-autonomous features, including adaptive cruise control and collision mitigation capabilities, as well as improved object recognition. The Audi A8 with self-driving features has only been initially approved for release and made street-legal in Europe in April 2020. But company seems to be taking a step back: its A8 sedan won't be equipped with the Level 3 partial automation system, called Traffic Jam Pilot, due to safety concerns and the lack of a legal framework.

BMW AG

In 2016, the company announced an alliance with Intel and Mobileye, which Chrysler and Magna also joined in 2017. The alliance plans to create an open standards-based platform for bringing self-driving cars to market, aiming to put its first vehicle, the BMW iNEXT, on the road by 2021. In 2018, BMW opened an autonomous driving campus near Munich, Germany, to work on self-driving pilot projects. In September 2020, it inked an agreement with Tactile Mobility, an Israel-based startup whose technology detects road conditions by analyzing wheel speed, gear position, and other non-visual sensors.



Audi A8 self-driving hardware

Daimler AG

Daimler announced it would be investing $570M in autonomous truck technology at CES 2018. In March 2019, Daimler acquired the US-based self-driving company Torc Robotics and integrated it into ATG (Autonomous Technology Group, an organization focused specifically on developing "automated roadmaps"). The new partners have expanded the testing of autonomous trucks to New Mexico. Their goal is to bring SAE Level 4 vehicles on road by 2030. Daimler has also invested in Luminar, to gain access to vital sensors that will be a part of its autonomous trucks. Daimler has teamed up with Waymo in late 2020, wherein Daimler will provide a customized truck chassis that will be integrated with Waymo's self-driving system.

Ford Motor Company

As part of its 10-year autonomous vehicle plan, Ford is steadily increasing its fleet and currently has around 100 autonomous test vehicles. Ford is testing out Argo's technology with its third-generation Fusion model sedan. And in October 2020, Ford and Argo AI released its fourth-generation autonomous test car. The new vehicle is equipped with better sensors, sensor-cleaning technology,

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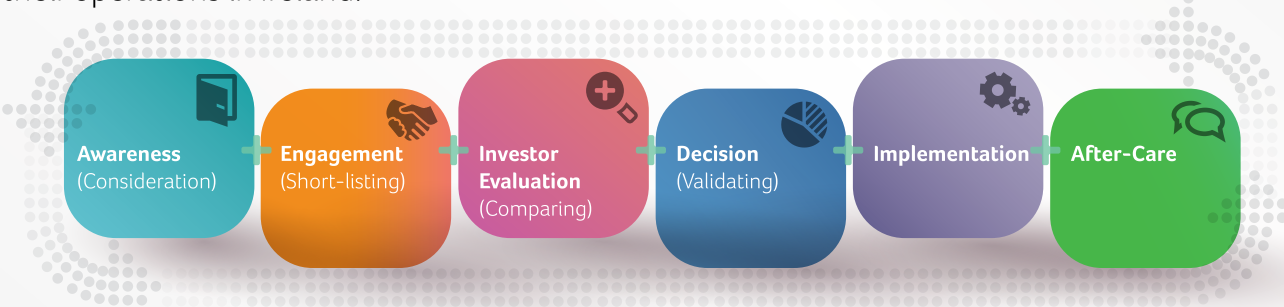

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Source: Ford

and an upgraded battery cooling system. Ford also has testing projects underway in Michigan, Miami, Pittsburgh, and Washington, DC.

General Motors

In January 2020, GM unveiled a self-driving 6-seater, Origin, calling it "the beginning of the future beyond the car." The vehicle lacks a steering wheel, brake and accelerator pedals, a rear-view mirror, etc. It announced in October 2020 that it will soon seek regulatory approval to deploy several Origin vehicles for testing purposes. Origin will not be available for purchase by customers but will be used as a ride-hailing vehicle through GM's Cruise service. The goal is to start producing the vehicle in GM's Detroit factory by the beginning of 2022. Amid the Covid-19 crisis, GM shut down its car-sharing service Maven and has delayed the relaunch of its Book by Cadillac luxury vehicle subscription service.

Honda Motor

Honda has received approval from California to test autonomous vehicles on public streets. In November 2020, Japan's Ministry of Land, Infrastructure, Transport, and Tourism approved Honda's plans to mass-produce its Level 3 Honda Legend. The car will be equipped with autonomous tech called Traffic Jam Pilot that can navigate through congested highways. The system will collect data on the vehicle's movement. When drivers want to take back control over the vehicles, the software will first check whether they are looking at the road ahead. The launch is planned for March 2021.

Honda Legend; Source: Honda

The Cruise Origin driverless shuttle stands during a GM Cruise reveal even in San Francisco; Source: Bloomberg News

Nissan Motor

In February 2020, Nissan achieved a major milestone in its self-driving journey: its battery-powered autonomous car Leaf successfully undertook a long and complex road journey in the UK, covering a total of 230 miles. The car was on self-drive mode 99% of the time, though 2 engineers were present in the car the entire journey. This is part of the project, HumanDrive, jointly funded by UK government through the Centre for

Nissan Leaf; Source: Nissan

Connected and Autonomous Vehicles (CCAV) and Innovate UK, and nine other consortium partners.

Tesla

Tesla offers two tiers of self-driving capability in its vehicles: Autopilot and Full Self-Driving. Full Self-Driving (FSD) costs an additional $10,000 and includes features like Summon and Navigate on Autopilot, which enables lane changes and interchanges. In October 2020, Tesla launched the Full Self-Driving beta, an update that initially went to a small group of customers. A full release is expected in the months ahead. Tesla's vehicles are only designated autonomy Level 2 by SAE, meaning they are capable of some autonomous maneuvers but are not considered fully autonomous. Development is currently underway on a next-generation chip.

Volvo Car Corporation

Volvo labeled its autonomous vehicle project "IntelliSafe," setting a zero-fatality goal for when it fully rolls out autonomous features to the public. In June 2019, Volvo and Uber announced that they had created "a production car capable of driving by itself"- Volvo XC90 SUV, which has Uber's self-driving system. In June 2018, Volvo announced partnership with LiDAR startup Luminar to work on both physical, car-mounted sensors and the software designed to process, label, and tag captured data. Volvo plans to integrate LiDAR and a perception stack into select vehicles, starting with the XC90, in 2022.

Project Vector, Jaguar Land Rover. Source: Jaguar Land Rover

Volkswagen AG

In October 2019, Volkswagen spun off its self-driving startup into a subsidiary, Volkswagen Autonomy, in a bid to "make autonomous driving market-ready." This was followed by Volkswagen's parent, Porsche SE, taking up a minority stake in self-driving tech startup Aeva. Volkswagen has also struck a deal to launch fully-functional autonomous van service in Doha, Qatar, by the end of 2022. In July 2019, Volkswagen announced, a joint venture with Ford to develop autonomous vehicle technology. It merged its autonomous vehicle initiative- Autonomous Intelligent Driving with Argo AI, which was being funded by Ford. Now Ford and Volkswagen have stakes of 40% each in Argo AI. Despite multiple partnerships, the company launched an internal organization, called Car. Software, in June 2020. The unit is tasked with increasing VW's share of its vehicles' software to 60% by 2025, up from the less than 10% it currently owns.

Jaguar – Land Rover

Up to 20,000 new Jaguar I-PACE models will be built to serve in Waymo's fleet for its ride-hailing transportation service, with production on the vehicles beginning in 2020. In February 2020, JLR unveiled an electric and "autonomy ready" shuttle pod designed for shared use in urban settings. "Project Vector" is just a concept, but JLR said it hopes to have some version of the vehicle on the road for testing by 2021. In November 2020, JLR set up a testbed for autonomous ground and air systems in Ireland, starting with the electric i-Pace. The driverless car testbed will work on autonomous, connected, electrified and shared vehicles in a smart city zone to test technology in the real world.

Hyundai Motor

Hyundai is working with Yandex on building a driverless car. In June 2020, Yandex announced it would buy 100 customized versions of Hyundai's Sonata cars. Test drives will initially be carried out in Detroit. The duo is working on creating both a driverless car and a self-

FAW's J7+ commercial truck

driving software system that could be sold to automakers and car-sharing startups. Hyundai said that it would test 6 autonomous vehicles on the roads of Seoul, with plans to take this number to 15 by 2021. In January 2018 at CES, Hyundai said it would begin testing an autonomous SUV, aiming to test the technology by 2021 and to go to market by 2025.

PSA Group

In April 2016, PSA Groupe announced that two Citroën cars had driven without driver supervision from Paris to Amsterdam. The vehicles navigated over 300 km without supervision on authorized stretches of road, with PSA claiming the cars had achieved Level 3 automation in this mode. The "eyes off" mode is slated to arrive by 2021, while Level 2 semi-autonomous "hands off" modes are already available with models such as DS7 Crossback, DS 3 Crossback, and Peugeot 508 & 508 SW. These features, along with electric vehicles and new models, form the core of PSA's broader Push to Pass growth strategy. PSA is also working with roads operator VINCI Autoroutes on testing autonomous cars as part of its "Autonomous Vehicle for All" (AVA) program.

FAW Group

In November 2020, FAW's J7+ commercial truck, jointly developed with the startup Plus, passed a certification test conducted by the China Automotive Technology & Research Center. This means it can begin on-road operations. Mass production is set to start in 2021. FAW J7+ is the first intelligent truck that passed the certification test in China. FAW Group has invested in autonomous tech startup Pony.ai as well.

Yutong

Chinese bus manufacturer Yutong has been researching driverless buses since 2012. Yutong revealed a range of mobility solutions in September 2020. Its L4 autonomous driving buses were showcased operating in different scenarios. They were capable of autonomously navigating open roads, arriving at bus stops, and parking themselves.

Tier 1 (Supplier)

Aptiv

Aptiv is a global technology company that develops safer, greener, and more connected solutions, which enable the future of mobility. In February 2020, self-driving software company Aptiv and Lyft reached a major milestone: the companies crossed 100,000 rides of its autonomous passenger service in Las Vegas. The expansion into China is a major strategic move for Aptiv. Another major Aptiv initiative is Motional, its autonomous driving venture with Hyundai. The venture was officially unveiled in August 2020. Motional aims to build and commercialize SAE Level 4 vehicles, and make this technology available for robotaxi fleets in 2022.

L4 Yutong self-driving bus; Source: Yutong

Mando's autonomous driving vehicle 'Hockey'; Source: Mando

Mando Corporation

Mando Corporation, a major car parts supplier, successfully tested Level 4 autonomous tech in February 2019 with a vehicle called Hockey. The car navigated 2.7 km of public roads in the city of Pangyo, moving at a speed of 40 km/h (24 mph). Mando plans to commercialize this technology by 2021.

Startups & subsidiaries

In the compilation of startups in autonomous vehicle space, we have also included the year of their launch and their present Crunch Base ranking (CB Rank).

TU Simple

2015 / CB Rank: 4195

TuSimple is a self-driving truck company based in San Diego and operating self-driving trucks out of Tucson, Arizona. In July 2020, Navistar and TuSimple have entered into a partnership to co-develop SAE Level 4 self-driving semi-trucks targeted for production by 2024. In September 2020, TRATON and TuSimple have launched a development program to operate the first SAE level 4 autonomous hub-to-hub route between Södertälje to Jönköping in Sweden using Scania trucks. It is patterning with ZF to co-develop sensor solutions, cameras, lidar, radars used in autonomous vehicles.

Waymo

2009 / CB Rank: 108

Waymo is a self-driving technology company with a mission to make it safe and easy for people and things to move around. The company revealed a partnership with logistics company UPS in late January 2020 to test delivery of packages along a pre-set route in its self-driving vans in Arizona. Waymo has further expanded its footprint in the logistics sector by signing a deal with FCA in July 2020. The duo will develop a range of autonomous vehicles designed for moving goods, including cargo vans. In October 2020, Waymo announced that members of Waymo One in the Phoenix area will be able to take fully driverless rides with no safety driver present.

Yandex SDC

1997 / CB Rank: 760

Yandex's self-driving unit was initially integrated into MLU BV, a ride-hailing venture with Uber. But in September 2020, Yandex announced that it was spinning out the unit into a separate company and investing $150M into it. Yandex has assembled 130 vehicles that run tests across Russia, Israel, and the US.

Zoox

2014 / CB Rank: 81

Zoox, a startup developing autonomous driving tech geared toward ride-hailing customers, was acquired by Amazon in June 2020. Last month, Dec'20, Zoox unveiled its fully autonomous, electric robotaxi, which can seat 4 passengers and reach speeds of up to 75 mph. The vehicle is currently in testing.

Baidu

1999 / CB Rank: 721

Baidu is a Chinese website and search engine. Apollo, Baidu's open-source autonomous driving platform, which originally launched in 2017. On Jan. 7, 2020, Wind River announced its collaboration with Baidu to develop an autonomous vehicle solution. On Mar 25, 2020, Baidu announced it received an RMB 52.8 million ($7.3 million) government contract to build an autonomous vehicle testing site within the Chinese municipality of Chongqing. The 20-kilometer square test region will be fully equipped with vehicle-to-infrastructure communication technology using 5G networks.

Nuro

2016 / 4,346

Nuro was established by two ex-Google engineers in 2016. Nuro specializes in developing electric autonomous vehicles that have one purpose: the transportation of goods from storefronts to customers' homes. In November 2020, Nuro has raised $500 million in its latest funding round. The company has partnered with a list of big name companies, including Walmart, Domino's Pizza, CVS Pharmacy, and Krogers. In Feb 2020, Nuro unveiled its second-generation vehicle, the Nuro R2. It was granted an exemption by the U.S. Department of Transportation, allowing it to be tested on public roads without certain features of traditional, passenger-carrying vehicles.

Nuro self-driving R1; Source: Nuro

Voyage

2017 / CB Rank: 2,490

Voyage aims to accelerate the autonomous vehicle market's community impacts by building networks of driverless cars in retirement communities, helping senior citizens access better and safer transit options. In May 2020, Voyage has inked a deal with Fiat Chrysler to supply purpose-built vehicles, a partnership that will help accelerate its plan to launch a fully driverless ride-hailing service. The Voyage launched its next-generation robotaxi, Voyage G3, in Aug 2020. It is designed to drive without the need for anyone behind the wheel.

Embark Trucks

2016 / CB Rank: 2,883

Embark is building self-driving truck technology to make roads safer and transportation more efficient. Embark's autonomous trucks are already moving freight for five unnamed Fortune 500 companies in the southwest U.S. Embark has done autonomous truck testing with Ryder, Frigidaire and Amazon. Embark also have a relationship with Peterbuilt, which is part of Paccar.

Argo AI

2016 / CB Rank: 520

Argo AI is an autonomous driving technology company. The company was co-founded in 2016 by Bryan Salesky and Peter Rander, veterans of the Google and Uber automated driving programs. It is an independent company with two major investors: Ford Motor Co. (2017, $1 Billion) and the Volkswagen Group (2020, $2.6 billion). In June 2020, Audi's Autonomous Intelligent Driving (AID) unit merged with Argo AI, and became its European headquarters and fifth engineering center. In October 2020, Argo AI released its fourth-generation autonomous test car with Ford.

Cruise

2013 / CB Rank: 131

Cruise, a subsidiary of General Motors has autonomous fleet of 180 vehicles that are undergoing testing. In December 2020, Cruise has started testing self-driving vehicles without driver monitors in San Francisco. Cruise autonomous vehicles, on the road in San Francisco, navigating some of the most challenging and unpredictable driving environments.

Tactile Mobility

2012 / CB Rank: 9,975

Tactile Mobility, an Israel-based company whose technology detects road conditions by analyzing wheel speed, gear position, and other non-visual sensors. In March 2020, Porsche announced to integrate automotive tech developed by

Voyage G3 Robotaxi; Source: Nvidia

Cruise's Continuous Learning Machine predicts the unpredictable on San Francisco roads; Source: Medium

Tactile Mobility into future vehicles. In September 2020, BMW Group has signed an agreement with Tactile Mobility to install sensing software across its product line and brands that will provide information about road and vehicle conditions to increase performance and safety.

Autonomous Technology Group

2019

Autonomous Technology Group is part of Daimler Trucks' global effort to put highly automated trucks onto the roads within a decade. To achieve this, Daimler Trucks announced an investment of more than EUR 500 million at the 2019 Consumer Electronics Show (CES) in Las Vegas. In commercial trucking, level 4 is the logical next step after level 2 to increase safety as well as efficiency and productivity. In 2020, Daimler Trucks and Torc Robotics have expanded the testing of autonomous trucks to New Mexico. Their goal is to bring SAE Level 4 vehicles to the roads by 2030.

Pony.AI

Dec 2016 / CB Rank: 11,630

Pony.ai is builds full-stack autonomous driving solutions. Pony.ai announced on Feb 2020 that it has raised $400 million from Toyota Motor Corporation to deepen and expand the two companies' collaboration in mobility services. In November 2020, FAW Group has invested in autonomous tech startup Pony.ai as well. Pony.ai's technology will be integrated into a vehicle platform used in the Red Flag electric vehicle brand.

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AUTOCRYPT C-V2X to support China C-SCMS Standards

AUTOCRYPT announced the launch of its new C-V2X solution, supporting Chinese Secure Credential Management System (C-SCMS) standards. AUTOCRYPT received verification tests for compatibility by the C-V2X working group at China Academy of Information and Communications Technology (CAICT), under the new International Mobile Telecommunications-2020 (IMT-2020(5G)) Standard for 5G networks, devices, and services. In Nov'2020, AUTOCRYPT's solution was verified for interoperability by the China Industry Innovation Alliance for Intelligent and Connected Vehicles (CAICV), undergoing testing for "four-layers" interoperability between OEM, OBU terminal, V2X communication module, and PKI to comply with C-SCMS standards.

NIO OS 2.8.0 in-car operating system launched

In Nov'20, NIO launched its updated in-car operating system, the NIO OS 2.8.0, which will be introduced to the ES6s, the ES8s and the EC6s through FOTA (firmware-over-the-air). Through FOTA, features such as automatic door-locks and memory front passenger seat will be newly added to vehicles. Besides, the NIO OS 2.8.0 will feature upgrades in the performance of network connections and charging port illumination. According to NIO, these FOTA updates introduced 136 new features and 289 optimizations, bringing up to 425 improvements to NIO's fleet. The updatable functions cover many system-level functional domains, such as powertrain system, chassis & suspension, driver assistant, body control and infotainment. The company said NIO's FOTA can support the updates of up to 35 electronic control units of a vehicle.

GPSLive Security, Source: Rewire Security

Rewire Security launches telematics platform and app for fleets

Rewire Security announced the release of their GPS & Telematics software, GPSLive. The new software allows business owners and fleet managers to view the location of vehicles in real-time, as well as providing detailed information on fleet driver behavior, driver route history, vehicle service reminders.

"GPSLive provides a set of powerful tools for collecting information from vehicles and delivering useful information for fleet managers at an affordable cost.", says Ilir Bakiji, chief operations officer at Rewire Security.

The company provides its customers with hardware and software solutions, which is ready to go right out of the box. Once the hardware is integrated into a vehicle, all the information can be viewed through an interface. The software provides fleet managers with information on; vehicle position, speed, date and time, ignition state, engine diagnostics, and more.

ContiConnect ™ Live- Digital tire monitoring in the cloud


Image Source: Continental

Continental has launched ContiConnect ™ Live, digital solution for tire monitoring to complement ContiPressureCheck and ContiConnect Yard. With ContiConnect ™ Live, the collected data on tire pressure and temperature are sent in real-time to a cloud using a central telematics unit. In addition, the unit transmits the vehicle's location using GPS and records the operating hours of the tires. By evaluating the information, the fleet benefits from reduced downtimes, lower maintenance costs, and an extended operating time. ContiConnect ™ Live is available for all special tires from Continental equipped with sensor technology. The application will first be rolled out in Spain, Switzerland, Austria, Denmark, UK, Sweden, Norway, France and Portugal.

ContiConnect ™ Live: Flexible and location-independent fleet management- Fleets with high tire costs and a high need for machine availability require constant monitoring of the tire condition. In contrast to ContiConnect ™ Yard, the live version does not require any location-specific yard station on the application site with access to the cellular network. Instead the data is transferred directly to a cloud and can be accessed there.

Cloud solution increases speed and reliability- The fully integrated control solution for the tire condition consists of various components: The intelligent tire from Continental measures inflation pressure and temperature with the factory-fitted sensor inside the tire. The sensor data are sent in real time to the integrated central telematics unit.

From there, the data is transferred to the cloud, where it can be accessed via the web portal. In the web portal, a detailed view of the vehicle including alarm, pressure and temperature history as well as GPS data and operating hours is made available. If the data is not ideal, fleet managers are proactively informed via SMS or email, which minimizes flat tires and increases the safety of drivers and vehicles. This enables fleet managers to monitor tires flexibly, regardless of where the vehicles are located.

TDK announces worldwide availability of IMU platform for automotive

TDK Corporation announces availability of the InvenSense IAM-20680HP, a 6-axis MotionTracking sensor platform for non-safety relevant automotive applications, which includes the IAM-20680HP IMU MEMS sensor and the DK-20680HP developer kit. InvenSense's IAM-20680HP combines a 3-axis gyroscope and a 3-axis accelerometer in a thin 3 x 3 x 0.75mm (16-pin LGA) package and is automotive qualified based on AEC-Q100 Grade 2. The IAM-20680HP shares pin-to-pin and register compatibility with the full automotive non-safety product family from InvenSense: IAM-20680 (6-axis IMU), IAM-20380 (3-axis gyroscope) and IAM-20381 (3-axis accelerometer). It also features an extended FIFO up to 4096-bytes that can lower the traffic on the serial bus interface and reduce

Image Source: TDK Corporation

power consumption by allowing the system processor to burst read sensor data and then go into low-power mode. In addition, the IAM-20680HP provides industry-leading sensitivity tolerance and temperature stability in combination with proven high robustness by supporting 10,000g shock reliability. The IAM-20680HP platform is designed to enhance positioning systems accuracy, to enable advanced telematic features and to stabilize vision system by delivering precise and reliable inertial data up to 105°C. It also provides best-in-class low noise performance, on-chip 16-bit ADCs, a 3-axis gyroscope with user-programmable full-scale range of ±250 dps to ±2000 dps, and a 3-axis accelerometer with user-programmable full-scale range of ±2g to ±16g. Other industry-leading features include programmable digital filters, an embedded temperature sensor, programmable interrupts, and factory-calibration of both sensors, ultimately reducing production-line calibration requirements. The device features I2C and SPI serial interfaces and voltage operating range of 1.71V to 3.6V.

Aurora acquires Uber's self-driving vehicle unit

Uber's self-driving unit has been acquired by Aurora Innovation, another tech company developing and testing autonomous technology in the city.

Aurora did not disclose the financial terms of the deal, which is set to close in the first quarter of 2021, but a spokesperson for the company said the acquisition and Uber's new investment in the combined operation brings Aurora's value to $10 billion. The acquisition, officially announced Monday, is meant to accelerate development of Aurora's driverless application focused on heavy-duty trucks and later on light-vehicle products such as self-driving cars.

Though Uber's Advanced Technologies Group will now fall under Aurora's umbrella, Uber will still be a part of the autonomous vehicle field, it is investing $400 million in Aurora and Uber's ATG CEO Dara Khosrowshahi will serve on Aurora's board. With this acquisition, Aurora plans to continue testing on Pittsburgh roads. It will bring on the majority of Uber's ATG staff, according to a spokesperson for the company.

NXP's suite of Radar Sensor solutions

NXP Semiconductors has announced a suite of new radar sensor chipset solutions that can surround vehicles in a 360-degree safety cocoon and enable the identification and classification capabilities of imaging radar. The solutions, comprised of new NXP radar processors and 77GHz transceivers, offer carmakers flexible and scalable configurations that address NCAP requirements for corner and front radar applications while offering 4D imaging radar's first commercially viable path to volume production. 4D imaging radar expands radar's capabilities from measuring range and speed to include direction, angle of arrival, and elevation measurement. Together, these solutions are part of the effort to reduce the 1.3 million yearly road deaths and represent radar's evolution as a central part of driver assistance systems.

NXP is enabling the ongoing evolution of radar with 2 new solutions.

Imaging Radar Solution- Imaging radar is a technology that significantly enhances radar's performance. It delivers multi-modal capabilities and extends L2+ features, like highway pilot and lane change assistance, by offering super-resolution images for precise environmental mapping and scene understanding. This enhanced "understanding" is an important part of enabling full autonomy in urban settings where vehicles and vulnerable road users create driving complexity.

The combination of NXP's new purpose-built S32R45 radar processor and the TEF82xx transceivers delivers the fine angular resolution, processing power and range required to not only distinguish between small objects in the distance, but also to accurately separate and classify vehicles and vulnerable road users like cyclists or pedestrians in crowded environments. This imaging capability aims to deliver better driving decisions.

Scalable Corner and Front Radar Solution- Targeting cost-effective and small footprint NCAP corner radar requirements for high volume vehicle production, the NXP solution also provides scalability for long-range front radar and advanced multi-mode use cases like simultaneous blind-spot detection, lane change assistance and elevation sensing. These advanced applications require extended range and significantly enhanced angular resolution for detecting and clearly separating multiple objects simultaneously and provide the ability to surround the car in a 360-degree safety cocoon. NXP's new S32R294 radar processors combined with the NXP TEF82xx transceivers provide a scalable solution that helps carmakers address both NCAP and advanced corner radar as well as long-range front radar sensor requirements in an effective way, while allowing tailoring for individual use cases.

OPTIMIZE THE PERFORMANCE OF YOUR FLEET WITH TIRE MANAGEMENT SYSTEMS

TUSHAR BHAGAT
UFFIZIO INDIA

Fleets run on fuel and tires, these being the most expensive assets that need special care and attention. Their ineffective handling could quickly hamper productivity and profitability. Tires are the second-largest operating cost drivers for most fleets. As fleet owners constantly seek possibilities for reducing operating costs, they cannot overlook the maintenance of their tires.

Managing tires made easier

Unchecked tire costs negatively impact the cost-effectiveness of freight businesses. At the same time, keeping track of tire inventory and conditions is very difficult for carrier or passenger vehicle owners, irrespective of their fleet size and vehicle type. It requires recording axle wise tire allocation, calculating miles traveled by each tire, and identifying maintenance requirements. The biggest challenge is to calculate the actual expenses incurred on tire sustenance, that is, the tire cost per mile.

Tire Management Systems (TMS) help in optimizing fleet performance beyond just knowing the tire pressure and temperature. The software records details and alerts including maintenance of a tire inventory, knowing the tire pressure and temperature and preventing mishaps that happen due to incorrect pressure or temperature abnormalities.

The primary reason why organizations implement fleet management software is that manual management of the tire inventory becomes difficult beyond a level. In absence of inventory management, they have no record about which tire is allocated to which vehicle. Additionally, crucial information such as the kilometers traveled by the vehicle after the tire's allocation become tough to record. In absence of a proper system, knowing which tires have been replaced, re-treaded, or unstable are difficult to monitor. The result is the inability to identify the money spent on tire-related expenses.

In an interview with Guy Walenga, the tire engineering manager with Bridgestone-Firestone's North American Commercial Products division states "A tire only works as well as it is maintained. It's only as good as the application it's designed for. Eventually, every tire gives up its life. But it just doesn't fail. Bad things happen and when they do, a tire becomes an expensive tattletale as to how good your maintenance program is." This explains how useful these tire management systems are to improve performance and lengthen a tire's lifespan.

Benefits of Tire Management and TPMS

The modules designed in a tire management system allows maintaining an inventory of tires. The lifecycle of the tire can be mapped out. This starts from the time a tire is added to stock, its allocation to the vehicle and monitoring the kilometers traveled after being assigned to a vehicle. Tire pressure and temperature monitoring are a part of the TPMS. Reports and alerts are generated when the pressure or temperature shows irregularities. Live pressure and temperature details can be accessed at all times.

Fleet owners can inspect the tires through the portal and identify the tires that need repair, re-treading and the unstable as well as the good ones. Expenses can be tracked at all times and the cost can be optimized. The additional benefits of tire management software include:

1. Improves efficiency: Tire Management Systems maintain the ideal pressure, shape, and temperature of tires which prevents premature tire wear. It also ensures economical utilization of fuel and considerably reduces delivery timelines to enhance efficiency.
2. Helps you stay informed: Tire Pressure Monitoring Systems (TPMS) eliminate speculations as it warns about existing or impending problems in a specific tire. Depending upon the size and miles traveled by the vehicle, you can mount it with a Direct, Indirect or Active TPMS to avoid accidents by detecting low pressure and high-temperature conditions.
3. Reduces Total Cost of Ownership (TCO): A well-implemented TPMS prevents unplanned downtime by warning you. This system avoids equipment damage and cuts down replacement costs in repairable cases.
4. Maintains inventory: The software system generates axle-wise reports of your fleet with details of the date of installation, and miles traveled so you can plan inventory procurement. You can also get an insight into the tire conditions and consider them for retreading to save costs.
5. Enhances safety: Under or over-inflated tires could be hazardous. Sensor-based TMS ensures vehicle and driver safety with features such as automatic inflation and pressure maintenance.

Way Forward:

Tires manufacturers are adapting their products to match the digital framework of passenger and carrier vehicles. With the advent of digital tires or ones that are smart, electrical, and intelligent, the demand for automotive TPMS is steadily increasing. It is estimated to reach US$18.5 Billion by 2025, as stated in the Tire Pressure Monitoring Systems (TPMS) - Global Market Trajectory & Analytics. The development of universal TPMS sensors and integrated direct TPMS is reported as emerging industry trends for 2021. New-generation TPMS will enable the vehicles of the future equipped with smart tires, cloud technology, and autonomous driving capabilities. ❑

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TVS Motor acquires Intellicar Telematics

TVS Motor Company Ltd. on last month, Dec'2020, acquired Intellicar Telematics Private Limited for INR 150 million cash. The acquisition will allow TVS Motors to accelerate its ongoing digital initiatives and enhance the customer experience. TVS Motors, in the BSE filings, has noted that the acquisition will not require any approvals and will be completed by December 31, 2020. Intellicar was founded in 2015 and has a reported revenue of ₹161 million in FY2020, up from ₹96.6 million in FY2018. It had a turnover of INR 145.4 million in FY2019. The company was also a part of the Nasscom Emerge 50 Awards, back in 2017. It was also a part of the Karnataka government's Elevate 100 Programme, which invested in 100 most innovative startups, in 2017.

Teltonika FMB208 tracker for India

Image Source: Teltonika

Teltonika launched Teltonika GPS tracker, a SPECIAL category model FMB208 has been successfully certified by Automotive Research Association of India (ARAI) with Automotive Industry Standard AIS-140. Teltonika FMB208 is registered on the National VLTD Backend (BSNL) and Vahan, C-DAC has now empanelled our FMB208 for the state of Kerala, other states will follow.

This tracker is specifically designed for the India market. It helps to succeed and maximise your client fleet efficiency – IRNSS/GPS/Bluetooth connectivity, GAGAN support, 3rd server functionality helps the private server to receive data on your favourite Teltonika protocol, internal battery, accelerometer and gyroscope, RS-232 interface, embedded SIM (e-SIM), digital Input/Output, tamper and waterproof IP67 rating robust casing, to say at least.

It is designed and manufactured using the well-tested electronic components and the most cost-efficient automated robotic assembly lines to ensure unquestionable tracker quality, Teltonika stability, and the best possible price.

Certified for the country and states, FMB208 tracker has undergone evaluation and testing according to specific regulations to verify that it performs as stated by Teltonika.

Relevant tracker accessories and Bluetooth 4.0 LE connectivity additions, such as temperature, humidity, magnetic sensors, ID beacons, as well as fuel consumption counters combined with time-saving Teltonika FOTA WEB solution ensures its versatility, great business potential, and income streams.

Ola announces plans to set up world's largest EV scooter factory in Tamil Nadu

Ola signed the MoU with the Tamil Nadu government for an investment of INR 24 billion in setting up its first factory in the state. Upon completion, the factory will create almost 10,000 jobs and will be the world's largest scooter manufacturing facility, which will initially have an annual capacity of 2 million units. In line with Prime Minister Narendra Modi's vision, Ola's factory is an important step in making an AtmaNirbhar Bharat. The factory will also galvanize India's electric vehicle (EV) ecosystem and establish India as a key player in the EV manufacturing space. Ola's factory will cater to customers not only in India but in markets around the world including Europe, Asia, Latin America, and more. The company is gearing up to launch the first of its range of highly anticipated electric scooters in the coming months.

HOW IS

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