V2X – Driving towards connected cars

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ABSTRACT

Vehicle to everything (V2X) is a new generation of information and communication technologies that connect vehicles to everything and it is expected that by 2021 more than 70% of vehicle manufactured will be connected. Connected cars require vehicle systems like advanced driver assistance systems, body & chassis systems, infotainment systems, powertrain systems to be integrated into telematics systems to ensure the functioning of various V2X features and applications. V2X not only creates a more comfortable and safer transportation environment, but also has much significance for improving traffic efficiency, and reducing pollution and accident rates by up to 80%. Developing and testing V2X applications and emulating real-world conditions with multiple cars with their movements, roadside infra, and multi-way communication in a connected test environment are some of the challenges faced by the industry. This whitepaper mentions different types of V to (X), associated V2X applications, the two types of communication technologies, and the challenges faced during V2X testing with some industry available solutions. A robust connected test environment setup capable of recreating complex real-world scenarios like dead-reckoning would help in the development of mature V2X solutions paving the way for Intelligent Transportation Systems.

V2X – CONNECTING CARS TO THE WORLD

As the world progresses towards autonomous driving, V2X is becoming an integral part of modern cars. V2X technology paves the way for an efficient and safer driving environment as the cars communicate with each other, infrastructure, and vulnerable road users among others.

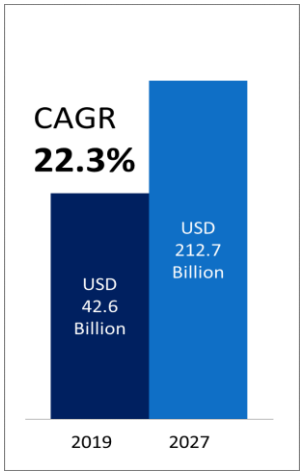

Figure 1: Global Connected Car Market,Source: MarketsandMarkets

Going forward V2X will be considered as the only sensor that could detect the objects in Non-Line of Sight because of which the driver would be warned of road accidents, traffic congestions, diversions, and other potential road hazards even before he starts his journey and thus helping in reducing the overall environmental impact of transportation.

In a connected car ecosystem, the cars communicate with the world through high bandwidth, low latency, highly reliable links enabling the communication from vehicle to everything and eventually autonomous driving.

Some of the undisputed advantages of V2X are:

Accurate vehicle information: Provides precise information on vehicle direction, speed, acceleration, braking, time, range and charging stations for EV, vehicle condition and more.
Sensing obstructions: V2X connectivity can detect the objects which are not in the field of view thus aiding in safety and better decisions by the driver.

Figure 2: V2X Key Applications

Works in all environmental conditions: Since V2X works with connectivity technologies it works under sun-glare, dense fog, intense rain or night conditions where other sensors fail.

It is expected that there will be more than 380 million connected cars on the road by 2021 paving the way for a connected ecosystem and intelligent transportation systems. Through the advent of the connected car ecosystem, car companies tend to benefit in terms of data acquisition, targeted marketing, and a range of new personalized in-car apps, products and services to offer customers. Some of the direct benefits to drivers, passengers, other road users and the environment as a whole are as below:

1. **Increased traffic safety**

According to the WHO report on road safety, 2018, more than 1.3 million road traffic deaths occur every year. According to research, V2X could help in road accidents by 80%. It could help reduce the fatalities by detecting and letting the driver know of invisible objects. For example, a V2X application like Emergency Brake Light could detect a sudden deceleration by a leading vehicle in a blind turn and alert the driver of following vehicle well in-advance thus aiding in the avoidance of a crash. The US DOT estimates that V2X would save >1,000 lives/year and reduce 2.3 million non-fatal injuries.

Figure 3: Road Traffic Injuries Fact, Source: WHO road safety report, 2018

2. **Time savings**

V2X technology helps to establish efficient traffic management and time savings for vehicle users. As cars communicate with surroundings, information on road signs, traffic signs, traffic congestions, traffic diversions help in deciding the best route from A to B. Some applications like Green Light Optimal Speed Advisory even let the driver know the optimum travel speed to reach a signal when it's green. The technology also provides data to transport management authorities for better traffic, road and infrastructure management. This would help the authorities in developing smarter solutions for transportation.

3. **Money savings**

A more efficient, safer transportation system can help to save money: According to US DOT, V2X would save society $871 billion annually in the U.S. In Europe, congested roads cost nearly 100 billion euros annually. Blocked roads lower productivity, cause delays in supply chains and increase the cost and complexity of doing business. With V2X technology, vehicles can detect congestion-causing factors in advance, and react accordingly. Optimized routes can be identified by combining real-time data with simulation models to make journeys faster and more efficient.

4. **Environmental factors**

V2X helps lessen the environmental impact of transportation. Through V2X technology huge traffic congestions and long queues at traffic lights will be a thing of the past and roads with smooth continuous traffic can be maintained. Cars traveling in free-flow conditions at optimum speeds produce fewer emissions than cars in congestions decreasing the overall carbon footprint.

5. **Convenience**

As vehicle users get increasingly dependent on the applications of V2X technology, the driving experience is bound to improve multifold as the driver would be aware of unseen hazards, congestions, traffic diversions, optimum routes and speeds to reach his destination safely and efficiently.

PRACTICAL BENEFITS

- Elimination of road accidents by up to 80%
- Reduction in traffic congestion by 20%
- Decrease in fuel consumption & emissions by 10-20%
- Enhanced sensing for cooperative autonomous driving

"While there are a good many obvious benefits to a connected car, from safer cars to more economical use of road infrastructure, one of the less appreciated is the sheer amount of vital data that connected cars can capture and share. This is already leading to a revolution in how we insure cars, how we improve their designs, and how city builders and traffic managers can use both real-time and historical data to create far better and more effective driving experiences in the future." - **Dion Hinchcliffe** — VP and Principal Analyst, The New C-Suite

CHALLENGES FACED

V2X works between cars, infra, cloud/internet, navigation systems and even people's devices in RF dense city environments. The communication in a connected car ecosystem, where a car communicates with its surroundings, is achieved through two technologies: Network-based communication and Direct Short Range communication.

Network-based communication: Vehicle to network communications allow the vehicles to communicate with other vehicles (V2V), pedestrians (V2P), devices and infrastructure (V2I). Since it has a larger communication range it enables V2H (vehicle-to-home) and V2C (vehicle-to-cloud) for enabling smart applications and services through spectrum provided by mobile network operators.

Figure 4: Vehicle To Everything (V2X)

Direct Short Range Communication: DSRC is employed for communication of vehicles with other vehicles, pedestrians, infrastructure which are in a short-range without relying significantly on cellular networks. DSRC is recommended for safety-critical V2X applications that should be able to work in the absence of cellular coverage.

Regardless of the type of communication, ubiquitous connectivity is the key to facilitate connected cars and intelligent transportation systems. Current generation wireless technology has considerable latency and reliability issues considering enormous amounts of data that require aggregation and processing to enable more advanced use cases and increased use of cloud capabilities to combine in-vehicle data with environmental data. Fifth-generation wireless technology, or 5G, will be a key enabler of more reliable communication for vehicles, which will play a critical role in managing the safety challenges that come with connected cars and autonomy. There are multiple, often complementary technologies that can be used for both direct and network-based communications— including 4G/LTE, satellites, DSRC, and 802.11p.1 5G will significantly reduce latency and increase reliability compared with current technologies.

V2X Applications: Development of V2X applications that enable safe driving, driving assistance, traffic congestion, fuel economy, emergency help, in-car services, etc and connected test set-up for quick rounds of regular testing is a challenge the industry is facing. The copious sensors that enable a connected car generate an abundant amount of data and it creates a huge opportunity for the development of applications and services. These new application platforms should be capable of real-time analytics and strong integration with the hardware generating the data. And as the ecosystem widens these applications should also interact with OEMs, and third parties, such as insurance companies or service providers to bring in a host of services to end consumers.

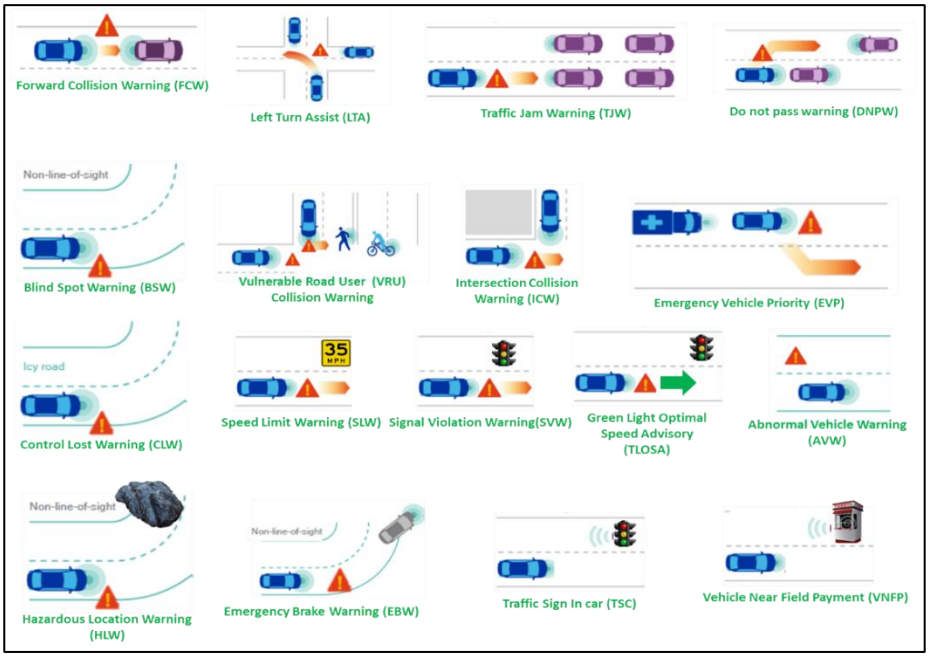

Figure 5: V2X Applications; Image Source Qualcomm

Challenges in V2X testing

As V2X becomes more common and the vehicle users' start relying on it for their daily commute, the reliability of the technology, associated equipment, various on-board applications, and services becomes more significant. In the real-world, cellular signals degrade, interfere, become noisy, or drop off. It is very challenging to emulate real-world conditions with multiple cars reproducing millions of road scenarios or setting up of roadside infrastructure requiring dozens of units for a realistic simulation. Even the test tracks where these tests can be carried out attracts a huge cost which is a roadblock for many V2X ecosystem partners apart from OEMs and large Tier-1s.

Some of the common challenges faced in V2X field testing are:

High cost: Huge costs in setting up test tracks, real vehicles, and the infrastructure required for testing
Simulation of High Traffic: Setting up high-density traffic with millions of scenarios is practically challenging & cost-intensive.
Safety Concerns: Certain traffic scenarios are fatal to test with humans. For example testing of applications like Hazardous Location Warning (HLN), Control Loss Warning (CLW), Abnormal Vehicle Warning (AVW)
Spectrum Availability: Non-availability of the specific spectrum a deterrent to testing on real roads
Scenario Repeatability: Replicating Test Scenarios in the Real World is challenging.

ROAD TO V2X

The traditional automotive ecosystem was dominated by OEMs and Tier-1s with Tier-2s and other suppliers and service providers addressing their technology and engineering requirements. But with the emergence of V2X and connected cars, a broader ecosystem is shaping up with tech giants, mobile operators, infrastructure providers for smart-cities, mobility-service providers and service providers like Insurance giants coalescing with OEMs, Tier-1s and service providers to address the rising demands of smart connected-cars.

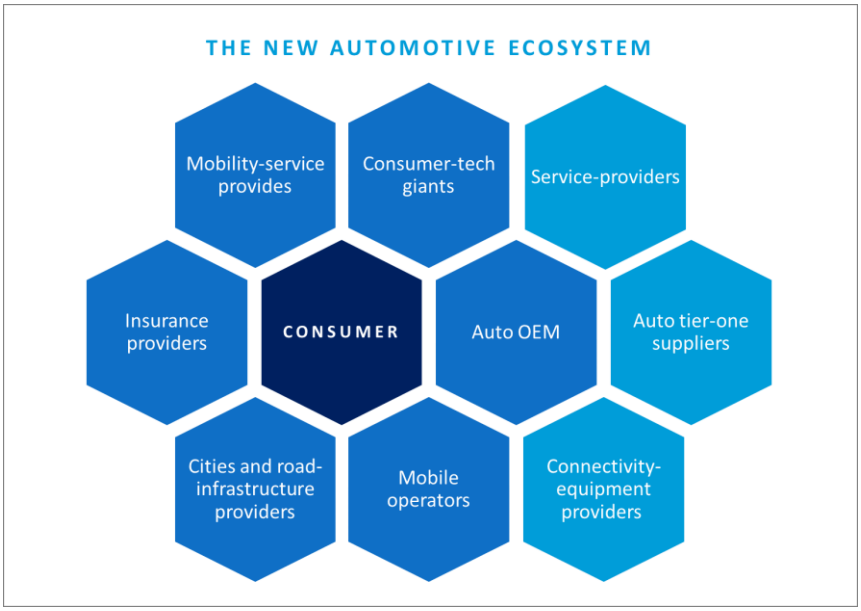

Figure 6: New Automotive Ecosystem

Considering the huge investments required in the development of infrastructure, equipment, technology, software/ applications/ services, and vehicles for realizing an environment for connected-cars this coalition is need of the hour. Network operators invest in developing next-generation cellular technologies like 5G with the infrastructure needed for ensuring reliable connectivity while telecom-equipment manufacturers provide tailored systems and solutions spanning the entire technology stack, including network access, connectivity devices, data management, and applications. The foray of tech-giants into automotive has caused a disruption with their roles as platform providers for connected-autonomous-cars of the future. There are also traditional technology and engineering service providers and tech start-ups who provide specialized niche solutions that address the requirements of V2X development and testing of other ecosystem partners.

Tier-1s, tech start-ups and service-providers supply V2X software stack that are both radio technology and radio vendor-agnostic supporting both DSRC and C-V2X and have integration with major chipset providers like Qualcomm, NXP etc. Their hardware-agnostic V2X stacks are used for connected-cars trials, truck platooning concepts and collision avoidance systems among others. Some of the V2X applications provided by them include V2V Apps like Forward Collision Warning (FCW), Left Turn Assist (LTA), Traffic Jam Warning (TJW), Electronic Emergency Brake Light (EEBL), Do Not Pass Warning (DNPW), Blind Spot Warning (BSW), Lane Change Warning (LCW), Intersection Movement Assist (IMA), Emergency Vehicle Priority (EVP), Control Lost Warning (CLW) and V2I apps like Speed Limit Warning (SLW), Green Light

Optimal Speed Advisory (GLOSA), Signal Violation Warning (SLW), Hazardous Location Warning (HLW), Curve Speed Warning (CSW), Work Zone Warning (WZW), Vehicle Near Field Payment (VNFP) and V2P apps like Vulnerable Road User Warning (VRU).

Testing the functioning and reliability of applications through DSRC and cellular networks in real-world conditions have many limitations like reproduction of limited real-world conditions, test repeatability, safety, time, cost and quality. Testing of V2X applications and ECUs through lab based simulators and emulators address the challenges to a large extent while usage of augmented reality in field testing brings in a new scope to mitigate the hurdles. Service-providers are also providing automated test solutions running WAVE/ ITS-G5 conformance test tests to ensure V2X system implementation are compliant to different test specifications like USDOT, ETSI, IEEE. The lab based test beds simulate or emulate real-world traffic scenarios significantly reducing the cost, complexity and time associated with extensive field testing. Augmented reality has also been leveraged by nice service providers with the help of which any normal road can be used as a field testing track eliminating the cost of investments in track, vehicles, and infrastructure but providing the assurance of field testing.

CONCLUSION

Though still in development and on the way to the mass market, V2X is a technology that helps in providing a more comfortable and safer traffic environment by improving traffic efficiency, reducing pollution and accident rates. But various V2X applications that help in driver assistance and safer commute demands a robust framework for development and testing to address challenges like cost, time, complexity in-field testing. Tata Elxsi helps in V2X application feature development with radio agnostic V2X application framework, stack & feature porting to custom hardware, Cloud Big Data Framework – Data Collection and Analysis, Vehicle Integration, HMI Development, and Cyber Security Analysis. Tata Elxsi also helps in addressing the challenge of validation of V2X features in complex road use cases through Tata Elxsi's patented V2X Emulator which creates a virtual simulation of the real-world inside lab. With the help of augmented reality, field testing can be carried out real roads by creating a virtual V2X environment and *Tata Elxsi's AR-V2X has been awarded AutoSens 2019 silver award for best validation tool in this regard*.

ABOUT TATA ELXSI

Tata Elxsi is a design and technology services company that blends technology, creativity, and engineering to help customers transform ideas into world-class products and solutions. A part of the $100 billion Tata group, Tata Elxsi addresses the Automotive, Communications, Consumer Electronics, Healthcare, Media and Semiconductor sectors. Tata Elxsi has been at the forefront of automotive design and engineering for over 20 years and is certified for ISO 9001 and 27001 standards with compliance to Automotive SPICE® Organization Maturity Level 5 requirements, premium member of the AUTOSAR consortium and other industry partnerships help us gain a competitive advantage in the global market place.

Tata Elxsi works with leading OEMs and suppliers in the automotive and transportation industries for R&D, design and product engineering services from architecture to launch and beyond. Tata Elxsi stays invested in developing solutions that would help clients achieve a faster time to market. Supported global brands in the automotive space (OEMs and Tier-1 suppliers) for testing and validation of their programs too. Tata Elxsi has designed and developed 40+ HILS for testing single and multiple ECU's (Infotainment, BCM, Chassis, and Powertrain ECUs).

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