

# X of V2X - Applications and Market Trends

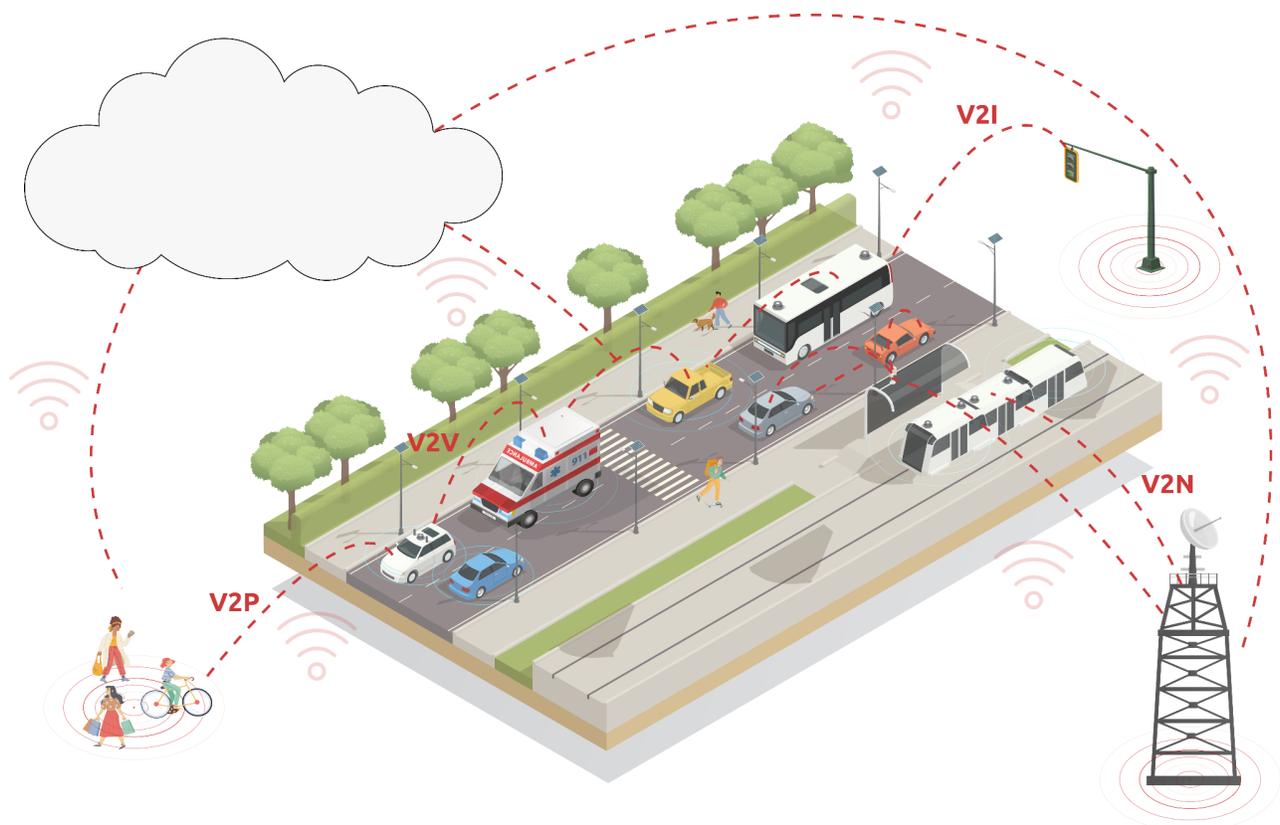
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# Introduction

This document describes Vehicle-to-Everything (V2X) applications and market trends to deploy more connected, autonomous, and safer vehicles. It also describes SolidRun's solutions that were purposely designed for addressing the increasing demand for secure, flexible, and performance-based V2X applications. Some V2X applications include road safety, traffic management, and efficiency. The main objective of road safety applications is to reduce traffic collisions and improve awareness on the roads. The primary objective of traffic management and efficiency applications is to improve traffic fluidity.

Furthermore, this paper covers the market trends that support the timing of implementing a V2X system into the roads and on vehicles. The two main market trends promoting the implementation of a V2X infrastructure are all classes of vehicles becoming more software-defined and the need for complementing safety systems with the gradual integration of autonomous vehicles. SolidRun is able to provide an IoT SOM solution to assist manufacturers with keeping up with the fast-developing market.



# 1. What is V2X

Vehicle-to-Everything (V2X) is the technology enabling the communication of a vehicle with any nearby entity. The overriding concept is to ensure safer and more efficient road management. In order to connect the vehicle to the other entities and exchange data, V2X utilizes Dedicated Short-range Communication (DSRC) and Wireless Local Area Network (WLAN) technology. Dedicated short-range communications are wireless communication channels designed especially for automotive use and a reciprocal collection of protocols and principles. In addition to DSRC, cellular V2X technology (C-V2X) allows the vehicles and infrastructures to communicate with each other through cellular modem technology rather than directly between one another. C-V2X technology, alongside DSRC, are especially popular solutions in the growing connected vehicle market.

V2X reduces accidents and enhances road safety in numerous ways. Primarily, it functions as a wireless sensor system that permits inter-vehicle communication so that vehicles can observe their surroundings, make predictions, and adjust for positive outcomes. V2X, unlike standard sensors (radar, LIDAR, lasers, ultrasonic detectors, etc.), derives its information from out-of-sight messages and detects hidden threats. These tools expand the scope of driver perception and in doing so, allow for more comfortable, safe, and efficient transportation.

## 1.1 Types of V2X and their functionality

Types of V2X include V2V (vehicle-to-vehicle), V2I (vehicle-to-infrastructure), V2N (vehicle-to-network), V2P (vehicle-to-pedestrian) and V2D (vehicle-to-device).

V2V encompasses the transfer of data between vehicles. Information is exchanged via IoT solution technology that can arrive from vehicles a few hundred meters ahead and even from signals sent from behind large structures, trucks, or buses.

V2I, similarly to V2V, is a communication model that allows vehicles to share information, however, V2I supports the exchange between the vehicles and traffic

management infrastructure placed along the road. Such infrastructures include overhead RFID (radio frequency identification) readers and cameras, traffic lights, lane markers, streetlights, signs, and parking meters.

V2N connects a vehicle to data centers, road infrastructure, and other cars. This effectively turns other drivers into road scouts, so if a navigation system is having trouble with accuracy or changing roads, a V2N-connected car can communicate with other vehicles to update and improve driving directions based on other drivers' locations.

In V2P vehicles will be able to use both onboard safety monitoring tools and some degree of communication with a pedestrian's mobile device to avoid accidents. This could include people walking, riding bicycles, or even people entering and exiting mass transit vehicles. If a vehicle is having trouble stopping at an intersection, its onboard systems would deliver a notification to nearby pedestrians to wait before crossing the street.

## 1.2 Implementation Of V2X

Governments around the world consider V2X a crucial development in the reduction of road fatalities and a technological milestone in the path toward fully autonomous vehicles. As such, the automotive industry, in an effort to streamline the interoperability of V2X between vehicle brands and the road infrastructure to get standardized messages, persistently works with regulatory bodies.

Constructing the communication V2X system consists of Onboard Units (OBU) and Roadside Units (RSU). Onboard Units are stationed on the moving objects on the road, they communicate with each other and the roadside unit to ensure a safe flow of traffic. An OBU allows wireless communication with other Onboard and Roadside units. Roadside Units (RSU) are attached to street signs, traffic, and road lights as well as mounted in construction sight zones. The Roadside unit connects road users to the street infrastructure to help manage overcrowding in certain parts of the road and prevent casualties. V2X Onboard and Roadside Units are an essential part of promoting safety for vehicles of all levels of automation.

## 1.3 Potential Usage Of V2X Products

The automotive industry can vastly benefit from the V2X infrastructure and so can other manufacturers of transportation vehicles. With the option to create a portable V2X instrument, it is assumed that this technology will be integrated into smartphones or consumer electronics, such as bicycles (electric/regular), motorbikes, wheelchairs and other devices. Roadside workers may also have the opportunity to keep it with them in the construction zone, protecting them from any oncoming traffic.

V2V communication grants vehicles the ability to detect traffic and foreign obstacles before they enter a driver's visual field. Consequently, not only do drivers experience a safer road, but so do passengers, bikers, and pedestrians. In addition to its ability to create a safer road, V2X technology potentially creates safer experiences on tolled roads and in parking structures. V2I is more effective in detecting a vehicle that enters a parking structure or a tolled road than license plate scanners because the vehicle does not need to be in a direct line of sight.

The main industry that is promoting the implementation of a V2X system, is the automotive industry which is creating vastly more digitized products. However, a V2X system brings a plethora of new potential connected products to the market to make our roads safer and more efficient.

# 2. Software Defined Vehicles Encouraging V2X Infrastructure

## 2.1 Digitizing Vehicles and Implementation of new technology

More and more smart applications are being implemented into the new generation of vehicles, and what was once a marvel of machinery has become an evolution of the computer. For example, map updates, live traffic information, third-party navigation apps, and remote control functions all require backend connectivity. The growth of new technological features in automobiles serves as the perfect window to introduce and implement a V2X system to assist with driver

awareness and safety. With the growing rate of employing new technological features on cars, comes the perfect window to introduce and implement a V2X system to assist with driving safety and awareness.

## 2.2 Software updates and Connected cars

Many vehicles are being manufactured with the ability to update their systems from afar. Software systems will make it easier to change and improve cars continually, throughout their life cycles. As a result, automobile manufacturers can improve cars long after they leave the factory. The digital services built for connected vehicles should create business value as well as customer value. The closer we get to software defining vehicles through testing, the more data can be collected based on feedback to provide well-targeted software updates on the vehicle.

Roughly 91% of cars released in the United States are “connected cars,” meaning they have built-in 3G, 4G, or 5G cellular modems placed in them as part of the manufacturing process. The car, due to this internet capability, can utilize apps and services, just like a smartphone. These cars can also communicate with external infrastructure--other vehicles, electrical grids, roads, and buildings. In 2019, 92 million cars were manufactured, 35 million of them were connected cars. In the past year, however, 72 million connected cars were shipped out of 80 million that were manufactured. With Asia, North America and Western Europe in the lead, it is clear to see the increase in connected cars being shipped around the world. With the rapid increase of connected vehicles on the road comes greater opportunities for a safe and reliable V2X system.

# 3. V2X Alongside Autonomous Vehicles

## 3.1 Road congestion and a need for safety systems

One of the bigger reasons that cars are becoming so heavily digitized is to create a structure that would allow the implementation of fully autonomous vehicles. As more automated vehicles and tech-leading features are presented on the roads there is a need to implement complimenting safety systems to support

the continuous traffic. The introduction of new vehicles into the market creates increased congestion on roads. Technology, and more specifically V2X systems is a great way to solve this congestion issue.

By sharing data, such as the vehicle's position and speed, with surrounding vehicles and infrastructures, V2X communication systems enhance driver awareness of upcoming potential dangers and dramatically improves collision avoidance, resulting in heavily reduced fatalities and injury severity. In addition, V2X technology will enhance traffic efficiency by providing warnings for upcoming traffic congestions, proposing alternative routes and ensuring eco-friendly driving, reducing CO2 emissions through adaptive cruise control and smarter transportation management. With overcrowded roads, communication between the machines is a key element to ensure people's safety as they travel to their next location.

### 3.2 V2X Technology to complement the growing penetration of highly automated driving vehicles.

The last five years yielded tremendous innovation in the field of automated and assisted driving. In addition to increased automated driving capabilities, improvements in V2V technology systems account for increased communication between vehicles and improved situational awareness. With the growing penetration of highly automated driving vehicles, the need for cooperation between the vehicles will increase, which instantly will lead to a broader exchange of information between the vehicles, other traffic participants, and the related traffic infrastructure.

V2X can improve safety and traffic efficiency at all levels of vehicle automation. At levels 0 to 2 (View Chart Below), V2X can significantly better all types of information delivered to drivers allowing them to avoid accidents and reduce traffic congestion. At levels 3 to 5, V2X can give information to sensors that they cannot detect and continuously stay one step ahead of any potential danger and negate all traffic congestion. V2X safety is meaningful at every step of the way, now and in the future. Its mobility will bring more to higher levels of automation. As far as of now, V2X and autonomy are evolving in parallel with their own roadmap.



Although the technologies behind V2X and autonomous driving differ, the combination of them assists with key features such as maneuvering and sensing. The combination of V2X and autonomous driving technology can help improve efficiency, safety, and driving comfort. The V2X market is forecasted to increase exponentially, given the increased demand for autonomous vehicles.

### 3.3 Security, Privacy and Tracking

To prevent privacy-related abuses and encourage voluntary participation in the V2X system, it is important to minimize the risk of tracking the vehicles by monitoring the messages transmitted in the system. To this end, the requirements of untraceability and unlinkability should be respected. Untraceability means that, except for authorized entities, it should be hard to derive the vehicle long-term identifier from temporary identifiers, and that unlinkability means that, except for

authorized entities, it should be hard to track the movement of the same vehicle on the basis of temporary identifiers used in the system.

To alleviate possible consumer or regulatory concerns, there is a clearly established requirement that third parties (outside the V2X system) should not be able to use V2X messages to track a user over an extended period. Some local or regional regulations may contain explicit requirements on the prevention of vehicle tracking.

## 4.SolidRun V2X solution

### 4.1 Why Choose a SolidRun System-on-Module (SOM)?

Manufacturing the next generation of connected vehicles may bring many challenges, not only do the companies have to focus on building a road-legal vehicle but they also have to add new and interesting technologies in order to stay competitive. Therefore, SolidRun offers these companies an effective solution to allow product developers to shift their focus back on making creative and advanced new products.

A System-on-Module (SOM), is a printed circuit board that is integrated into a processing subsystem and has an embedded microprocessor, memory chips, peripheral interface controllers, power management circuits, and a timing source. In addition, SOMs permit product teams to drastically accelerate software development schedules and reduce costs as the complexities of the computing architecture are handled within the module. By utilizing SOMs in the new products, the focus may be directed to building the most effective infrastructure on the road to maintain safety and traffic congestion.

### 4.2 The “solid” solution we recommend

The objective of a SOM device implemented into a wide range of connected vehicles is to enhance safety and security on the roads, infrastructures and subsystems. The SolidRun i.MX 8XLite SOM, in conjunction with the NXP longevity program, provides a dependable, high-speed V2X networking system. Available in 1-

and 2- core configurations the SOM comprises real-time synchronization and control for a wide range of industrial and smart-city applications. The i.MX 8XLite features an array of high-speed interfaces – including Ethernet, PCIe Gen 3, USB 2.0, CAN-FD and is the prime solution accommodating advanced, vehicle-based communication applications.

The i.MX 8XLite starter kit entails a complete V2X communications system consisting of the i.MX 8XLite SOM, the HummingBoard i.MX 8XLite Carrier Board, and a variety of accessories, equipping product developers with a comprehensive platform for both evaluation and application development purposes.

The HummingBoard encompasses multiple connectivity features such as LTE, WiFi and Bluetooth in a compact form factor of 70x50x30mm. Furthermore, users can find additional feature options such as CAN, automotive ethernet, expansion header and GPIOs which allow customers to create prototypes quickly and structure a basis for deployment of their applications and devices.

The SolidRun NXP i.MX 8XLite supports V2I communications between the vehicle and the road infrastructure containing embedded RSUs supplied with V2I chipsets. The RSUs control key “smart transport” devices to direct traffic and assist emergency vehicles in getting to their patient. The emergency vehicle may utilize the RSU system to safely pass through red lights when required. Furthermore, the V2I system improves safety for vulnerable road users such as cyclists and pedestrians. While approaching an intersection they may be identified by all nearby connected vehicles and a caution notification is sent to both road users.

The i.MX 8XLite SOM is equipped with a high-performance agile security engine, SXF1800, which provides tamper-resistant cryptographic functionality for V2X applications.

To simplify deployment for our customers and assist the developing V2X industry, SolidRun provides the i.MX 8Xlite SOM as a robust and effective communications processing system.

## 5. V2X Use Cases

### 5.1 Case #1: Vulnerable Road Users

A pedestrian or cyclist, a typical vulnerable road user (“VRU”), signals their intention to cross through an intersection. The signal goes to the traffic light they intend to cross as well as to any other nearby vehicles or roadside units which then send a message of the VRU’s position, direction and speed to any oncoming vehicles. The RSU on the traffic light then has the option to either turn the light red for any oncoming traffic and/or send a signal to the vehicle approaching to either slow down or come to a complete stop at the intersection. The vehicle then, depending on its abilities, may either notify the driver to come to a halt or the car itself can slow down for both the vehicle and the VRU to safely cross through the intersection.

To further assist the case, the cyclist receives an alert when a vehicle with V2X technology poses a threat to him or her. An Infrastructure Assisted Environment Perception helps send information from the infrastructure containing environment data from dynamic and static objects on the road. This also enables all road users, including cars, bicycles, scooters, motorcycles, and pedestrians, to communicate through V2X and form a safety network. This data is used to increase the trust level of the car’s own sensor observations and extend its viewing range. These OnBoard and Roadside units continuously communicate important information about their location, speed and routes to assist with decision-making on the road. Communication vastly improves road safety and awareness. Motorcyclists, bicyclists and electric scooters are more susceptible to serious injuries, therefore, deserve special attention on the roads. V2X provides the ability to make the invisible visible and make roads safer for all vulnerable road users.

### 5.2 Case #2: Accidents on the Road

After an accident occurs on the road, all present V2X units may alert officials for help. Using assigned communication methods between the vehicles and the infrastructure around, a V2X system to reduce the disturbance that obstacle has on traffic. The vehicles communicate their position and direction to manage an

organized flow around the obstacle in a safe manner avoiding any hazardous situations. Once the ambulance is nearby, by utilizing the V2X communication technology, traffic is thoroughly directed to make room for it to maneuver allowing easier access to the patient.

After the patient has been picked up, and the hazard zone is cleared, an accident report containing all that was recorded by the vehicles near the accident and the infrastructure around, describing environmental conditions and any available camera views is sent to government and private data centers.

### 5.3 Case #3: Construction Zones

V2X technology may be utilized to manage traffic around blocked-off construction zones. An effective method to assist traffic congestion through an area on the road with construction sites is called a “green wave”. A green wave allows one group of vehicles to pass through a series of traffic lights (usually three or more) which are dynamically coordinated to allow continuous traffic flow over several intersections in one main direction. To assist the connected vehicles with managing traffic any vehicle traveling along with the ‘green wave’ will see a progressive cascade of green lights, and does not have to stop at the intersections. The traffic lights Roadside system, coordinating with the connected vehicles on the road may then proceed to use the same technique to let any other waves approaching pass through. Once the construction zone is cleared and the vehicles can pass freely the traffic lights will return to their original settings. V2X communication and coordination will help prevent any jams caused by roadside construction or other obstacles on the road.

## Conclusion

After examining the market trends of a V2X system and deploying more connected vehicles into our roads it is evident that implementing this technology will make our roads safer and improve traffic flow. SolidRun’s SOM i.MX 8X Lite is able to accelerate development schedules and reduce costs, as well as support vehicle-based communication between the OnBoard and RoadSide Units.

The rise of connected vehicles released on the roads today makes it much easier to implement the technology necessary to craft an effective V2X system. Furthermore, as vehicles are becoming closer to being fully autonomous, allowing them an extra safety measure to make smart calculated decisions is important to harmoniously share the streets. Without IoT SOM circuit boards supporting the movement, it would be a great challenge to proceed. To assist this sharp rise in connected vehicles, SolidRun provides fast, reliable, and secure V2X networking, to enhance safety and security in a wide variety of vehicle-oriented subsystems.

## About SolidRun

SolidRun is a global leading developer of embedded systems and network solutions, focused on a wide range of energy-efficient, powerful and flexible products. Our innovative compact embedded solutions are based on ARM and x86 architecture, and offer a variety of platforms including SOMs (System-on-Module), SBCs (SingleBoard Computer) and industrial mini PCs. We offer a one-stop-shop for developers and OEMs, providing a complete service from hardware customization, to software support and even product branding and enclosure design. Our mission is to simplify application development while overcoming deployment challenges, and so we can proudly offer our customers faster time-to-market and lower costs.