Understanding ADAS Limitations and V2X Communication Technology

December 23, 2021 by Dan Loop, NXP Semiconductors

In today's data-driven world, devices are constantly striving to connect with one another, especially in the automotive industry. How can vehicle-to-everything (V2V) communication change the world of vehicle communication?

As the world strives to create safer and more autonomous vehicles, advanced driver-assistance systems (ADAS) technology is coming to an industry forefront.

With this need in mind, this article discusses the importance of driver-assistance systems, their current limitations and drawbacks, and how intelligent connected vehicles and roadside infrastructure could help prevent accidents.

This article will also provide an example processor that could be useful in driver-assistance systems to see how this device could help engineers accelerate the future of V2X communication and autonomous driving.

Modern Driver-assistance Systems and Their Limitations

Most new vehicles come with driver-assistance systems that alert drivers of or help them avert dangerous situations. Such systems help drivers stay on the road, see objects and other traffic participants in blind spots, and offer the driver convenience features such as automated parking.

While these systems, in general, increase road safety for the driver, they are often mostly isolated from their surroundings because they don’ t communicate with other vehicles, roadways, and other smart-city infrastructure.

Despite this limitation, these systems would greatly benefit from exchanging data with other road users and roadside infrastructure, especially since a large number of global accidents come from human error (Figure 1).

By creating more intelligent and communicative systems could enable:

- Traffic light prediction
- Traffic-dependant cruise control
- Parking spot availability monitoring
- Increased safety by warning other drivers of dangerous conditions
- Platooning for trucks and industrial vehicles

- Pedestrian and personal mobility vehicle detection
- Emergency vehicle approaching alerts

Figure 1. A statistic that shows data on global car accidents. Image used courtesy of [NXP]

Overall, the main limitations of driver-assistance systems are their cost and limited availability beyond higher-end models.

Entry-level vehicles often lack an ADAS so that carmakers can offer them at a competitive price. However, connected assistance systems work better when there are more participants. It is important to offer a cost-effective solution that car manufacturers can use to increase the safety and comfort of all road users.

Forms of Vehicle Communication

Due to their sensors and available processing power, modern vehicles can be considered edge nodes on wheels with missing connectivity options.

Besides sensors needed for efficiently operating a combustion engine, such as a mass-airflow, oxygen, and manifold pressure sensor, modern automobiles come with a range of additional sensors for various safety and comfort features.

Frequent safety functionalities include the anti-lock brake system (ABS) and traction control, which help drivers regain or keep control over their vehicle in dangerous situations.

Besides these basic features, many car makers nowadays install additional sensors to enable more advanced ADAS.

Such sensors may include

- Radar system
- Different cameras
- GPS
- Various IMUs
- Rotary sensors

In the future, car manufacturers may add cutting-edge technology such as a complete LiDAR system and pair it with AI algorithms to detect potentially dangerous situations and alert drivers before they occur. The addition of more sensors and elaborate algorithms means that each vehicle requires more processing power to handle the gathered information in time.

As mentioned earlier, these features will most likely be first available in more expensive trims and models.

Concerning traffic, however, is a collaborative team effort, and it would be beneficial for every road user if there were a way that all vehicles could work together. That way, vehicles traveling ahead could alert other drivers of upcoming dangers, for example, a slippery road surface.

This example shows how our cities could look in the future with vehicles communicating to exchange important information through V2V, V2I, and V2X communication. Image used courtesy of NXP

The previously discussed sensors and AI algorithms could automatically detect such changes and adjust the vehicle's speed accordingly. In addition, a connected car could communicate sensor data and information coming from other sources, such as GPS, to other road users to increase the safety of all traffic participants.

Additional inter-vehicle communication needs add further requirements and constraints, which this article discusses later. Before doing that, it’s important to define the different types of communication between vehicles and other infrastructure.

V2X Communication

V2X, on the other hand, is an Internet of Things (IoT) application that combines vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) principles, enabling vehicles to communicate with all kinds of V2X-enabled traffic participants and infrastructure.

In a sense, V2X combines safety and convenience features to support drivers, pedestrians, bicyclists, and other road users alike.

V2V Communication

In this sense, V2V describes a technique where a vehicle equipped with V2V technology exchanges information to other V2V enabled vehicles. Some of the information they collect includes:

- Current speed
- GPS position
- Steering angle
- Vehicle traction
- Braking pedal position
- Airbag deployment warnings

The other vehicles can then use that data to predict dangerous situations and warn the driver of potential accidents before they happen.

Scroll to continue with content

V2I Communication

V2I, on the other hand, allows vehicles to communicate with smart-city and smart-home infrastructure.

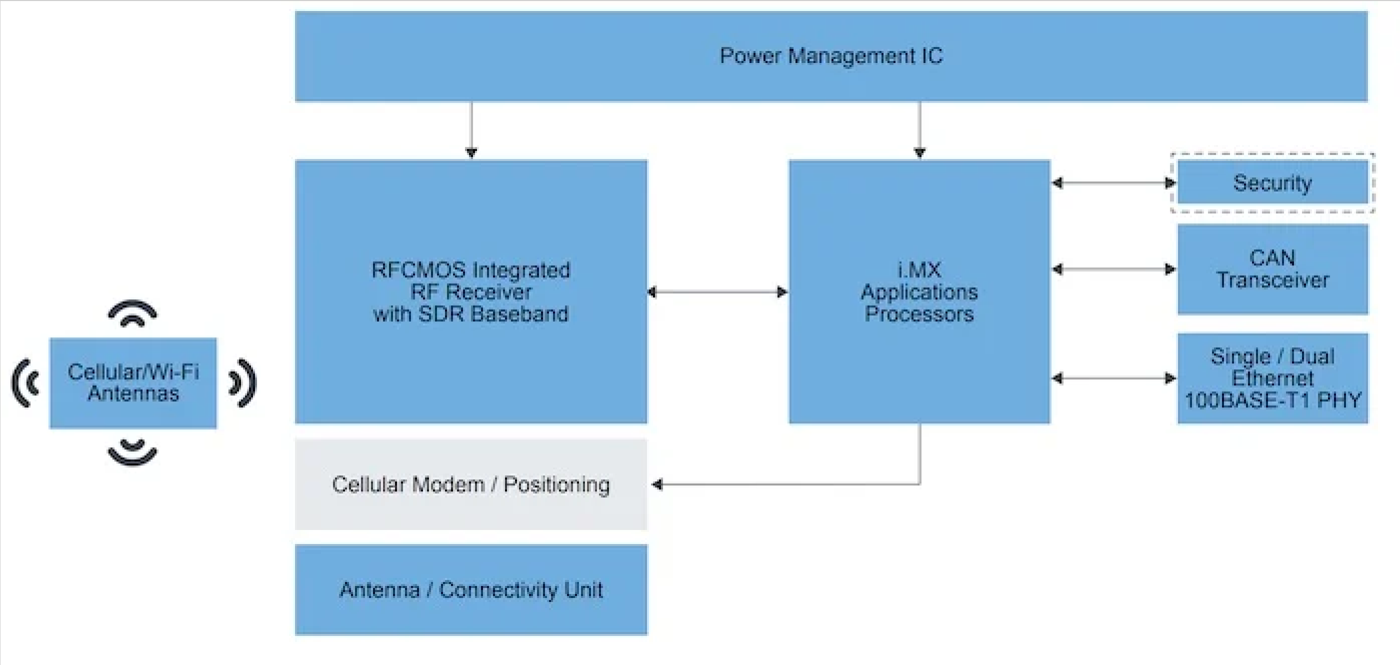
Thus, V2I has the potential to enable a variety of useful convenience features such as traffic light prediction, parking spot availability monitoring, and automatic garage door operation.

Considerations For a V2X System

When designing V2X systems, there are a variety of considerations to keep in mind. From security to hardware accelerators, the following section briefly outlines some components necessary in creating a V2X system.

As V2X systems communicate with numerous other vehicles, smart-city infrastructure, and connected devices in general, car manufacturers must keep their systems safe from potential security threats.

The first consideration is security. Keeping the driver’s data and all traffic participants secure is an important task. Many connected systems use a dedicated external security IC that implements modern encryption and decryption algorithms and other useful features.



A typical V2X system consists of the components outlined in this high-level block diagram. Image used courtesy of NXP

Another consideration is the overall bill of materials (BOM). As more external components are added, the cost of the finished product, as well as the PCB size, increases. Some additional components are:

- Ethernet communication
- Power management integrated circuit (PMIC)
- V2X accelerators

Dedicated Gigabit Ethernet communication requirements and the need for time-sensitive network or TSN-enabled Ethernet networks can quickly further increase the cost of a V2X system, which is an undesirable effect when trying to equip a large number of vehicles and smart-city infrastructure with dedicated short-range communication (DSRC) capabilities.

A dedicated PMIC, such as the PF7100, ensures accurately regulated and consistent power delivery to all components in a V2X module. Powerful processors and wireless communication may be too much for some PMICs to handle, so choosing one capable of powering all devices even during high-load situations is of utmost importance.

Overall, the applications processor sits at the heart of each automotive electronic control unit (ECU), and a V2X communication unit is no exception.

As DSRC-enabled vehicles may communicate with many other devices at any point, carmakers must choose an adequately powerful applications processor. Doing so ensures low latency even when handling thousands of requests each second.

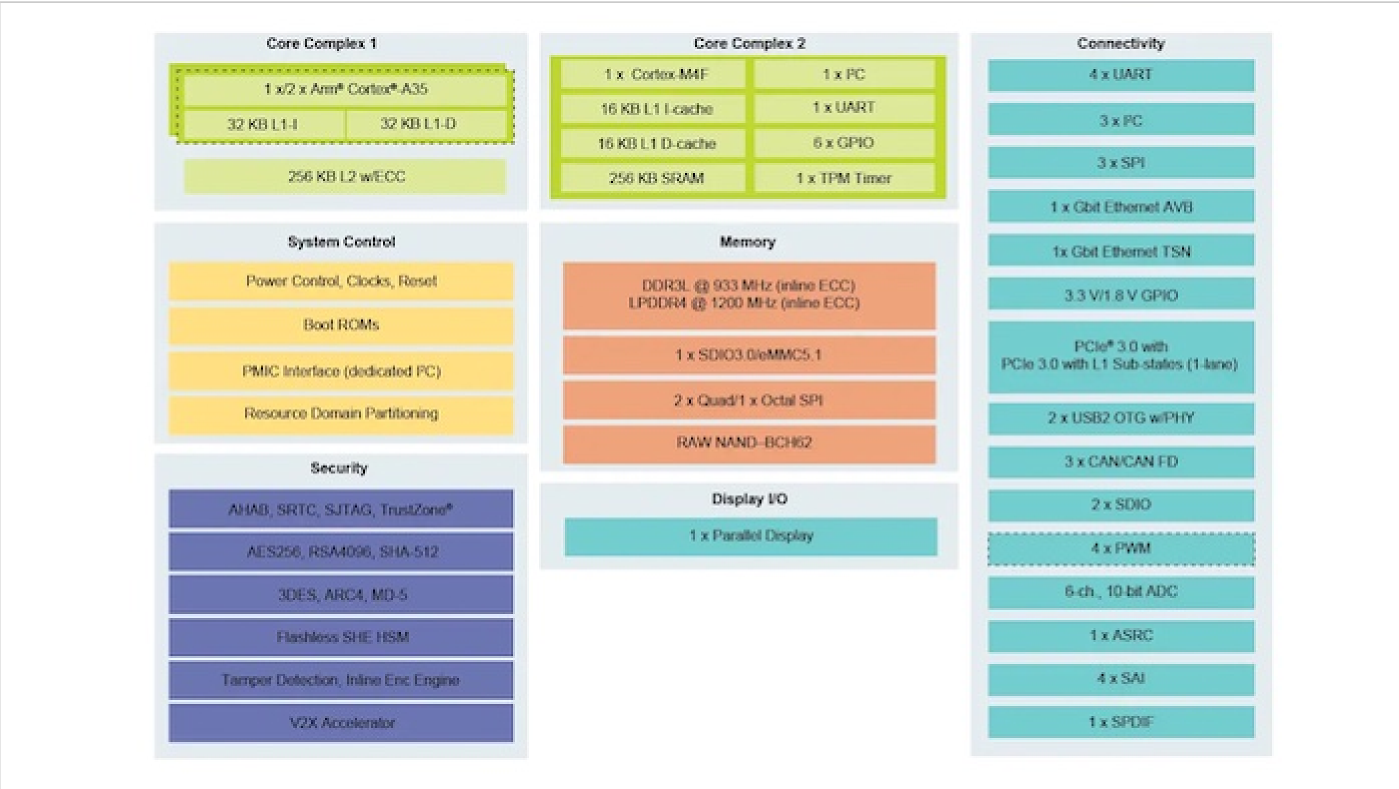
One potential option for processing on a V2X system is the i.MX 8XLite, which was designed with connected automotive applications in mind.

With the inclusion of an on-chip V2X accelerator and telematics support on a single SoC, engineers could reduce the number of parts required for their connected automotive designs. A reduced BOM, in turn, reduces the complexity and overall cost of the finished product.

Example V2X Processor: i.MX 8XLite

With all these requirements, limitations, and goals on the table, there’s a clear need for an efficient, powerful, connected, and affordable solution that carmakers can pick up to enable connected driver-assistance systems in their latest models.

As mentioned above, one possible processor that could be beneficial in a V2X design is the i.MX 8XLite, which targets vehicle telematics, V2V, V2I, road infrastructure connectivity, industrial equipment control, and building automation.



A block diagram for the i.MX 8XLite. Image used courtesy of [NXP](https://www.nxp.com)

This processor includes on-die security features, which were mentioned as an important aspect of designing a V2X system. Some of the security features that could be beneficial to exploit in a system are its:

- Secure enclave
- Secure key storage
- Tamper pins
- Built-in encryption engine that supports SM and AES algorithms
- V2X-optimized high-security module
- FIPS 140-3 certification

One problem of currently available IoT technology includes its limited usability in the automotive sector.

While having delays of multiple milliseconds and the occasional package loss may be acceptable in most current IoT applications, for example, home automation and home security systems. The automotive market, on the other hand, requires manufacturers and engineers to implement stricter guidelines to prevent catastrophic failure, which could result in excessive financial loss, injuries, or even human casualties.

Besides advanced on-chip security features, automotive devices must offer exceptional reliability and work in even the harshest conditions.

With up to two Cortex-A35 cores and a dedicated Cortex-M4F real-time processing unit, the i.MX 8XLite fulfills the previously mentioned need for additional computing power when processing a lot of sensor data and running complex algorithms.

It further offers:

- Support for 16-bit DDR3L-1866 and LPDDR4-2400 memory
- Two SD 3.0 card interfaces
- One FlexSPI interface for fast-boot from SPI NOR flash
- One eMMC5.1/SD3.0 interface

Another common problem of many industrial and automotive applications is that each manufacturer implements a slightly different communication standard in their products.

This solution is not beneficial in V2X, V2V, and V2I communication that involves many different makes and models of vehicles and other communication equipment. Therefore, NXP strives to advance the widespread adoption of TSN, a set of networking standards that sit on top of standard ethernet. Besides other communication interfaces, such as three CAN / CAN FD interfaces, the i.MX 8XLite includes a 1Gb Ethernet interface with TSN support.

Most sensors, actuators, and control devices in a modern automobile communicate via a CAN network. The on-chip CAN / CAN FD support allows the i.MX 8XLite to directly communicate with the existing vehicle and industrial infrastructure, enabling carmakers to easily incorporate a V2X and telematics unit in their designs without the need for major changes. The i.MX 8XLite applications processor could thus directly communicate with a vehicle’s sensors and control modules to receive vital information when required.

The added TSN support means that all TSN-enabled vehicles and roadside infrastructure can rely on the fact that other TSN-enabled devices understand and implement the same time-sensitive communication protocols.

Therefore, connected vehicles of all major brands can communicate without any problems.