Accelerating Global V2X Deployment for Road Safety
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V2X (Vehicle-to-Everything) is a technology allowing vehicles to communicate with each other, with other road users and the infrastructure, for enhancing road safety and mobility. The technology uses a wireless signal to communicate with compatible systems, thus enabling vehicles to improve their situational awareness to objects and events in their environment.

The key objective of a V2X system is safety. It is a reliable non-line-of-sight sensor working in all environments and weather conditions to prevent road collisions in dangerous situations. In manned vehicles, V2X systems convey important information to the driver in the form of alerts and notifications and can also actuate the vehicle in dangerous situations. In Connected Autonomous Vehicles (CAVs), V2X complements existing sensors, thus allowing them to take more informed and coordinated decisions with information beyond their reach. It enables CAVs to get accurate and reliable information from traffic lights and enables interaction with other road users.

To fully realize the benefits of V2X, significant penetration is needed. Vehicles must have V2X systems on board which speak the same language, since without interoperability, cars will not be able to talk to one another thus diminishing the value of connectivity.
Similarly to other communication technologies, in recent years the V2X market had split into two different camps based on different technologies:

- DSRC (known as ITS-G5 in Europe), a Wi-Fi based standard dedicated to vehicular use, heading to mass-deployment in Europe and US.

- C-V2X direct communications, which is derived from cellular standards, is leading in China and endorsed by players from the cellular industry and some automotive OEMs.

Both technologies have the same goal of saving lives by protecting road users, drivers, motorcyclists and pedestrians, improving mobility by platooning, optimizing traffic, and easing the introduction of autonomous vehicles by facilitating their interaction with other road users.

V2X cannot be considered as yet another communication technology. It is a safety technology, aiming for the highest reliability and security. In order to realize V2X to its full potential, vehicles must be able to trust the messages arriving from their surroundings. No less than the highest cybersecurity requirements must be met.

With the split in V2X technology standards comes the challenge of meeting the requirements of safety communication in a cost-effective manner. Global OEMs and Tiers must examine this carefully in order to choose a quick and risk-free path to mass-deploy V2X while leveraging economies of scale.

While DSRC chipsets have traditionally been productized as dedicated chipsets for the purpose of safety-first, direct V2X communications, C-V2X tries to bring both direct V2X connectivity and network connectivity under one roof.

While the latter concept seems appealing when thinking about connected vehicles with integrated telematics capabilities, one must consider whether architecturally V2X direct communication should reside in the same chipset as the NAD (Network Access Device, essentially a cellular modem). Safety, security, reliability and cost are among the key criteria to examine.
2 Automotive Safety Communication Requirements

To enable reliable and robust V2X operation, V2X requirements were developed by government, by government entities (USDOT), standardization bodies (like IEEE, SAE, ETSI), industry consortiums (like CAMP and C2C-CC) and OEMs. While there are many requirements related to safety communication, in this section we will focus on the requirements impacting global V2X deployment such as cost, safety and security, regardless of the V2X technology used.

2.1 Security

Cybersecurity is a key requirement. Any wireless entry point to the vehicle must be hermetically protected, and in particular, one that can influence vehicle actuation or alert the driver to take an emergency action. Both regulators and the general public are expecting the highest cybersecurity protection for uncompromised safety.

V2X certification schemes have been defined. The cryptographic material should be securely stored in Hardware Security Module (HSM), where two certifications apply: FIPS 140-2 level 3 in US and Common Criteria EAL4 in Europe. The entire operation of V2X has to conform with system architecture and implementation guidelines defined by CAMP in US and C2C in EU.

Figure 2: Isolated V2X and NAD integrated V2X
Isolation is the key requirement and method for achieving secured and certified V2X operation, by separating the V2X functionality from all other domains. A failure, either intentional or non-intentional, in other domains should not impact V2X operation.

A dedicated V2X solution is isolated by design. Cryptographic assets are secured and accessed only by authorized processes which simplifies certification. On the other hand, using NAD for V2X operation opens the door to attacks, and imposes concerns on the ability to certify a solution.

Security certification challenges with NAD integrating V2X are as follows:

> Common V2X and cellular network access layers: without separation, cellular access can become a point of entry for attacking V2X. For example, there have been cases of fake base-stations pushing malware into smartphones.

> Common CPU running both safety and non-safety applications: certification requires fine-grained process isolation and memory protection to guard against system malfunctions, malware, and cyber security breaches. This complicates the system and its development, which eventually translates into cost.

> Preventing unauthorized access to cryptographic assets with common CPU and peripherals: non-safety applications cannot access the HSM to forge messages. HSM that can be accessed by non-authorized processes, is analogous to an unbreakable vault placed in a public place with the key hanging next to it.

When a different NAD is needed per each Telematics flavor, the V2X solution would be replaced as well. Additional development, and even more painfully, additional certification, would be needed. Telematics flavor is typically defined per geography and per vehicle class (entry level, medium level, high level). The complexity of security certification, and the burden of proof for every configuration, adds risk, cost and complexity to V2X system development.

2.2 General Requirements:

> High operating temperature: Vehicle roof-top mounted electronic system (such as roof antenna or headliner) temperatures can reach 105° on a sunny day. NADs are not designed for automotive high-temperature operation, but for consumer devices like mobile phones. V2X operation at high temperatures cannot be compromised. NAD integration with a high throughput cellular modem and a powerful CPU makes heat dissipation a real challenge, while a dedicated V2X chipset is robust enough to handle extreme weather conditions.
> Short boot time: Safety technology should operate quickly after the vehicle is turned on. USDOT proposed V2V rulemaking specifies boot time of 2 seconds. The basis for this requirement is the notion that vehicles should not be moving unless V2X is transmitting and receiving. This is a challenging requirement for chipsets with multi-core CPUs running a full Operating System.

> Functional safety: Currently, light vehicles are not using V2X for actuation, hence not needing ISO26262 certification. Trucks do rely on V2X for actuation, needed for platooning, hence ISO26262 ASIL B requirement emerges. In the near future, light vehicles will also use V2X to trigger vehicle actuation, for example, automated braking when a vehicle ahead is suddenly breaking (Emergency Electronic Brake Lights) or vehicles bursting into an intersection (Intersection Movement Assist). Autonomous vehicles will require V2X to be functionally safer in a wider set of scenarios. An architecture in which V2X is integrated in the NAD cannot practically achieve functional safety due to the high complexity and conflict with consumer market requirements and cost targets.

2.3 Cost-Effectiveness
Cost, as always, is unarguably a crucial consideration. Nevertheless, in the V2X case, it is even more important since it is a safety communication technology with value which is proportional to the square of the number of connected vehicles (based on Metcalfe’s law). Therefore, it is of upmost importance to compare between NAD-integrated V2X and isolated standalone V2X, in terms of system-level cost. Cost of a NAD with integrated V2X is derived from several parameters:

> Added cost when V2X is not used: a solution created solely for V2X, can be assembled only when V2X is installed and has no hidden costs. V2X in NAD can be costlier than anticipated, as it is useful only when running C-V2X. In regions heading toward DSRC deployment, C-V2X capabilities are not likely to be used. In some regions, there would not be any V2X. All these cases will unnecessarily burden the cost of the NAD.

Figure 3: Forced Marriage of C-V2X & NAD is undesirable and costly
> Forced usage of expensive NADs: it is likely that C-V2X will be integrated in the most expensive high category NADs. This forced marriage limits the device selection. With a dedicated V2X solution, even entry-level to mid-level NAD, targeting the common LTE cellular network performance (e.g. Cat 6 modem with a speed of 300Mbps), can be used. The decoupling of C-V2X from the NAD enables optimizing the solution to the appropriate Telematics class (basic / luxury) and fit the system to the specific geography.

> Partial integration increases cost: integrating V2X into NAD leaves the security outside. Lack of off-the-shelf V2X security solutions would lead to increased overall system cost. A dedicated V2X solution is cost-efficient since it combines communication and security. A system combining a dedicated V2X solution with a dedicated NAD benefits from the integration of each of its components without hidden (or not so hidden) inefficiencies and costs.

> V2X cost burden on NAD: The myth of “zero cost V2X” is far from the truth. NAD cellular throughput is a main property and as such it cannot be degraded when V2X is activated. Since V2X is expected to work all the time, it should have dedicated processing resources.

> Supporting both DSRC and C-V2X: while the two technologies have different characteristics, many common elements can be shared and provide a cost benefit in large deployments. Among the shared elements in both cases are DSP resources, memories, HW signal processing elements and the RF IC for the globally harmonized ITS spectrum (5.9GHz).
Markets in which there is more than one standard are typically served by multi-mode devices. For example, this happened in the Telecom transmission market when SDH and SONET merged into a single product line. V2X will not be different. OEMs and Tier1s are aiming to reduce costs, and once given the alternative, they will avoid two different solutions, one for each standard, with fundamentally different architectures.

Cellular coverage and capacity varies significantly across countries, and within countries. Vehicles are also far from being homogeneous. This is a major challenge for Telematics Control Units (TCU) forcing multiple variations with geographic and class customizations. Having V2X integrated in each NAD flavor, would require multiple V2X testing efforts, and worse, multiple V2X certifications. The contrary approach of integrating V2X only in high-end NADs will struggle to meet OEMs target cost for mass-deployment in everyday vehicles. NAD integrated solution mixes two different technologies built for different needs and having different development cycles, cellular and V2X. While a cellular modem may have to be upgraded due to changing network requirements, there is no reason to update and recertify the V2X solution, causing unnecessary development and certification burden.

Since the V2X market has been split into two technologies, there is great importance in creating a global V2X platform in order to enable the fastest and most effective deployment for this life-saving safety technology everywhere. One global platform with one certification process will save time and hassle for OEMs and Tier1s alike and will provide the needed stability for long-term support of V2X technology. It will reduce the total cost of ownership for OEMs to deploy a V2X system by lowering the cost of sourcing, logistics, inventory and other expenses. Consequently, economies of scale will create a cost-effective product which can be deployed in motorcycles, economy vehicles and premium vehicles everywhere.
Impact on Transportation Verticals

When looking at different transportation verticals, the impact of a standalone global V2X solution is greater than it initially appears. Light vehicles, motorcycles, trucks and other road users have unique characteristics and their relative share of transportation varies in different parts of the globe. Here are a few examples of the impact of a global V2X solution in different market verticals:

> **Motorcycles** – their high speed and maneuverability coupled with their vulnerability generates a great need for alerting other vehicles on their whereabouts and direction. The need for high-end cellular connectivity for motorcycles is questionable at best, and since the size and cost of a TCU are inhibitive for most motorcycle models, a standalone V2X solution is needed. A standalone global solution capable of supporting both DSRC and C-V2X direct communication (PC5 protocol) will enable B2V (Bike to Everything) communication in all regions.

> **Trucks** – beyond the safety benefits of V2X, platooning is a key use-case for trucks which is vital for the business case for deploying V2X communication in trucks. In a platoon, trucks rely on V2X for actuation, and therefore it must be functionally safe (ISO26262 certified). This hard requirement is needed for the direct communication in the truck platoon, whether the V2X technology is DSRC or C-V2X.

> **Autonomous Vehicles (AVs)** – this future transportation vertical has been getting the media and public attention since its inception due to its outstanding potential. There are quite a few obstacles to overcome before we will see AVs traversing our roads. One key obstacle is the AV’s ability to perceive its environment and accurately act on its dynamics. This is known as situational awareness. Transportation experts, academic researchers, policy makers and others have avidly shown and explained that V2X is a crucial sensor for AV, providing safety when there is no visibility and complementing other sensors in all environmental conditions with more information at lower latency. Actuation based on V2X is a must for AV, therefore it must be cybersecure and functionally safe (similar to trucks) regardless of the V2X technology. A global V2X solution will pave the way for autonomous vehicle everywhere and increase their acceptance in the general public.
Summary and Conclusions

The goal is simple – deploying V2X and start saving lives as soon as possible, in the safest and most effective way. The V2X solution must be cybersecure and therefore isolated to achieve this goal. A global V2X solution is needed for an accelerated deployment with cross-region coverage.

A global V2X platform which supports DSRC or C-V2X would be suitable for US, Europe, China, Japan and other markets, and would allow reducing the development, testing, certification and maintenance costs and efforts. Additionally, it would save time, as mass-market deployment can happen sooner if long certification processes will not be needed.

The global platform must be cellular network agnostic to be truly global and therefore physically separated from the NAD. Additional considerations requiring this separation are:

- Meeting V2X safety and reliability requirements: for guaranteeing robust and continuous operation in harsh Automotive environment, while enabling vehicle actuation and alerts based on V2X for present and future use-cases.

- Secure V2X operation: fully isolating and protecting the V2X cryptographic assets for secure communication.

- Cost-effective V2X solution: breaking the linkage to an expensive NAD which results in a non-optimal system. Offering a cost-effective highly-integrated solution, for maximal system flexibility in all regions.

The promise of V2X for safe, efficient and greener transportation is closer than ever before. The fact that there are two alternative technologies should not slow down the market since a global solution path exists. The V2X path should progress on a route of its own, without dependencies or roadblocks so it could realize its full potential in making our roads safer for both manned and autonomous vehicles.

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