

## V2X Technology Trends for Next-Generation Mobility

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### **Abstract**

*We describes V2X technology, a connectivity-based recognition technology that is attracting attention as a key technology for implementing autonomous driving technology, and autonomous communication modules that implement ADAS technology, a sensor-based recognition technology. It also explains the trends in V2X technology standardization centered on IEEE 802.11p, which is a WAVE technology standard based on Wi-Fi/DSRC. Finally, we will discuss the market growth trend of V2X communication modules in the United States, the leading V2X technology module, and the development of technology development trends of major domestic and international companies that are leading the global technology market related to V2X communication modules. V2X and ADAS technologies will be the biggest influence on automotive purchasing decisions. In recent years, V2I mandates have been promoted beyond V2V, mainly in developed countries such as the United States. The related industry needs to focus on the development of information transmission network technology that can support high frequency high efficiency(transmission rate) and sophisticated positioning accuracy beyond conventional vehicle communication.*

**Keywords:** *Autonomous driving, V2X technology, ADAS technology, V2X communication module, IEEE 802.11p, V2V/V2I mandatory, High frequency/High efficiency, Positioning accuracy*

### **1. Introduction**

This study describes Vehicle-to-Everything(V2X) technology, a connectivity-based recognition technology that is attracting attention as a key technology for implementing autonomous driving technology, and autonomous communication modules that implement Advanced Driver Assistance System(ADAS) technology, a sensor-based recognition technology. It also explains the trends in V2X technology standardization centered on IEEE 802.11p, which is a Wireless Access in Vehicle Environments(WAVE) technology standard based on Wireless Fidelity/Dedicated Short Range Communication(Wi-Fi/DSRC). Finally, we will discuss the market growth trend of V2X communication modules in the United States, the leading V2X technology module, and the development of technology development trends of major domestic and international companies that are leading the global technology market related to V2X communication modules. V2X technology, a connection-based recognition technology, and ADAS technology, a

sensor-based recognition technology, are attracting attention as autonomous communication modules for implementing autonomous vehicles. V2X technology includes a wireless communication technology that can share the road infrastructure and relative vehicles and traffic information(real-time traffic situation/sudden situation/traffic flow/control state, etc.) while driving.

(Vehicle-to-Vehicle(V2V)/Vehicle-to-Infrastructure(V2I)/Vehicle-to-Pedestrians(V2P)/Vehicle-to-Nomadic device(V2N)) as well as combined with precision positioning technology that tells the driver and the car the location of the car to support autonomous driving. ADAS technology is equipped with state-of-the-art sensors(Camera/Radio Detection And Ranging(RADAR)/Light Detection and Ranging(LiDAR) system/Ultrasonic etc.) that inform you of the risk of accidents that may occur while driving[4]. This has grown the industry of transportation, such as reducing traffic accidents or distributing traffic in a smooth direction to reduce carbon dioxide, electronic parking(e-parking) and toll payment automation.

We describes v2X technology, a connectivity-based recognition technology that is attracting attention as a key technology for implementing autonomous driving technology, and autonomous communication modules that implement ADAS technology, a sensor-based recognition technology. It also explains the trends in V2X technology standardization centered on IEEE 802.11p, which is a WAVE technology standard based on Wireless Fidelity/Dedicated Short Range Communications(Wi-Fi/DSRC). Finally, we will discuss the market growth trend of V2X communication modules in the United States, the leading V2X technology module, and the development of technology development trends of major domestic and international companies that are leading the global technology market related to V2X communication modules.

## 2. V2X Technology Standardization Trends

The initial V2X technology used as a toll payment system, etc., had a short transmission distance and a limit of the data transmission amount. In July 2010, IEEE developed Wi-Fi/DSRC based IEEE 802.11p WAVE Technology standard(frequency 5.9GHz, maximum travel speed of 200km/h, maximum transmission distance of 1km, maximum mass data rate of 27Mbps) based on the international standard. The IEEE 802.11p standard is based on the OSI 7-layer model having a physical layer and a computer network structure of the Media Access Control(MAC) layer. The physical layer is responsible for hardware transmission technology, and the MAC layer is a data link layer that is responsible for effective access control management of shared media[1][2][4][5][6][7]. In a brief summary of the national and international IEEE 802.11p standardization trends related to V2X communication modules, it is as follows in Table 1.

**Table 1. V2X Communication module to domestic and international IEEE 802.11p standardization trends**

Standard instruments		Standardization trends
Global	ETSI	- DSRC development using ITS to allocate 30MHz in the 5.9GHz band - Development of Cellular-V2X(C-V2X) technology using LTE network for telecommunications in addition to Wi-Fi/DSRC-based technology
	NXP Semiconductor	- DSRC-MODEM(SAF5400) development (Integrated firmware into a complete standalone single-chip modem with advanced transceiver technology) - Led the regulatory recommendations of the US Department of Transportation and standards in Europe, Japan, and Korea

<b>Domestic</b>	<b>LG Electronics</b>	<ul style="list-style-type: none"> <li>- Led the Rel-14 V2V standardization as LTE-V2X standardization organizer</li> <li>- Led the standardization of Rel-15 enhanced-V2X(e-V2X) from mid-2017</li> <li>- Adopt V2V's signal configuration and efficient multi-connection method below 6GHz</li> <li>- Leading domestic and international markets in connection with automotive battlefield business</li> </ul>
	<b>5G Forum</b>	<ul style="list-style-type: none"> <li>- Establishing domestic standardization and 5G termination industry requirements, including automotive industry and V2X technology in the 5G mobile communication termination(Vertical) industry</li> </ul>

- ※ 1) ETSI : European Telecommunication Standards Institute
  - 2) C-V2X technology has the advantage of being able to secure time to avoid collision between vehicles because there is a difference of about two times wider coverage and reaction time compared to Wi-Fi/DSRC
  - 3) LG Electronics' Rel-15 eV2X standard focuses on developing vehicle-specific MIMO and millimeter-wave band vehicle-to-vehicle communication technology standards
  - 4) ETRI : Electronics and Telecommunications Research Institute
- \* Source : Mega Economy(April 13. 2019), TechWorld(November 6. 2017), Dong-gu Kim et al.(May 2017), Hyundai Motor Group Homepage, KI-Taek Lim et al.(August 2016), 5G Forum(March 2017) / re-composition.

### 3. V2X Technology Market Trends

#### 3.1 V2X Communication Module Growth Trend of U.S.

In order to share the traffic information between vehicles in real time to lower the probability of a collision, a V2X communication module Communication Control Unit(CCU) is required. CCU development companies, security solution development companies, and telecommunications service companies are actively engaged in the global market, focusing on policy projects(government-finished car-parts cooperation) of leading countries(USA, Europe, Japan, Korea, etc.) that are leading the global technology market related to autonomous driving. In particular, the United States, a leader in the V2X technology market, has announced regulations that mandate V2V communication equipment for all new vehicles by 2022.(Early 2017) the U.S. National Highway Traffic Safety Administration(NHTSA) estimates the cost of installing V2V per vehicle by \$341 to \$350 per vehicle in 2020, and new cars equipped with V2X communication modules are projected to be between 5million vehicles in 2015 and 18.7million in 2020(2013-2020: CAGR 30%)[8]. (See Table 2)

**Table 2. V2X Communication module growth trend of US**

	2015	2016	2017	2018	2019	2020	CAGR[%]: 2013~2020
<b>Number of installations [Ten Thousand]</b>	500	595	640	774	1,374	1,879	30



※ This is due to the US government's V2X legislation.

\* Source : Visiongain\_Data Synthesis(2019) / re-composition.

### 3.2 Corporate Trends related to V2X Communication Modules

Overseas major companies leading the global technology market related to V2X communication modules include NXP Semiconductor/Qualcomm/U-blox, and domestic companies such as LG Electronics/LG Innotek/ETRI/Samsung Electronics/Samsung Electronics/SK Telecom/VIT of SNU. A brief summary of major domestic and international corporate trends is the same as table 3[4][6][9][10][11][12].

**Table 3. Major V2X Communication module technology development trends**

Corporate name		Development trends
Global	NXP Semiconductor	<ul style="list-style-type: none"> <li>- Working with major parts companies and vehicle OEMs such as Cohda Wireless/Siemens/Harman/Delphi</li> <li>- 60% of global market share</li> <li>- Launched a high-performance single-chip DSRC-MODEM(SAF5400) in September 2017</li> </ul>
	Qualcomm	<ul style="list-style-type: none"> <li>- In September 2017, pC5(interface between 3GPP Release 14 handsets) launched c-V2X chip set(9150) based</li> <li>- Commercialization of 9150 C-V2X chip set in the second half of 2018</li> <li>- Continuous investment in 5G-NR-based C-V2X performance development</li> </ul>
	U-blox	<ul style="list-style-type: none"> <li>- Launched the next generation V2X module(VERA-P1 series) in June 2017, accommodating the IEEE 802.11p standard</li> <li>- VERA-P1: Connecting with the host processor via USB and SPI interface, accommodating WAVE/DSRC/ETSI ITS G5, approximately 1km transmission distance</li> </ul>
Domestic	LG Electronics	<ul style="list-style-type: none"> <li>- In July 2013, the Vehicle Components(VC) division was opened, focusing on the automotive business</li> <li>- In February 2015 Started development of 5G-based V2X platform</li> </ul>

<b>LG Innotek</b>	<ul style="list-style-type: none"> <li>- In 2015, the first-generation V2X full module was released</li> <li>- In September 2017, the second generation V2X full module development(ultra-compact product with V2X core components such as HCI module/HSM/AP)</li> <li>- 6Mbps transmission rate, 23dBm transmission power, -94dBm reception sensitivity, 120km/h vehicle driving speed, coverage 1km</li> </ul>
<b>ETRI</b>	<ul style="list-style-type: none"> <li>- Research and development of communication technology in IEEE 802.11p WAVE 5.9GHz band, development of core chips in vehicle communication</li> <li>- Development of MIMO transmission technology for high-speed vehicles through 5G-based V2X integration and Giga Korea research project</li> </ul>
<b>Samsung Electronics</b>	<ul style="list-style-type: none"> <li>- Developed a prototype of a next-generation communication system transceiver using a 28GHz frequency</li> <li>- Implementing a high-capacity transfer rate of 1.2Gbps in road environments above 100km/h</li> </ul>
<b>Renault Samsung Motors</b>	<ul style="list-style-type: none"> <li>- Developed remote parking technology, driver emergency services, V2X requirements</li> <li>- Development of V2X test bed for 4G network-based verification</li> </ul>
<b>Samsung/LG Electronics</b>	<ul style="list-style-type: none"> <li>- Development of standard and belief propagation-based channel code/decode-related standard technology for various mobile communication systems such as 3GPP and IEEE 802.11</li> </ul>
<b>SK Telecom &amp; IVIT of SNU</b>	<ul style="list-style-type: none"> <li>- Development of intelligent vehicle technology through a 5GHz band network dedicated to vehicles that supports V2X</li> </ul>

※ 1) DSRC-MODEM(SAF5400) is scalable, secure, advanced RF-CMOS function, Software Defined Radio(SDR) technology is applied.

2) C-V2X chip set(9150) is designed to integrate ITS-AP/HSM/GNSS functions to provide core autonomous driving functions

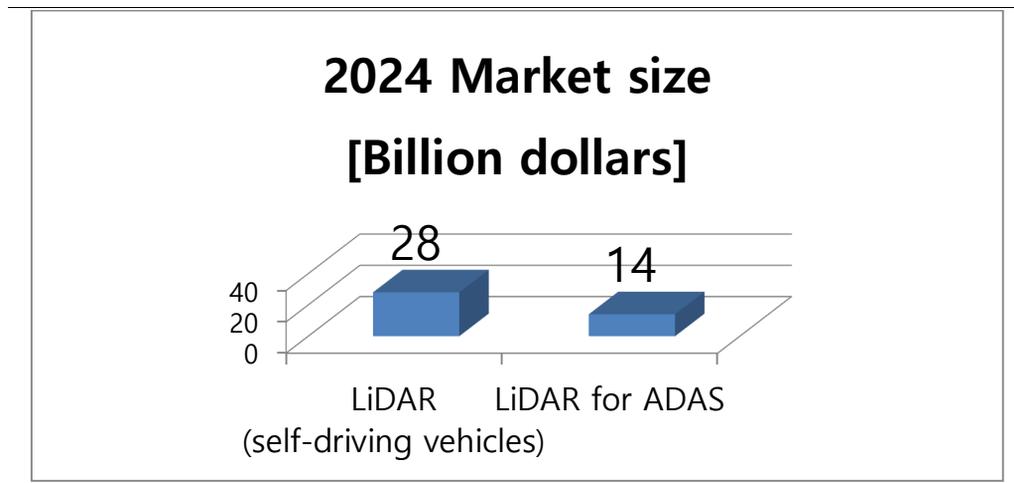
\* Source: TechWorld(November 6. 2017), KI-Taek Lim et al.(August 2016), Il-kyu Kim(December 2014), Hyun-kyu Jung(October 2016), Samsung Electronics Press Release(June 2016), SK Telecom Press Release(October 2016)) / re-composition.

### 3.3 LiDAR Market Growth Trends for Vehicles

LiDAR's global market for autonomous vehicles is expected to grow at an average annual rate of 55%, up from \$1.3Billion in 2018, and a massive market of \$2.8Billion in 2024. In addition, LiDAR's global market size for ADAS is expected to grow at an average annual growth rate of 113% from \$882Million in 2018 and will form a large market of \$1.4Billion by 2024. This is expected to account for 70% of the total LiDAR market in 2024 by car LiDAR[13]. (See Table 4)

**Table 4. LiDAR Global market growth trend\_2018~2024**

	2018	2024	CAGR[%]:2018~2024
<b>LiDAR(self-driving vehicles)</b>	13	28	55
<b>LiDAR for ADAS</b>	8.82	14	113
<b>Total</b>	21.82	42	84.00(Ave.)



\* Source : Yole Développement(2019) / re-composition.

#### 4. Conclusion

V2X and ADAS technologies will be the biggest influence on consumers' automotive purchasing decisions in the future. Therefore, in order to enter the turbulent global automotive technology market, it must be competitive, such as the development of software/hardware related to it and enhanced security functions. In particular, it is necessary to focus on early construction of general-purpose processors and open standard software that can accommodate more powerful performance, security, and connectivity to other devices. In recent years, V2I mandates have been promoted beyond V2V, mainly in developed countries such as the United States. Accordingly, the industry expects the V2X era to come in earnest by 2020 when 5G communications begin in earnest. As such, V2X communication technology provides safe services for drivers and pedestrians, and the market for autonomous driving and services in the next generation of 5G V2X environments is expected to continue to grow[14]. The related industry needs to focus on the development of information transmission network technology that can support high frequency high efficiency(transmission rate) and sophisticated positioning accuracy beyond conventional vehicle communication. V2X technology is driving the commercialization of autonomous driving with the development of the core sensor, RADAR/LiDAR/Camera system. However, these sensors have a constraint that can only be utilized within the visible distance. By complementing the constraints of these sensors, the development of core technologies that can provide 360° recognition capacity is not affected by the constraints of the field of view is urgent. In addition, institutional preparations such as safety regulations and technical verification, facility installation and protocol development for autonomous vehicles are necessary.

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