C-ITS and Connected Automated Driving in Japan

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ITS in Japan entered its second phase in 2014, when the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) embarked on its *"ETC2.0 Project"*, which aimed at delivering a range of applications for vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communications. These applications are being developed based on various types of Cooperative ITS (C-ITS) systems, and a number of innovations for resolving traffic issues are going to be released in Japan. Development of automated driving technology is also rapidly progressing, and automated-driving cars would be available in 2020, according to a statement made by Prime Minister Shinzo Abe on October 4, 2015 at an international conference on the future of science, technology and mankind. This report outlines the latest developments of C-ITS, connected and automated driving in Japan.

TRENDS IN C-ITS IN JAPAN

The first C-ITS system in Japan *"VICS (Vehicle Infrastructure Communication Systems)"* was launched in 1996. *"VICS"* is In-Vehicle Information (IVI) using 2.4 GHz radio wave communications for expressways and optical communications for highways and streets, as well as FM data broadcasts, to transmit information to car navigation

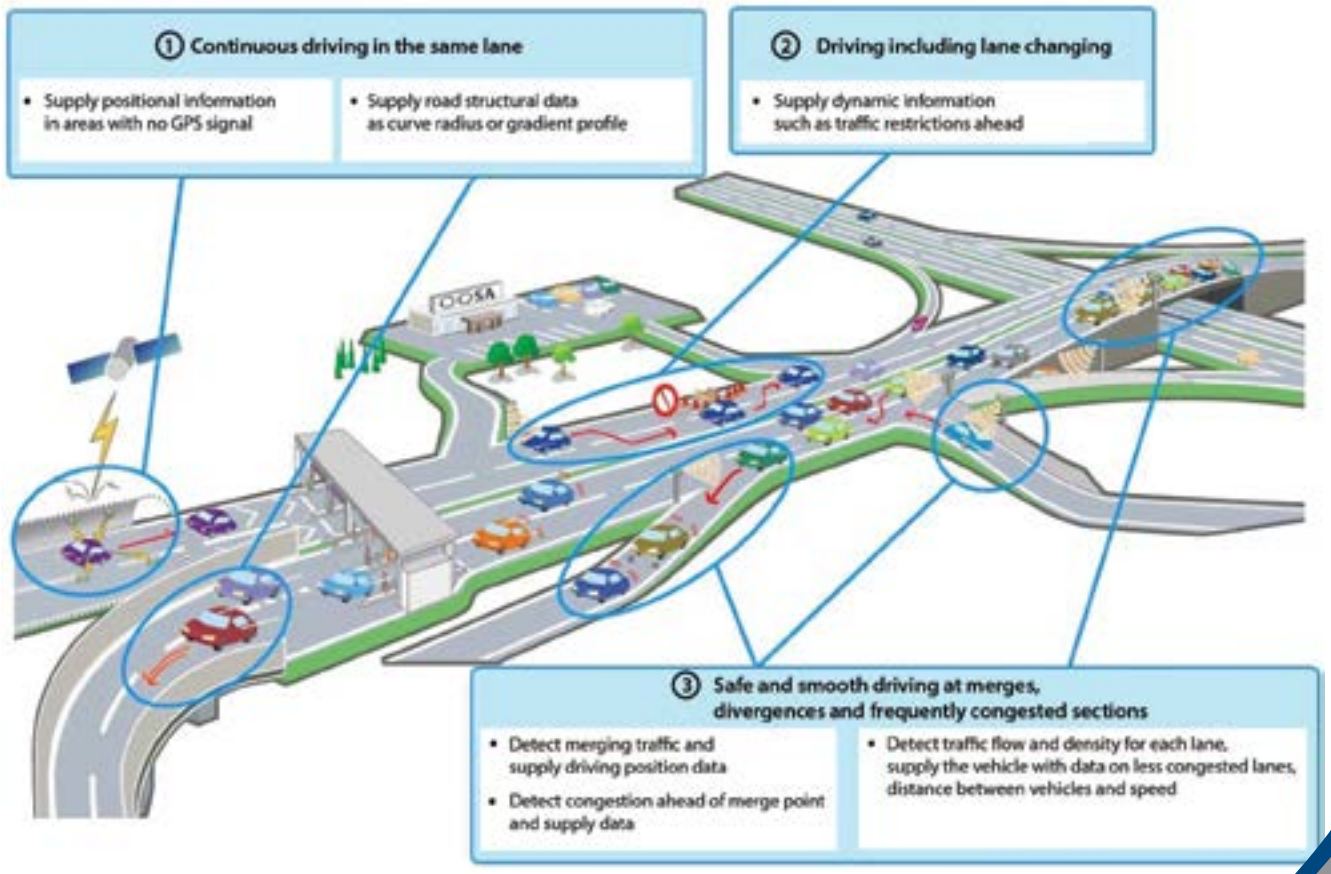

Illustration 1 - Major considerations required for the Autopilot System

systems. With the additional functions to provide a real-time information of traffic conditions, availability of parking areas, even traffic accidents and construction works on roads, *"VICS"* has become an essential element of car navigation systems. Approximately 70% of car navigation systems are equipped with the *"VICS"* function; a total of 53 million units are on the market as of December 2016.

Then, an Electronic Toll Collection service was started in 2001, which is called *"ETC"*. The payment system uses the 5.8 GHz band DSRC (Dedicated Short Range Communication), which enables non-stop toll collection. DSRC in Japan is based on ISO14906 standard published in 1998, and the 5.8 GHz band is the recommended frequency by the International Telecommunication Union (ITU) advisory in 2000. As of February 2017, 57 million onboard *"ETC"* units have been set up. The percentage of vehicles using *"ETC"* service when passing through tollgates also exceeded 90%, which relieved most of the congestion caused by toll collection. Introducing dynamic toll rate by period of time enabled to increase the number of *"ETC"* users during nighttime discount. That resulted in reduction of traffic on general roads, which led to improve roadside environment along these roads at night.

A new C-ITS project *"ETC2.0"* was launched in 2014. *"ETC2.0"* fully utilizes the higher capacity and bidirectional capabilities of active 5.8 GHz DSRC, and thus increases the capacity of the information provision and simultaneously includes a function to collect probe data. These features allow dynamic route guidance on expressways in the entire Tokyo metropolitan area, while probe data enable traffic congestion information to be more accurate and detailed, resulting in a platform capable of running multiple V2I applications. From that time, the platform can be utilized by private companies (e.g., providing assistance for logistics companies), although it could be used only by public services such as *"ETC"* and *"VICS"* previously. The number of on-board unit of *"ETC2.0"* installed reached about 1.5 million by February 2017, signaling a surge in the popularity.

TRENDS IN AUTOMATED DRIVING TECHNOLOGIES IN JAPAN

Japan as one of the earliest to initiate studies - Autopilot System Study Group

MLIT established the *"Autopilot System Study Group"* in June 2012. The interim report[1] released in October 2013 outlined a concept of the autopilot system, an image of the target future and a roadmap for achieving those goals. In particular, the three services were described in *illustration 1,previous page* that shows considerations and challenges required to achieve the Autopilot System. The goal of the Study Group is to achieve continuous driving on the main lanes of expressways (except for smooth driving during traffic congestion) with the use of advanced driving support systems by the first half of 2020s.

Public-Private ITS Initiatives and Roadmap

In June 2013, the Japanese government released the *"Declaration on the Creation of the World's Most Advanced IT Nation"*, and subsequently announced the *"Public-Private ITS Initiatives and Roadmap"*[2] in June 2014. With the aim of building and maintaining the world's best ITS which contribute to national and international communities, the roadmap outlines the development and deployment of driving safety support systems and automated driving

TABLE 1 - DEFINITIONS OF THE LEVELS OF DRIVING SAFETY SUPPORT SYSTEMS AND AUTOMATED DRIVING SYSTEMS

Categories		Outline	Responsibilities*	System to achieve goals on the left	
Information Provision		System provides warning message to drivers, etc.	Driver is responsible for driving	Driving safety support systems	
Automatic Control	Level 1 Standalone	System operates either the acceleration, steering or control function	Driver is responsible for driving		
	Level 2 Compounded systems	System operates multiple acceleration, steering and control functions	Driver is responsible for driving * driver must monitor and ready to drive safely at any time	Semi-Automated Driving Systems	Automated Driving Systems
	Level 3 Advanced systems	System operates all acceleration, steering and control functions, and requires driver input when requested by the system	System is responsible for driving (automated driving mode) * Automated driving under specific traffic conditions (automated driving mode) * No monitoring required (automated driving mode: before system requests driver's input)		
	Level 4 Fully automated driving	System operates all acceleration, steering and control functions without driver; No input is required to by the driver at all	System is responsible for driving * All processes completed with automated driving	Fully Automated Driving Systems	

* Note that at all levels, drivers in vehicles can take control of the system at any time

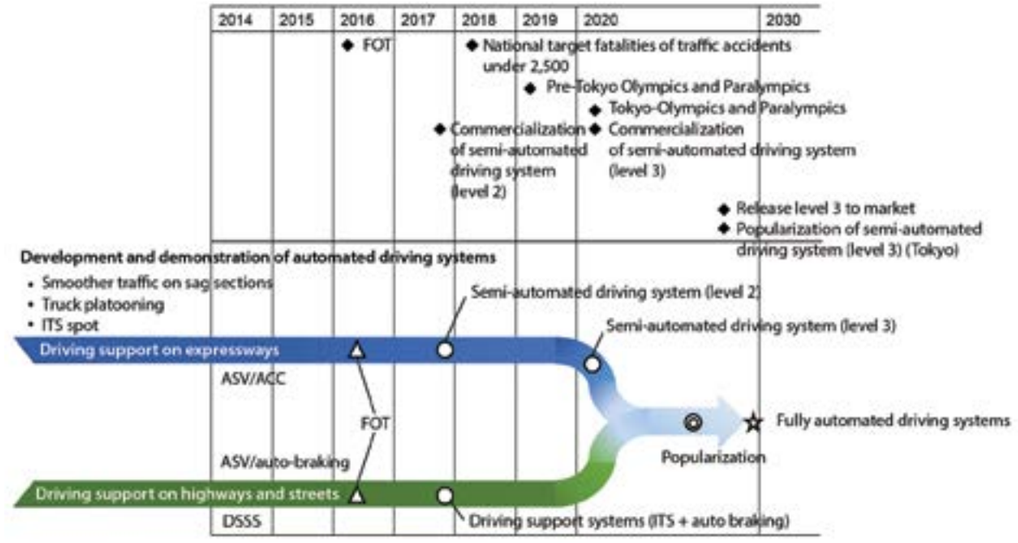

Illustration 2 - Roadmap for introducing Automated Driving Systems by SIP

systems, as well as the details of collaboration between public and private sectors for developing systems to utilize traffic data.

The *"Public-Private ITS Initiatives and Roadmap 2016"*[3] was amended by the statements of the Prime Minister in May and November 2016. In particular, the new roadmap included the development of *"semi-autopilot"* systems which is an automated driving on expressways, and mobility services by autonomous cars without driver in limited areas.

There are three key characteristics of this concept:

1. the definitions of the levels of driving safety support systems and automated driving systems *(table 1)*;
2. categorization of these systems based on the type of information collection technology (autonomous or cooperated; *table 2, next page*);
3. the strategy to include and integrate the functions of cooperative technology into those of autonomous technology as modules if necessary.

SIP Automated Driving for Universal Systems

As one of the topics under the *"Strategic Innovation Promotion Program (SIP)"*, the Council for Science, Technology and Innovation (CSTI) launched the *"Cross-ministerial Strategic Innovation Promotion Program Automated Driving for Universal Service (SIP-ADUS)"*[4] in May 2015. This SIP outlines that the competitive fields such as autonomous driving safety support systems are to be developed by private companies. Therefore, it mainly promotes development and deployment of the core technologies and cooperative fields (such as C-ITS) that require the collaboration of both public and private sectors *(illustration 2)*.

More specifically, the program focuses on *"Development of more advanced (dynamic) map information"*, *"Development and field operational tests (FOT) of look-ahead information technology using ITS"*, *"Development and field operational tests of enhanced sensing technologies"*, *"Development of Human Machine Interface (HMI) technology for drivers and autonomous driving systems"* and *"Development of enhanced technology for system security."*

Low-speed automated driving in mountainous areas

Automated Driving Strategic Headquarters headed by the Minister of Land, Infrastructure, Transport

1 Autopilot System Study Group: Interim report http://www.mlit.go.jp/road/ir/ir-council/autopilot/pdf/torimatome/honbun.pdf, 2013
2 Prime Minister's Office; Public-Private ITS Initiatives and Roadmap http://www.kantei.go.jp/jp/singi/it2/kettei/pdf/kanminits_140603.pdf, 2014
3 Prime Minister's Office; Public-Private ITS Initiatives and Roadmap 2016 http://www.kantei.go.jp/jp/singi/it2/kettei/pdf/20160520/2016_roadmap.pdf, 2016
4 Cabinet Office HP: Plan of Research and Development "Cross-ministerial Strategic Innovation Promotion Program Automated Driving for Universal Service (SIP-ADUS)" http://www8.cao.go.jp/cstp/gaiyo/sip/keikaku/6_jidousoukou.pdf, viewed on 2016.01

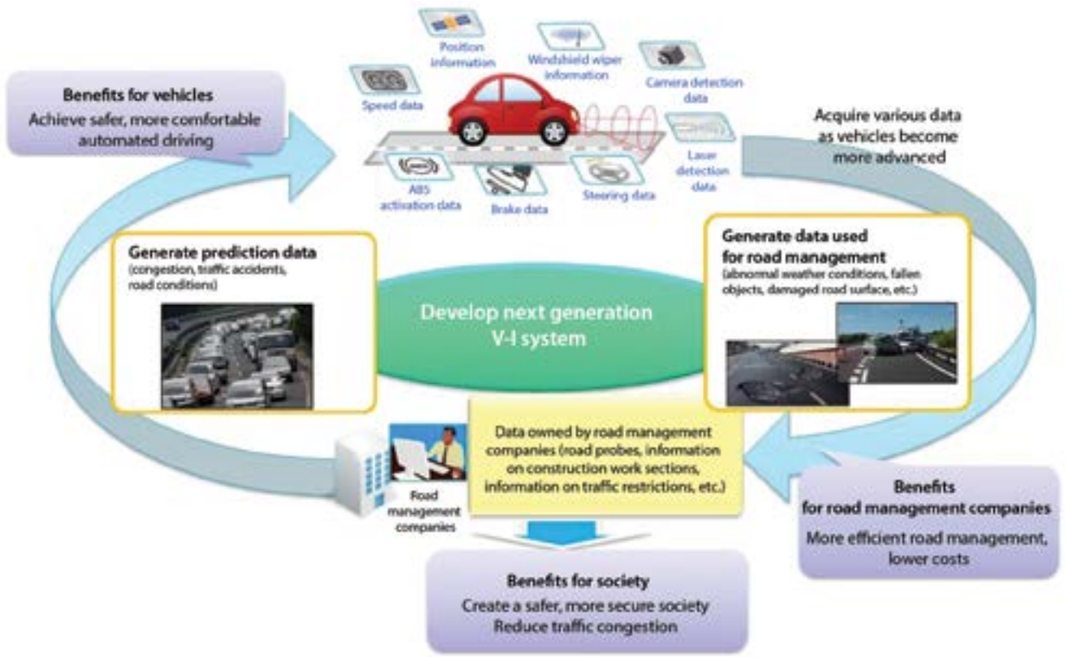

Illustration 3 - Schematic image of next-generation V-I system

TABLE 2 - TYPES OF INFORMATION COLLECTION TECHNOLOGY FOR DRIVING SAFETY SUPPORT SYSTEMS AND AUTOMATED DRIVING SYSTEMS

Type of Information Collection Technology		Details of Technology	Characteristics
Autonomous		Recognition of data such as obstacles via radar and cameras installed on vehicles	• Operates in almost all locations • Limited to "visible range" • Affected by surrounding conditions • Excellent real-time processing
Cooperative	Mobile	Recognition of various types of data from location information via GPS and map information via the cloud	• Operates in almost all locations • Can acquire information over wide area • Poor real-time processing
	Communication V2I	Acquires surrounding road traffic data from RSU (Road Side Unit)	• Operates in area of installation • Can acquire information nearby and over wide area • Excellent real-time processing
	Communication V2V	Collects location and speed data of the vehicle from equipment installed in other vehicles	• Requires other vehicles with equipment installed • Can also be used in "non-visible areas" • Excellent real-time processing

and Tourism, Keiichi Ishii, was established in December 2016 with the aim of promoting automated driving. One of their focuses to introduce automated driving is mountainous areas, where population decrease makes it difficult to maintain their public transportation services, and how to ensure daily-life travel mode for local residents (especially elderly people) is a key challenge. There seems to be a potential for level-4 automated driving with low speed, which can help people go to hospitals and shopping. To address this, MLIT began for the FOTs of automated driving services, connecting "Michi-no-eki"s (road stations) that serve as community centers in mountainous areas, with surrounding local villages. A call for private companies that could supply test vehicles was made in February 2017. Then, the relevant communities will be selected and the FOTs are planned to be carried out in this summer.

Through the tests, studies and discussions are to be made about the issues that may arise when introducing level-4 automated driving with low speed on ordinary roads; for example:

1. support from the infrastructure (i.e., for positioning, poor weather condition, maintenance and management),
2. clarification and indication of the automated driving areas (i.e., how to respond to cyclists and pedestrians, where to drive on roads, etc.).

STUDY ON V2I C-ITS SYSTEMS FOR NEXT GENERATION

NILIM (National Institute for Land and Infrastructure Management under MLIT) started a two-year program for the *"Joint public-private research on next-generation V2I C-ITS"* in April 2015. Seventeen private companies are taking part in this joint research, which covers three main topics:

1. roadside services (service for smoother road traffic and enhanced road management by providing information from vehicles to roadside infrastructure);
2. onboard-vehicle services (service for supporting safe driving and smoother road traffic by providing information from roadside infrastructure to vehicles);
3. common platforms (cross-platform for communication media and data processing systems for both roadside and vehicle services).

Among these, the research and development mainly progresses for the most demanded services, that is to say support for automated driving system by the look-ahead information, support for automated driving system at merging and diverging sections and measures to prevent wrong-way driving.

CONCLUSION

The Tokyo Olympics and Paralympics will be held in 2020. By that time, there should be automated driving cars around Tokyo Metropolitan Area. Everyone is invited to visit Tokyo in 2020 to experience an era of new technology. #