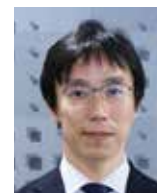


Towards the Realization of a Connected Car Society

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1. Introduction

Broadly speaking, the evolution of motor vehicles in recent years has progressed in two directions: self-driving and connected vehicles.

With the aim of promoting connected car technology and creating a connected car society against a background of developments in the 5th generation (5G) mobile communication system and other mobile networks, artificial intelligence (AI) and big data processing, we have studied topics including (1) new services and businesses created by the use of data, (2) the implementation of wireless communication networks to support a connected car society, and (3) measures for the construction of a safe and highly reliable platform. To this end, and with the participation of diverse stakeholders including experienced academics, automobile manufacturers, communication carriers, equipment manufacturers and providers of related services (insurance, tourism, home security, etc.), our study group was founded in December 2016, and has since held six meetings to discuss these issues.

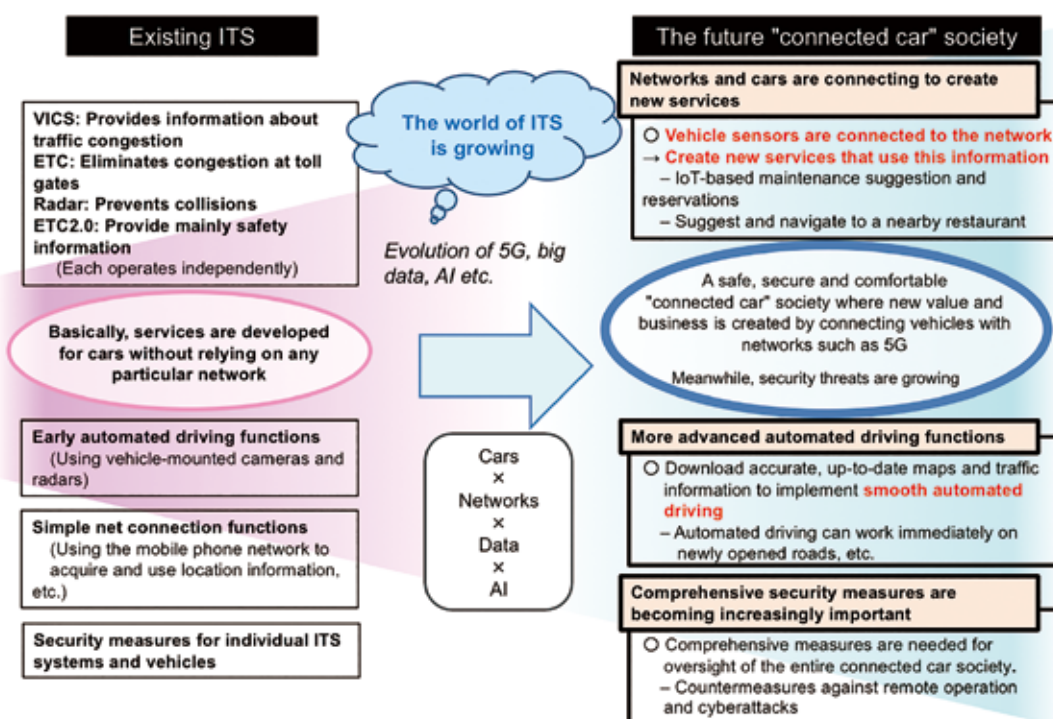
2. Study group report summary

2.1 What is a connected car?

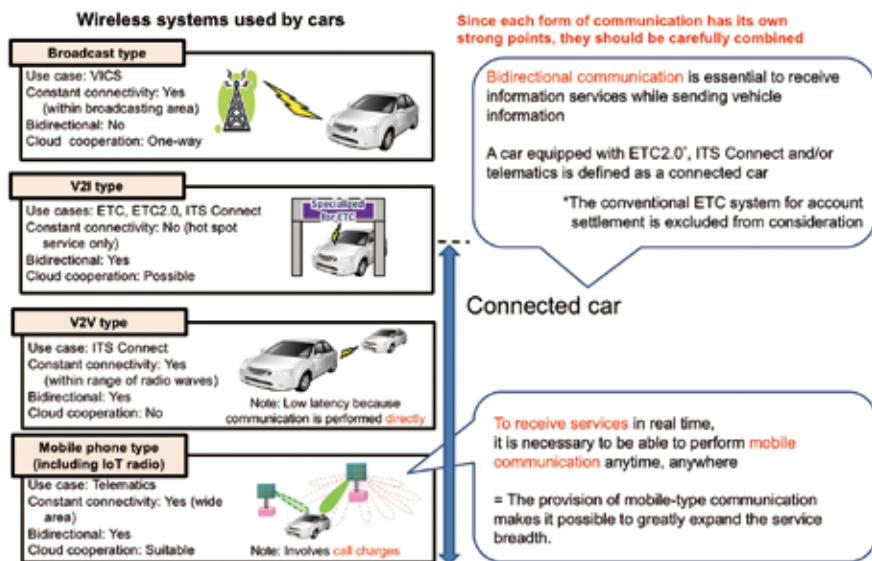
There are currently about 80 million cars on the road in Japan. Cars perform an essential role in people's livelihoods and leisure activities. As shown in Figure 1, a variety of useful ITS (intelligent transport system) technologies have been developed and used in practice, including VICS (Vehicle Information and Communication System) and ETC (electronic toll collection system). So far, these ITS technologies have basically operated independently, resulting in services that cars can without relying on any kind of network.

However, the world of ITS has recently been changing and expanding. In particular, in addition to the advances that are being made in communication networks in preparation for the arrival of 5G, dramatic changes are also being made to the vehicle environment, including advances in the application of big data in tandem with the spread of IoT technology, and the evolution of AI based on new theories such as deep learning. These changes are expected to bring about a "Connected Car Society" where

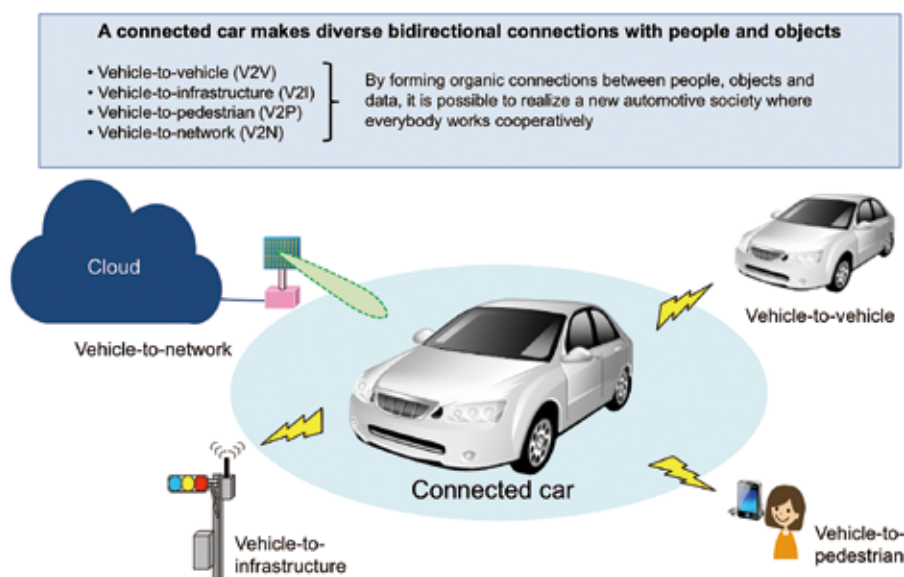
■ Figure 1: A connected car society



■ Figure 2: Connected car concept (1)



■ Figure 3: Connected car concept (2)



most cars are connected to the network, creating new value and business.

The images brought to mind by the phrase “connected car” differ from one person to the next. For the purposes of our study, we concentrated on the mode of connection and defined a “connected car” as a vehicle with the ability to communicate bidirectionally as shown in Figure 2 and 3.

In the data-driven society that is expected to be result from the use of connected cars, cars will need to be capable of bidirectional communication so that data can be collected from cars for analysis and provided to cars as feedback based on the results of the analysis.

2.2 National and international trends in connected cars

Efforts related to connected cars and automatic driving are

being actively promoted both in Japan and overseas.

In Japan, work is under way to develop technology in cooperation with industry, academia and government based on “the Public/Private-Sector ITS Initiative Roadmap”, which was drawn up by the government’s IT Strategic Headquarters on June 3, 2014 and revised on May 30, 2017. In 2014, the cabinet office created the Cross-ministerial Strategic Innovation Promotion Program (SIP), which included automatic driving systems among its ten themes. Research and development efforts were then promoted with the participation of related government ministries and agencies.

Connected cars and automatic driving are also becoming global trends, especially in developed countries that are actively pursuing connected cars and automatic driving as sources of innovation.

In 2016–17, for example, the European Commission invested about €100 million in projects related to automated driving in a project called “Horizon 2020”, and is working on projects with practical goals such as infrastructure improvements, demonstrations on public roads, and evaluating the acceptability of this new technology.

Meanwhile the US Department of Transportation is working on programs based on a 2015–19 ITS Strategic Plan with strategic themes that include safety improvements and increasing the efficiency of mobility systems. As a specific example, based on the same plan, they are setting up an ITS research

infrastructure called M-City including a traffic control system and high precision digital maps, and implementing demonstration experiments in collaboration with industry, academia and government.

In addition, there is growing interest in the use of mobile systems such as 4G and 5G in the ITS field, including V2X (Vehicle to everything) which is based on cellular technology. On the other hand, studies related to the use of radio waves for connected cars and automated driving are not necessarily sufficient, and there is currently a need for studies from the viewpoint of what sort of technology will gain popularity in the future.

Recently, the level of cooperation between the automobile and ICT industries has been growing at an accelerating pace around the world. This trend is also occurring in Japan, where the

major automobile manufacturers are increasingly cooperating with telecommunications carriers and cloud service providers. Similar moves are taking place at businesses based in other countries, including Volkswagen in Germany and LG Electronics in South Korea. In September 2016, three German companies — BMW, Daimler and Audi — announced that they had established the 5GAA (5G Automotive Association) to collaborate with other businesses including communication equipment manufacturers and semiconductor manufacturers in the development of connected car services using 5G technology. Since then, the 5GAA has been growing, and its members now include dozens of communication providers and equipment manufacturers, including some from Japan (Figure 4).

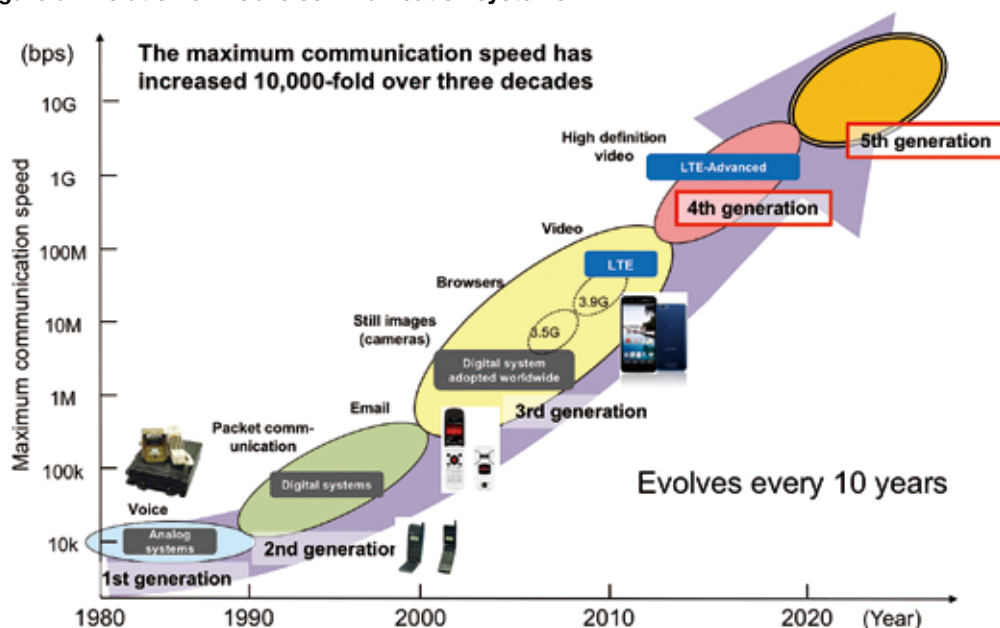
Efforts relating to connected cars include the evolution of mobile communication systems. 4G is currently in widespread use, but efforts are under way to introduce 5G technology from 2020. As shown in Figures 5 through 7, this will result in ultra-fast communication, support for large numbers of simultaneous connections, and ultra-low latency. In Japan, R&D and demonstration trials of 5G are already under way.

Some automobile manufacturers are planning to standardize in-car communication equipment to make it compatible with almost all vehicles sold in Japan and US by 2020. One of the benefits of connected cars is that they are able to communicate at any time over a wide area, and it is expected that this capability will contribute to the expansion of services.

■ Figure 4: Collaboration between the automobile industry and the communication industry (5GAA)



■ Figure 5: Evolution of mobile communication systems



Furthermore, if 5G systems become available at any time for high-speed, large-capacity and low-latency communication, then further improvements of services can be expected such as VR and advanced inter-vehicle communication available in cars.

As shown in Figure 8, progress is being made in other countries. For example, the automotive field is one of the main fields of 5G utilization in Europe and is interested in the 5G development for vehicles, so it will be interesting to see how 5G develops in this field.

As can be seen from the abovementioned activities of the 5GAA, the use of 5G in the automotive field is attracting interest not just in Japan but throughout the world. We must ensure that Japan plays a key role in the future of the connected car market by successfully seizing the opportunities presented by the introduction of 5G.

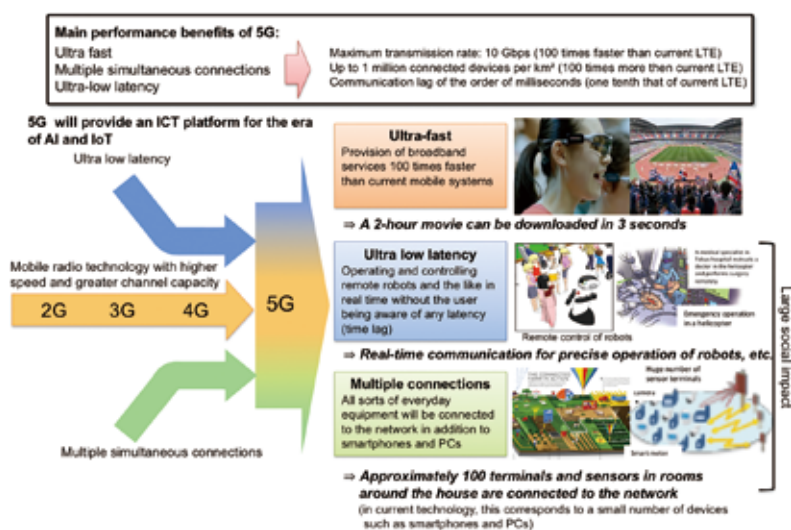
Trends related to AI including automated driving are also important movements with regard to connected cars. The performance of AI has recently improved due not only to technical breakthroughs such as deep learning but also to the increased computing power and the decreasing cost of memory, and the technology has evolved greatly over the last few years. For example, although there was once the accepted opinion that AI would be unable to defeat humans in the game of Go, where each move has to be selected from a huge number of possibilities, there have already been cases where professional Go players have lost to AI systems.

As shown in Figure 9, earlier systems achieved automated driving by relying on physical infrastructure such as tracks or magnetic markers to estimate the vehicle's position and perform steering. However, with advances in AI, it has become possible for vehicles to recognize their surroundings by means of on-board equipment such as sensors and radars, and by combining the information with high-precision maps, we can now expect vehicles to analyze and estimate their position and steering by themselves.

AI used in automated driving has the potential to bring about profound developments in ITS. As shown in Figure 10, when driving support is performed using conventional ICT, the road traffic information is conveyed to the driver, but since it ultimately has to be provided to the driver after it has been transformed into a form that can be understood by the driver (e.g., on displays), there are limits to the amount of information that is available. However, in automated driving vehicles, the AI processing is all performed digitally at high speed, so the amount of information available can be dramatically increased.

As a result, in the future ITS centered

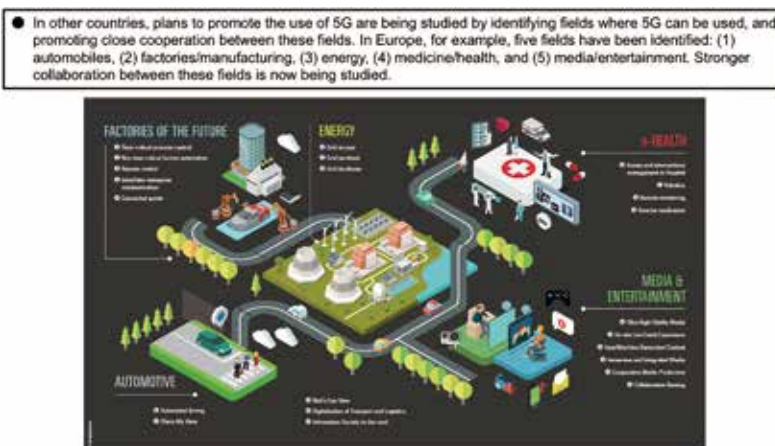
■ Figure 6: 5G requirements



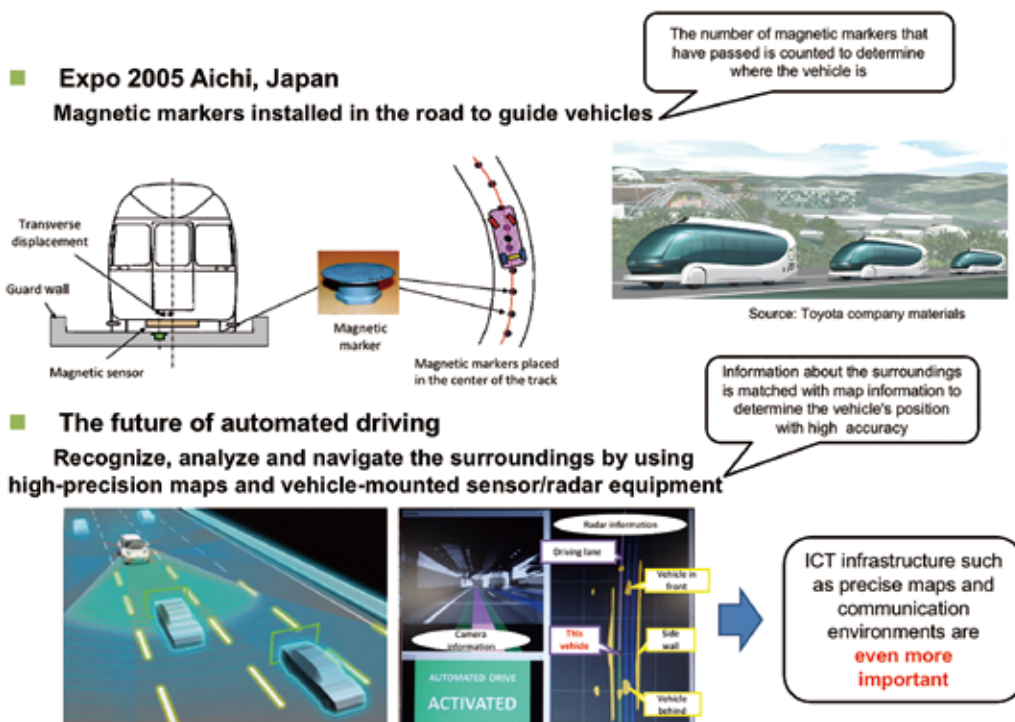
■ Figure 7: R&D and integrated demonstration trials aimed at the realization of 5G



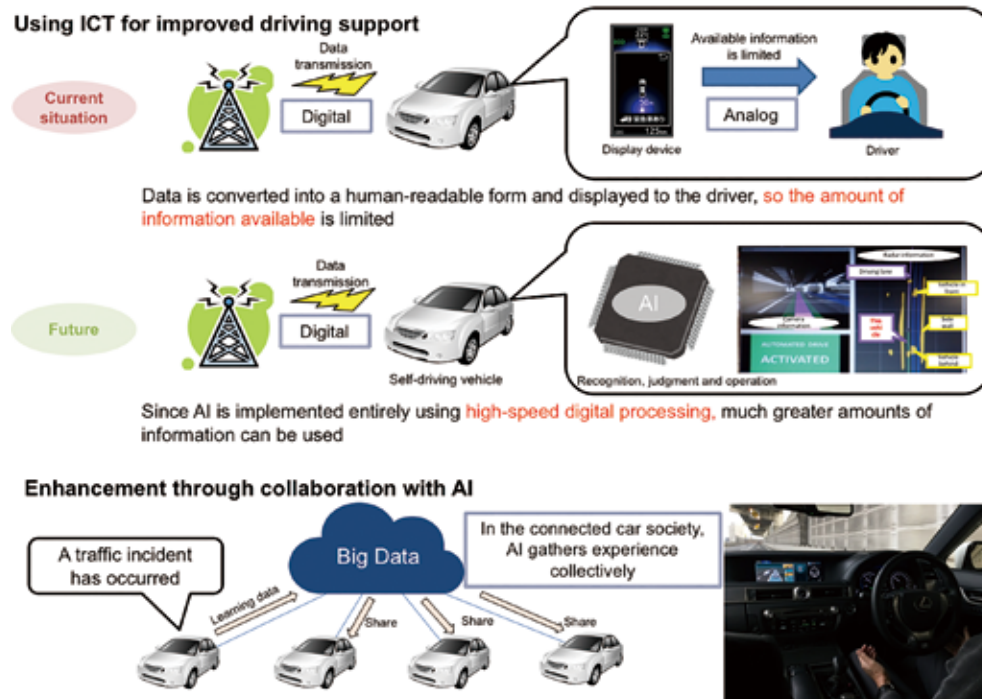
■ Figure 8: Cooperation between multiple fields in 5G (European example)



■ Figure 9: The effect of AI on automated driving



■ Figure 10: The potential of automated driving AI and connected cars



on connected cars and automated driving, it is also possible to use information provided through cooperation and integration between various sensors in roads and cars, and this could make automated driving safer than human drivers.

Furthermore, in a connected car society, AI data gathered by one car can be shared with other cars, thereby increasing the group awareness of all automated driving vehicles equipped with AI.

It will require medium- to long-term efforts to bring the

functions of automated driving to the critical point ("singularity") where AI will completely overtake humans in terms of safety. As shown in Figure 11, the levels of automated driving in Japan is currently defined by "the Public/Private-Sector ITS Initiative Roadmap". Basically, this roadmap adopts the definition of the SAE (Society of Automotive Engineers), which specifies six levels of automated driving from level 0 to level 5.

■ Figure 11: Automatic driving levels (from “the Public/Private-Sector ITS Initiative Roadmap”)

○ Definitions of automated driving levels (“Public/Private-Sector ITS Initiative Roadmap 2017”, IT General Strategic Headquarters, May 2017)

Level		Summary	Who is responsible for awareness and safe driving
Level 5 Full automation	An automated driving system performs all driving-related tasks	• The system performs all driving tasks (not limited to any area) • In case of difficulty, a human driver is not expected to step in	System
Level 4 High automation		• System performs all driving tasks (within a limited area) • In case of difficulty, a human driver is not expected to step in	System
Level 3 Conditional automation		• System performs all driving tasks (within a limited area) • In case of difficulty, a human driver is expected to respond appropriately to system intervention requests, etc.	System (Human driver in case of difficulty)
Level 2 Partial automation	A human driver performs all or some of the driving tasks	• The system implements a subset of tasks related to controlling the vehicle's position in the lateral and longitudinal directions	Human driver
Level 1 Driver assistance		• The system implements a subset of tasks related to controlling the vehicle's position in either the lateral or longitudinal direction	Human driver
Level 0 No automation		• A human driver performs all driving tasks	Human driver

○ When commercial automated driving systems and services can be expected (ibid.)

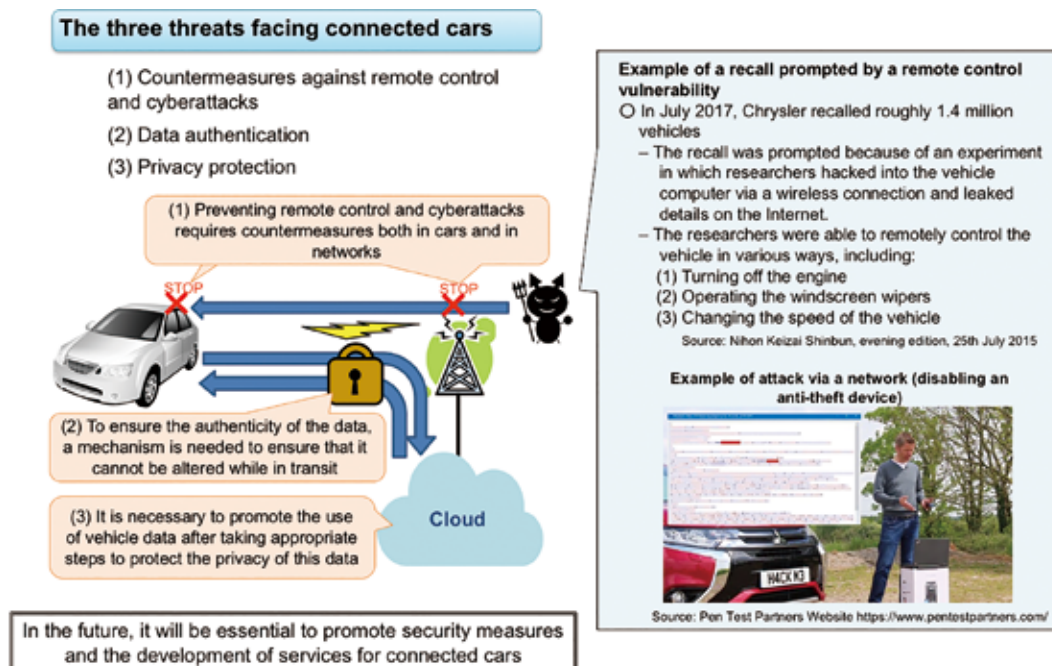
	Level	Expected technologies	When expected
Advanced automated driving	Private use	Level 4	Fully automated driving on expressways
		Level 3	Automatic pilot
		Level 2	Semi-automatic pilot
	Logistics services	Level 4	Fully automatic driving of trucks on expressways
		Level 2 or higher	Platooning of trucks on expressway
	Transport services	Level 4	Unmanned automated driving transport services in limited area
Advanced driving support	Private use	Advanced safe driving support services (tentative name)	
			(Early 2020s) Subject to future deliberation

Note 1: The 2017 Public/Private-Sector ITS Initiative Roadmap uses the definition of automated driving systems given by SAE International (the Society of Automotive Engineers) in Report No. J3016 of September 2016.

Note 2: For remote-type automated driving systems and the technology of SAE levels 3 and above, consistency with the conventions of road traffic will be a prerequisite when the time comes for commercialization. The timing of commercialization will be adjusted based on domestic and overseas industry and technology trends, including progress in the development of automated driving systems in other countries.

* Set as the target period in which the government aims to enable commercialization by private enterprises

■ Figure 12: New online threats

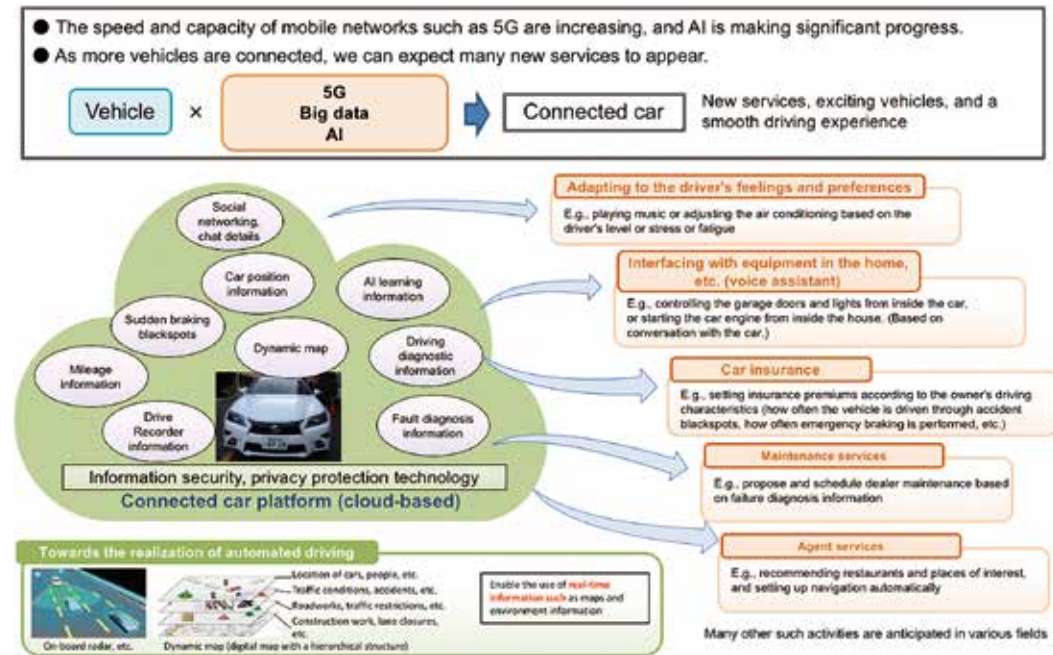


Vehicles currently on the market in Japan are said to have the functions of level 2, where driving is partially automated. A level 2 system supports the longitudinal and lateral movement of vehicles while assuming that the driver bears the responsibility for any collisions. Specifically, they include functions such as staying in the same lane while following the vehicle in front. It is expected that a greater level of sophistication will make it possible for a vehicle to change lanes based on an instruction provided by the driver, such as operating the turn signal lever.

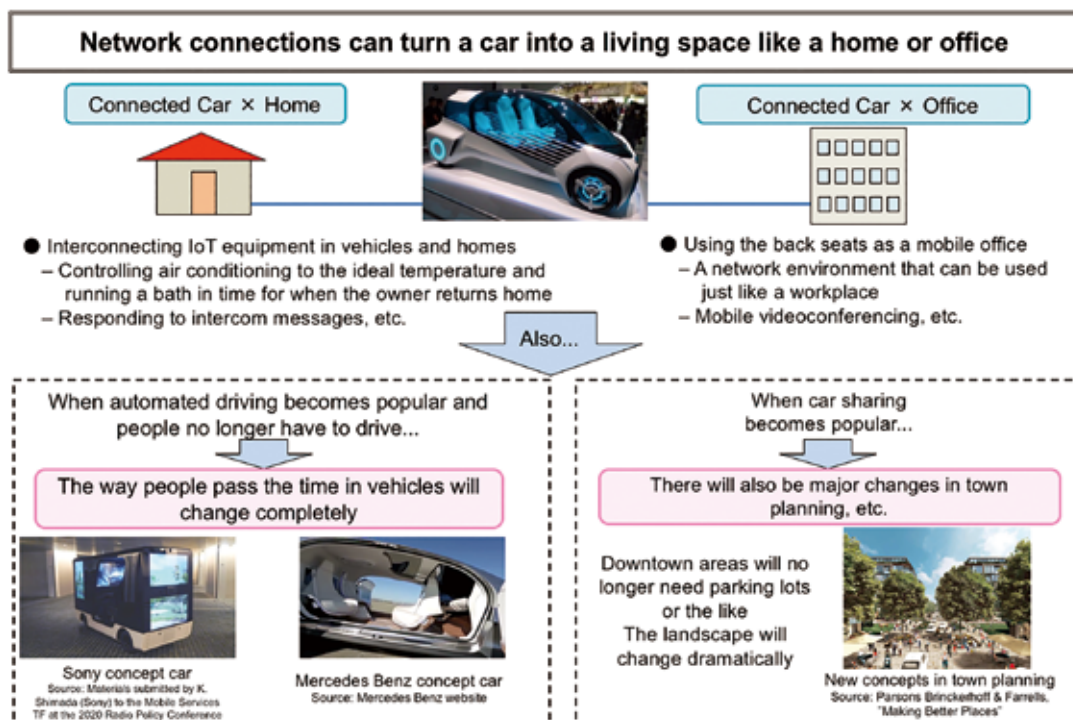
Currently, efforts are under way to develop products that are compatible with level 3 (conditional automated driving) by 2020. For example, progress is being made in the development of technology whereby driving on expressways can be almost entirely handled by automated driving systems.

Efforts are also being made to implement level 4 (advanced automated driving) in limited areas, and studies are being made of the technical and institutional aspects of this technology as a new means of transport, which is expected to promote regional development.

■ Figure 13: New services for connected cars



■ Figure 14: The potential impact of connected cars on society and lifestyles



Security is becoming an increasingly important consideration in initiatives related to connected cars. As shown in Figure 12, a connected car connected to a network can be exposed to diverse security risks, and these risks have to be properly controlled.

In particular, it is important to have appropriate measures in place to deal with (1) remote control and cyberattack threats, (2) data authenticity, and (3) privacy protection, which means that security measures will be an essential feature of the connected cars in the future. Since an attacker launches an attack by scanning the entire system for vulnerabilities, it is essential that the automobile

and communication industries cooperate with each other to ensure the overall security of their systems.

Security-related initiatives in other countries include a joint effort of the United States Department of Transportation Road Traffic Safety Authority and 18 automobile manufacturers, which have agreed to cooperate by sharing information related to cyberattacks (January 2016).

Meanwhile, the automotive and telecommunication industries in Europe joined forces by holding an EU Industry Dialogue on automated and connected driving (launched in September

2015), where they agreed to cooperate on (1) connectivity, (2) standardization, and (3) security.

Other new initiatives are also under way in the private sector. Tesla, a US electric vehicle manufacturer, has developed a bug bounty program that rewards people who report software bugs or vulnerabilities. When vulnerabilities have been detected, Tesla vehicles can download security patches via mobile phone networks, thereby keeping them updated at all times.

2.3 Expected services and businesses

This section discusses the new services and businesses that can be expected to arise as progress is made in the introduction of connected cars. In the future, as progress is made in big data technology, AI technology, and high-speed and large-capacity mobile networks such as 5G, we can expect to see various new services by connecting cars to networks (Figure 13).

These services will have the potential to bring about substantial changes to society and our everyday lives. For example,

as shown in Figure 14, by connecting a vehicle to the home or office, the driver can spend time relaxing as if he were at home, or working as he were at office. This has the potential to make traveling a much more relaxing or productive experience.

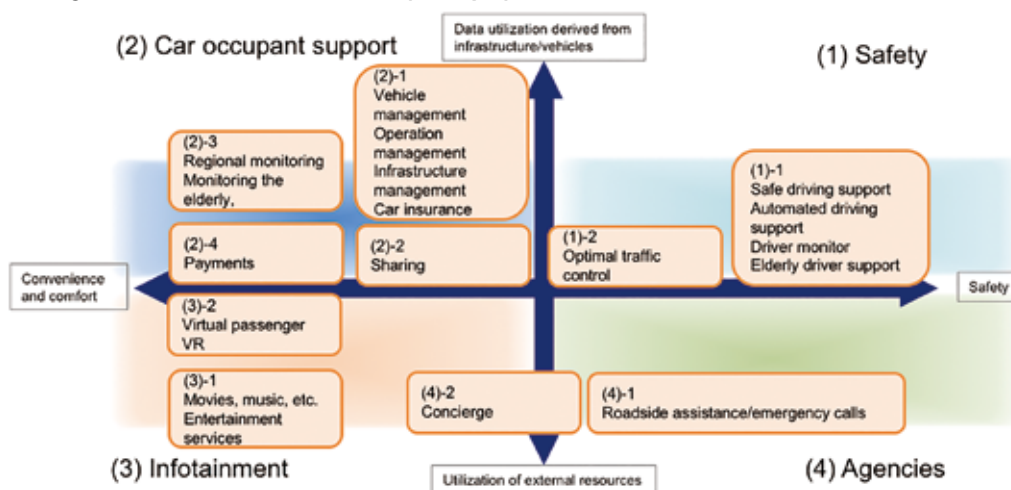
2.4 Service typing and modeling

In a connected car society, it is expected that diverse services will be provided without being limited to services that are directly related to cars. With further advances in connected car technology in the future, we can expect developments such as:

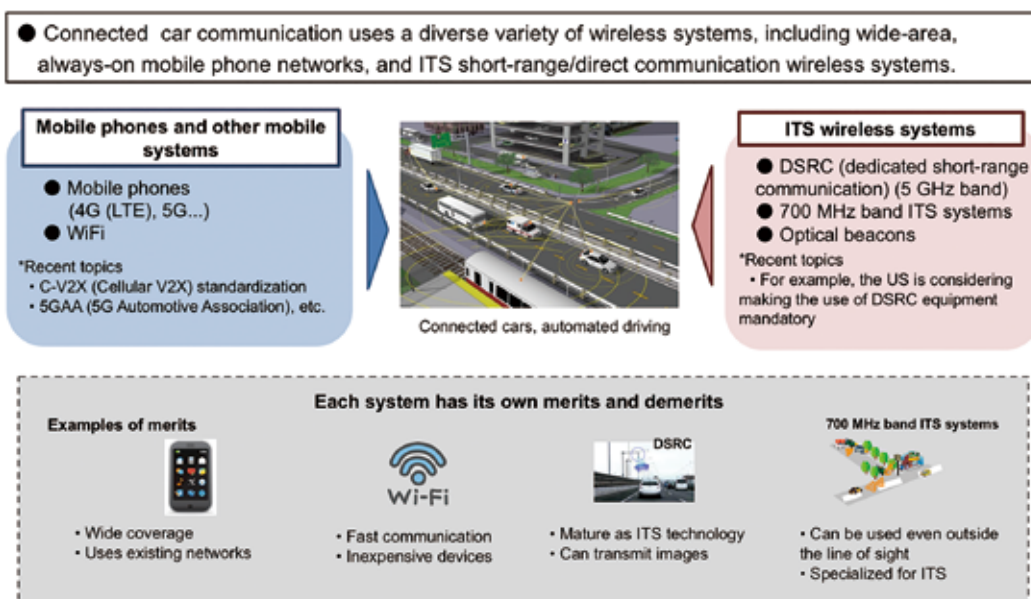
- creating new services and businesses across a wide range of sectors including tourism and entertainment,
- addressing various social issues in each region, and
- forging new ties with diverse stakeholders associated with these developments.

Assuming that a wide variety of services will be made available to connected cars, we should consider how to realize a connected car society. Firstly, it is important to organize and classify these

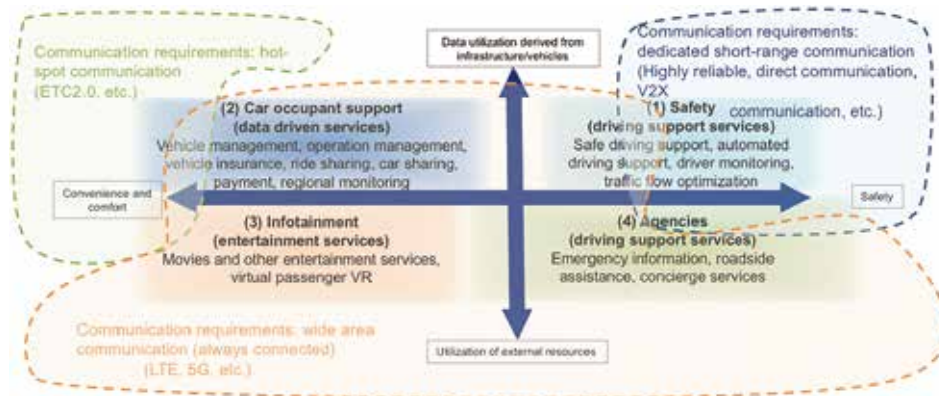
■ Figure 15: Service classification (example)



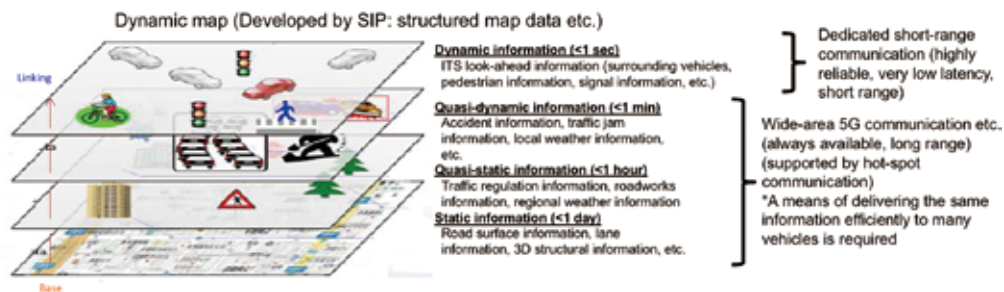
■ Figure 16: Wireless systems used by a connected car society



■ Figure 17: Communication required for the implementation of a connected car society (role-sharing of communication systems)



■ Figure 18: Communication requirements of a connected car society (dynamic map)



services.

In this study group, our most important aim in realizing a connected car society is to address social issues such as ensuring the safety and security of citizens, and providing them with a convenient and comfortable lifestyle. We defined one axis of analysis as follows:

- Is safety a primary objective?
- Is convenience and comfort a primary objective?

Furthermore, since “connected” implies the distribution of data, we defined another axis of analysis as follows:

- Is data obtained from the surrounding road traffic environment (vehicles, infrastructure etc.)?
- Is data obtained from external resources such as servers?

By classifying services according to these two axes (safety/convenience and comfort and data sources), we have grouped the diverse services provided by connected cars into the following four categories:

- (1) Safety (driving support services)
- (2) Car occupant support (data driven services)
- (3) Infotainment (entertainment services)
- (4) Agents (driving support services)

Figure 15 shows how the main connected car services can be mapped according to these two axes.

2.5 Communication requirements of a connected car society

To clarify the problems that should be solved in promoting the connected car society, it is useful to analyze what sort of communication and other technologies are needed by each kind of service.

As shown in Figure 16, connected car communication is expected to involve the use of multiple wireless systems with various features, for example, mobile phone networks offering constant coverage over a wide area, dedicated ITS wireless systems that are restricted to short range or hot-spot communication, and so on.

Since each wireless system has its own advantages and disadvantages, they must be appropriately combined to satisfy the diverse communication requirements of connected car services.

When considering the roles of radio communication systems, their characteristics can be broadly divided into three types:

Hot-spot communication: communication between a car and a server in a specific place

Dedicated short-range communication: Communication over short distances, such as between vehicles, or between vehicles and infrastructure

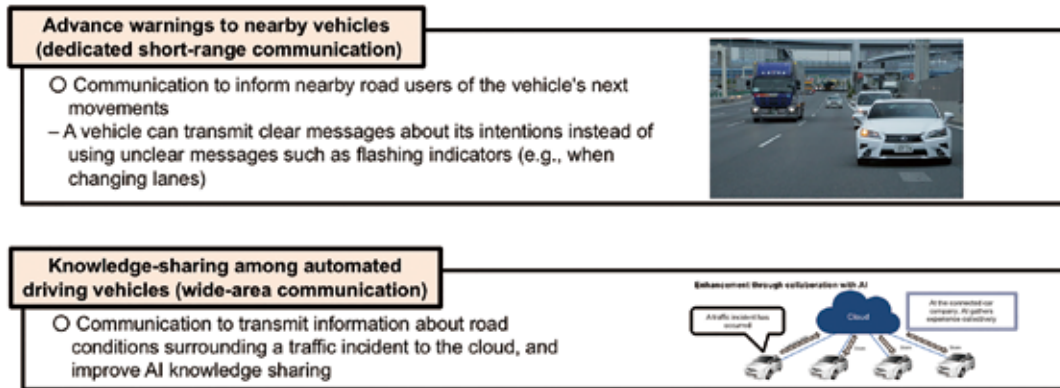
Wide-area communication: communication between vehicles and remote servers over a wide area

Figure 17 shows what sort of communication is required for each field based on the communication requirements of each individual service.

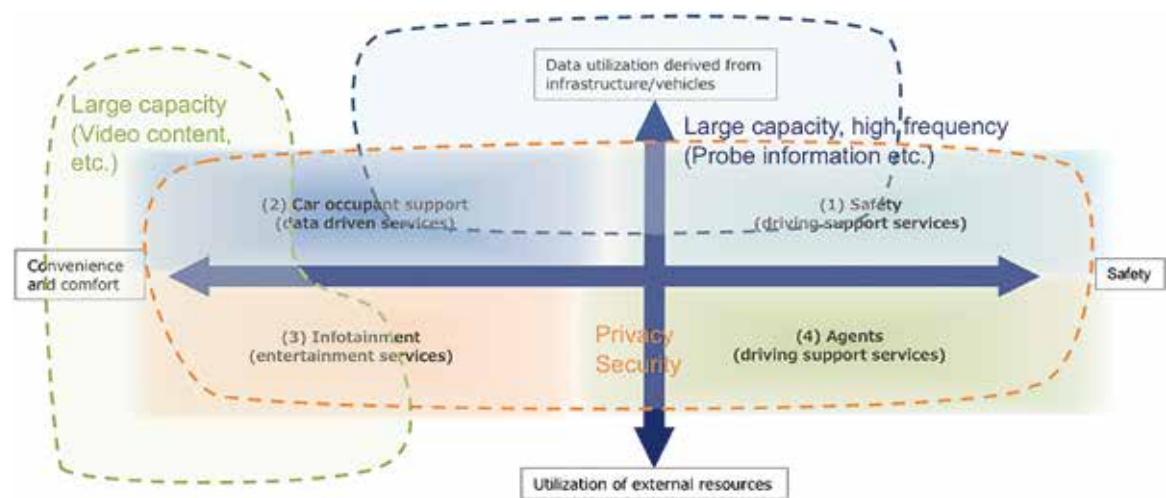
Since many different kinds of information are needed to realize and advance a connected car society, it is necessary to use a combination of radio communication systems that are suited to the characteristics of each kind of data.

Furthermore, it is expected that further improvements such as improving information precision and lowering lag times will also be required to keep up with the enhancement of services as the connected car society evolves in the future. To achieve this,

■ Figure 19: Useful forms of communication for an automatic pilot



■ Figure 20: Data needed for the implementation of a connected car society

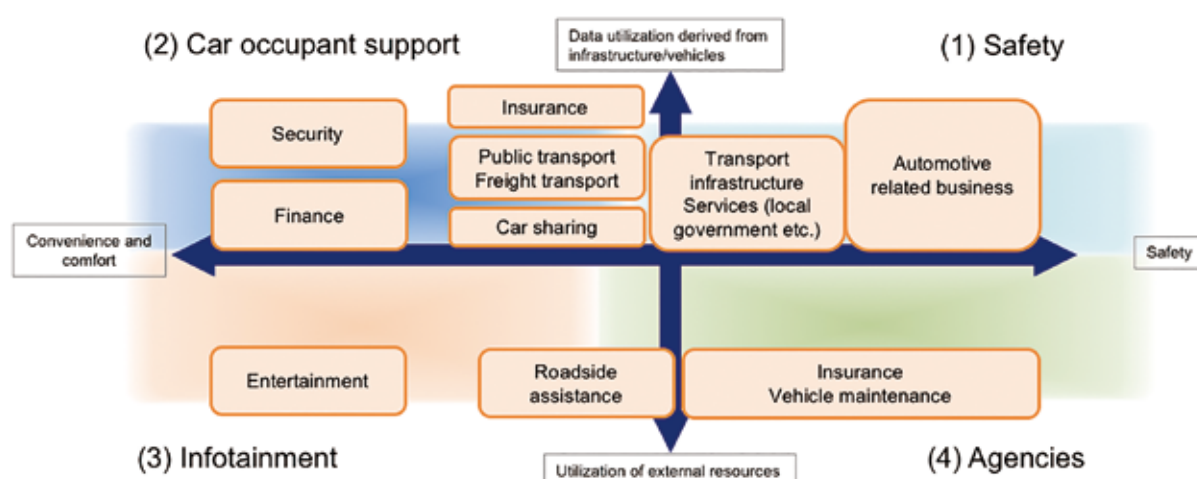


■ Figure 21: The explosive growth of data derived from vehicles

	2025 (Connected car society)	2035 (Automated driving society)
(1) Number of connected cars in Japan	Approx. 10 million (Fuji Keizai forecast)	
(2) Monthly data communication bandwidth per vehicle	Approx. 50 MB/month (Assuming a travel rate of 300 km/month)	If we include image data from devices such as cameras and LiDARs in automated driving, this could rise by a factor of 100
(3) Annual amount of communication data of all vehicles in (1)	Approx. 6 PB/year (10 million × 50 MB × 12 months)	Approx. 600 PB/year
(4) Number of servers (per year) (*Assuming the data transmitted in (3) will be stored in the cloud)	Approx. 200 per year	Approx. 20,000 per year

Source: Presentation materials by Mr. Sasaki (NTT Data) at the 3rd Connected Car Research Conference

■ Figure 22: The diverse players involved in a connected car society



it will also be necessary for the communication systems used by connected cars to evolve dynamically.

On the other hand, it should be noted that automobiles are durable consumer goods and are often used for more than 10 years from manufacture to disposal. We must therefore provide connected cars with future-proof communication systems that can support the evolution of communication systems while ensuring compatibility with existing vehicles.

For example, a dynamic map system as shown in Figure 18 consists of four layers of information linked to a high-accuracy map. These are combined for use inside the vehicle, and communication is needed to ensure that these layers accurately reflect the current situation in the outside world. Although this requires a fairly advanced level of communication, it is likely that even more advanced communication systems will be necessary in the future to keep up with the evolution of automated driving along with the need for information in greater quantities and with greater precision.

As automated driving systems become more advanced in the future, it is thought that other communication will also become necessary in addition to dynamic maps, including the following:

As shown in Figure 19, an automatic pilot is required to cooperate with AI by extending telematics services and enhancing V2I and V2V communication through the use of ITS communication.

The utilization of data is a major theme of connected cars, and this data can be classified into the abovementioned four quadrants as shown in Figure 20. Connected car services can be supported by using data with these diverse characteristics.

When considering the communication requirements of connected cars, it is also necessary to consider how the volume of data traffic will increase over time.

As shown in Figure 21, the volume of data is expected to grow explosively due to the increasing number of connected cars with more sophisticated data requirements.

In Japan, we will have to develop communication and data storage/processing infrastructures to accommodate the increased volume of data, based on the recognition that this data will

become a source of considerable added value.

2.6 Cooperation among various players

For the creation of new connected car services, it will be essential for the automobile industry to establish wide-ranging ties with other industries. For example, Figure 22 shows how relationships with various industries can be mapped to the four quadrants of Figure 15.

To realize services that are suitable for a connected car society, we should build frameworks and mechanisms for collaboration and cooperation with other industries while bearing in mind the clear division of roles of automobile manufacturers, equipment manufacturers, telecommunications carriers and so on.

2.7 Issues to be resolved in order to realize a connected car society

Our study group has identified three issues and one interdisciplinary issue as problems to be addressed in order to realize a connected car society:

[Issue 1] Construction of a reliable real-time wireless communication network

- Based on the widespread use of LTE as a general-purpose network, we will consider the technical and business aspects of various communication technologies (including newer LTE-based methods such as LTE-V2X) while keeping an eye on international trends.
- In the future, we will combine 5G and various other technologies to support services aimed at ensuring and improving the safety of communications. This will involve making improvements to characteristics such as reliability, robustness and real-time responsiveness in order to satisfy the individual requirements of these services in the best way possible.

[Issue 2] Use of data to promote the creation of new industries and businesses

- Improving the collection, storage and utilization of data

handled by connected cars requires not only technical measures but also the creation of a supportive environment (e.g., with bigger incentives to promote data utilization).

[Issue 3] Establishment of an environment for innovation and creation

- To construct a model where the added value of new services remains in Japan, we need a forum where diverse foreign and domestic stakeholders can meet the challenge of new initiatives.
- We need to establish an environment where data can be strategically collected, stored and utilized, and cooperate with local authorities to promote cutting-edge demonstration trials with diverse stakeholders. This will lead to the development of new services and promote social acceptance. By broadening the scope of these results, we will secure and strengthen Japan's international competitiveness.

[Interdisciplinary issue] Securement of privacy and security for safe and secure use

- It is important to accelerate efforts aimed at ensuring privacy and security are maintained to facilitate safe and secure use.

2.8 Measures for the implementation of a connected car society

To build the world's most advanced connected car society here in Japan, we need to strategically and comprehensively address the issues discussed in the previous section.

Promoting the Connected Car Society Project shown in

Figure 23 should be an effective way of achieving this.

A specific problem-solving approach could be to set up projects corresponding to each of the three issues mentioned above, and to promote collaboration between these projects while using testbeds to resolve interdisciplinary issues.

To promote each project, we will set up and work from an advanced model based on the specific use of each technology.

[Responding to the construction of a reliable real-time wireless communication network]

- The Connected Network project
 - Edge computing utilization model for driving support
 - Infrastructure cooperative driving support model
 - Vehicle-to-vehicle information sharing model

[Responding to the use of data to promote the creation of new industries and businesses]

- The Connected Data project
 - Efficient data collection model
 - A cloud data utilization model that offers convenience and comfort

[Responding to establish an environment for innovation and creation]

- The Connected Platform project
 - System architecture model
 - Cooperative platform model

[Ensure privacy and security for safe and secure use]

Privacy and security are defined as interdisciplinary issues in each project. We will accelerate initiatives such as using a

■ Figure 23: Connected Car Society Project

Project name	Model name	Concept
Connected Network Project Optimize and improve the functions of reliable real-time radio communication systems that support driving by appropriately connecting with information systems, infrastructure sensors and other vehicles	Edge computing utilization model for driving support	The ultra-fast response times of edge computing are used to improve safe driving and automated driving support services that are required real-time performance and severe restriction of lag
	Infrastructure cooperative operation support model	Provides better driving support by using various communication technologies including LTE and millimeter-wave communication to connect between roads and the vehicles (V2I radio system)
	Vehicle-to-vehicle information sharing model	Information about each vehicle's future movements is shared with other vehicles by various forms of communication such as LTE and millimeter wave communication to support automated driving (V2V radio system)
Connected Data Project Efficiently gather and store diverse kinds of data produced by vehicles by using radio systems suited to the current situation, and use this data appropriately via the network	Efficient data collection model	An efficient mechanism for collecting and rapidly organizing data by segregating and smooth switching between various communication methods
	A cloud data utilization model that offers convenience and comfort	Effective storage and cloud processing of collected data to implement services such as prediction and optimization that contribute greater convenience and comfort
Connected Platform Project By designing and evaluating a system architecture that supports a connected car society, create an internationally competitive connected car platform that can be used by diverse stakeholders	System architecture model	Design and evaluate a system architecture for all connected cars, including data centers that can support huge amount of uploads of vehicle information and advanced information processing for driving support
	Cooperative platform model	Make a model to efficiently promote shared use of data, and build a platform where diverse stakeholders can collaborate

testbed while developing stronger systems for ensuring privacy and security.

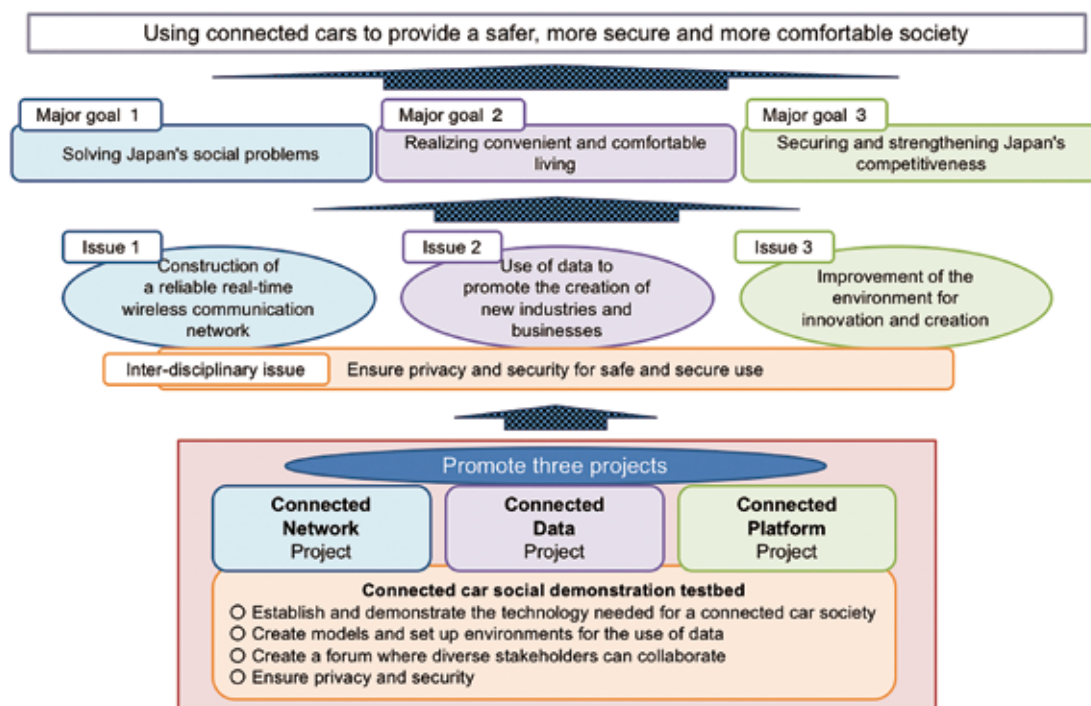
With this Connected Car Society Project, as shown in Figure 24, we aim to implement a safer, more secure and more comfortable society with connected cars while achieving our major goals by solving individual issues.

2.9 Connected car society road map

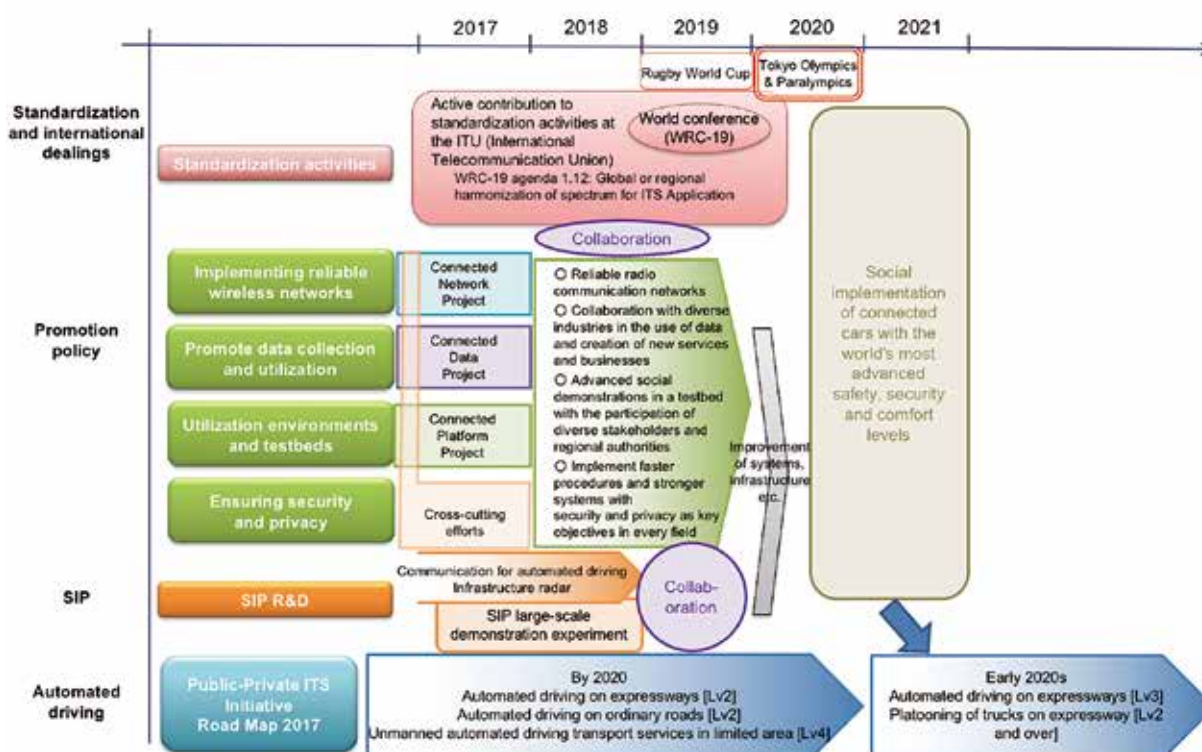
Figure 25 shows the roadmap for realizing a connected car society, which was formulated based on the government's overall strategy on automatic driving technology in the "2017 Public/Private-Sector ITS Initiative Roadmap".

In this roadmap, we decided to promote the Connected

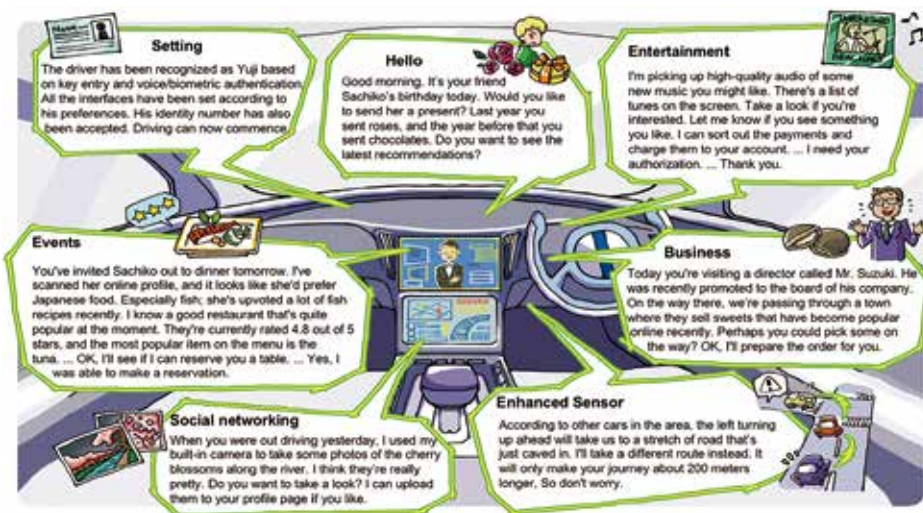
■ Figure 24: Measures for the promotion of a connected car society



■ Figure 25: Connected car society roadmap



■ Figure 26: Conceptual image 1 (concierge service)



Various sensors installed in a vehicle are connected to the network and seamlessly connected with online services. As shown in Figure 26, this makes it possible for the vehicle to offer concierge services that make various recommendations to the driver.

Also, by using a supercomputer that instantaneously processes information obtained from connected cars and other sources, it could be possible to optimize traffic flow, avoid congestion and promote safe navigation. It is expected that this will lead to the emergence of smart cities, where the entire city constantly learns and evolves autonomously based on this data processing capability (Figure 27).

3. Main points of discussion and issues raised at the meeting

This section summarizes the discussions on the major issues that are covered in the study group: infrastructure development, security, costs, and testbeds.

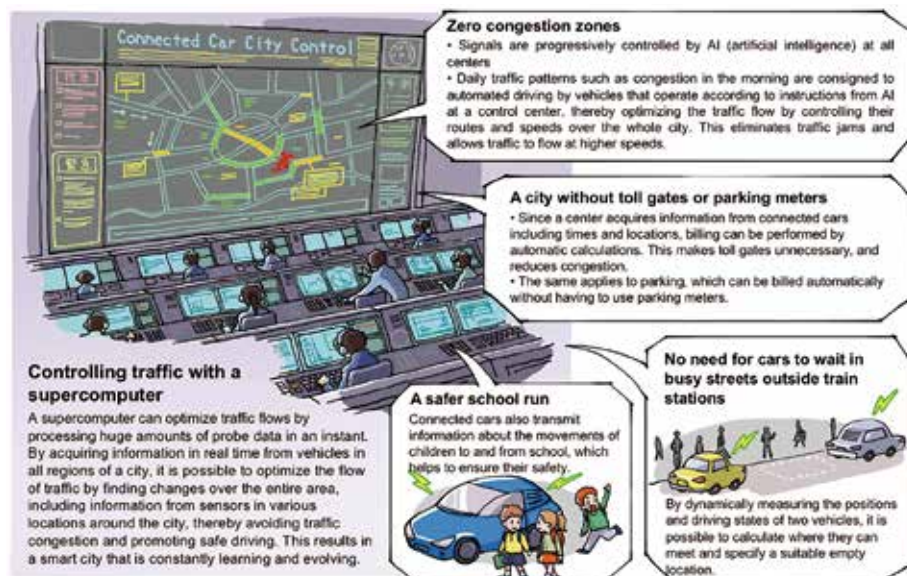
3.1 Infrastructure development

3.1.1 The role of each player

Building and maintaining a connected car society entails the establishment and operation of a new communication infrastructure.

Recently, attention has been drawn to V2X technology based on the cellular technology used in mobile phones. In the past, cellular technology with relatively large latency was basically used for infotainment purposes such as downloading maps. However, due to

■ Figure 27: Conceptual image 2 (smart city)



Car Society Project as a core initiative in conjunction with SIP activities and standardization activities at the ITU.

Specifically, we have decided that from FY2018 we will work on the development and demonstration of technologies that are assumed to be necessary for specific usage models, and we will utilize a test bed where diverse players are able to participate.

Through these efforts, we will implement the world's most advanced safe, secure and comfortable connected car society by 2020 by not only enhancing the capabilities of connected cars themselves, but also by treating them as tools for new mobility services and businesses, and we will also contribute to the realization of more advanced automated driving technology.

2.10 Conceptual images of a connected car society

For reference, a concrete conceptualization of a connected car society is described below.

advances in technology such as mobile computing and edge computing, the latency has been reduced. Cellular technology is now starting to be deployed in a wide range of applications including safety support. However, this raises the question of who installs and operates the communication infrastructure that makes up these cellular networks, such as cloud computing and edge computing.

The cost of installing communication infrastructure can be borne by the public sector, or by private business. In a connected car society, since a very diverse variety of stakeholders are involved, it is essential to sort out the role to be performed by each stakeholder. For example, it would be reasonable for facilities such as communication base stations to be installed either by communication carriers or by road administrators. There could also be cases where other stakeholders such as traffic managers might be involved.

To enable the communication infrastructure itself to develop soundly, some areas need to be standardized as a common infrastructure while others need to facilitate competition between businesses, and this also affects how the facilities are deployed and operated. From now on, it is important to firmly discuss how roles will be shared among the public and private sectors.

3.1.2 Improvement of communication infrastructure

The discussion of communication infrastructure for the construction of a connected car society was based on the premise that servers and networks could be used freely. However in other countries, there has been a high degree of specialization of servers, operating systems, CPUs and the like, and it is becoming impossible to build systems that can be used freely by combining general-purpose components. There was also a discussion of how it is not possible to rule out the possibility of a society where all the systems related to connected cars in Japan depend on foreign components and are operated in large-scale cloud services situated overseas.

In the world of ICT, there is a tendency for a small number of global players to dominate the industry. This move towards global consolidation will continue to accelerate. Unless Japan gets involved in this movement, we run the risk of becoming sidelined. We must therefore consider what sort of role we are going to play. As systems are consolidated and moved to cloud, ultimately all that is left is data. It is vital that each industry and business considers how to protect data in the future.

As for the servers, it is thought that the scale of data collected from vehicles will grow exponentially in the future, which raises the question of how this data will be stored. The volume of data currently being collected corresponds roughly to that of a Controller Area Network (CAN). But when big data becomes widespread, data collected from vehicle control information, video cameras and so on will also be uploaded to data centers. If every car in the country functions in this way, we will need an enormous group of servers to handle all the data. It would be difficult for a single manufacturer to invest in this infrastructure independently. But if we rely entirely on overseas servers, all the data will go abroad and we will lose not only the ownership of the data but also all of its value.

On the other hand, if there is a delay of several milliseconds in round-trip communication between Japan and the US, it may not even be possible to use overseas servers from inside Japan. In fields such as connected cars where response time is particularly important, it will be necessary to construct certain systems in Japan.

Also, if people depend on foreign operating systems and CPUs because they are cheap and convenient, there will be nothing left in Japan in the future. Japan will also have no resources for dealing with any problems that may develop in the future.

For this reason, it is very important for Japan to maintain a certain level of technology and to create circumstances where it is possible to supply and operate equipment domestically. Demand for cloud-based data management will rapidly increase in the future. Even though some companies may seem to have a large share now, the absolute size of these shares will seem tiny in 10 years. Instead of depending on overseas providers, it is essential

that Japan constructs its own technology.

One of the major issues is how to establish a communication infrastructure at a national level. In realizing a connected car society, it is important to think about how to build mechanisms that add value in Japan. From now on, we should reduce the entry barriers in this field, perform testbed studies, and consider the role each stakeholder should play.

3.2 Security

3.2.1 Viruses

In general, cyber criminals use various direct and indirect means to attack products and servers. Since a malfunctioning connected car is potentially a risk to human life, security measures are particularly important.

Recently, viruses called “cyber debris” have caused problems. For example, there is a computer virus called Slammer that was actually released fourteen years ago but is still active. Some viruses can be very difficult to eradicate once they have made it out into the wild. Since connected cars usually have a very long life, they must be able to deal with this sort of threat.

Also, viruses called bots have caused in the telecommunications industry for a long time. Unlike debris, bots are viruses that can remain dormant for a period of time without anyone knowing how or when they entered a system, until some later date when they become active and cause problems. By this stage, they cannot be blocked at the entrances to the system because they have already made it past the system’s defenses. Although it is very important to apply communication security measures and software updates as quickly as possible, it is difficult to find bots that have already made it into the network.

3.2.2 Security

Although connected cars can be thought of as a type of IoT, cars and their on-board equipment tend to have targets that are more clearly defined than those of ordinary IoT equipment. As a result, it can be easier to handle their security requirements. For example, the world of IoT includes items whose owners are unknown, whereas a connected car is obviously owned by someone, as can be demonstrated by performing proper authentication. However, viruses are not always delivered by intrusions from the outside. In some cases, backdoors can be formed in the original components of a system, or a bot may be hidden within its software. Even if no problems arise at the testing stage, a system can still be vulnerable to attack. Therefore it is necessary to guarantee the origins and authenticity of products and components used in a connected car.

Also, if an incident such as hijacking is detected in a connected car network, it is possible to adopt a new viewpoint by linking the vehicle’s emergency measures and cybersecurity measures, such as using the automated driving functions to make the vehicle stop suddenly at the side of the road. On the other hand, getting the car to stop may have been the original purpose of the cyberattack, so it is also possible that the vehicle’s emergency stop function could be targeted and abused.

Security measures generally assume that there will be incidents that have to be dealt with retroactively after they have taken place. This is equivalent to the way people resort to surgical or

medical remedies when they get sick or injured. In both cases, it is necessary to stop before getting back up again. For example, when assessing a human patient with an unknown condition, a doctor will collect various data, listen with a stethoscope, look at the patient's state of health, and combine this information with many years of experience and medical knowledge to make a diagnosis and decide what measures to take. If a similar diagnostic process can be applied to the big data collected by servers from connected cars, it might be possible to prevent security incidents before they actually occur.

Security is an essential factor in the use of data in connected cars. Since security is an ongoing battle and connected cars take charge of human life, the security measures must be updated constantly. From now on, we must engage the public and private sectors on the issue of connected car security.

3.3 Costs

It is well-known that the free use of data collected by connected cars in diverse locations will have far-reaching benefits. However, while the data gathered by connected cars is public data, it is also private data collected through the efforts of each company involved. The positioning of the data is therefore very important. We must consider how to compensate for the social costs of sharing data within or between industries. However, the connected car society is expected to become an enormous ecosystem involving vehicle manufacturers, parts manufacturers, communication carriers, cloud service providers, servicing companies, and companies that generate and lease out secondary data. Since the data is expected to be created, stored and used in different places, this makes the issue very complicated. We must discuss how an entire country or industry can cover the cost of promoting mutual utilization of data collected by connected cars.

The cost of maintaining and updating security and other systems is expected to be huge, but since this is essential for ensuring safety, we must also consider how these costs will be shared.

Unless these matters are studied in depth, it will be difficult for society and individuals to accept a connected car society. It has been estimated that the infrastructure investment costs of a connected car society could exceed ¥1 trillion per year. If we are not conscious of the need to engage in a project of such size in the future, then we will not progress beyond the discussions of technology. In the future, it will also be important for the public and private sectors to unite and discuss cost sharing.

3.4 Testbeds

The field of connected cars involves various stakeholders from diverse industries, including automobile industry, telecommunications industry and service industry, as well as national and regional governments. These will have to be brought together in order to resolve issues and make the connected car society a practical reality.

The automobile industry has traditionally excelled at implementing its own safety measures such as CO2 reductions and NCAP safety tests. However, the creation of completely new technologies and services that cross between different industries will benefit from the provision of a testbed. A testbed

is a place where it is possible to try out new approaches one after another in a short period of time. It is felt that this is a preferable development environment because it is possible to switch to the next idea straight away if one idea fails. Since multiple stakeholders cooperate not only with desktop studies but also with actual designs in the testbed, this should promote technical innovation, the use of diverse technologies, and the combination of different use cases to create new ideas that can be used in the creation of a connected car society.

On the other hand, there are various questions we will have to answer. Will Japan simply follow other countries who lead based on the development of connected car networks and cloud technology resulting from over a trillion yen of investment? What sort of technology will we use, and what will we do with it? What sort of characteristics should our testbed have? For example, if we perform R&D with other businesses and industries using previously unavailable probe data in new methods, this could become globally unique. Also, on the infrastructure side of things, there are, for example, about 200,000 traffic lights in Japan, only about 100 are currently equipped with sensors that can communicate with cars. If all the traffic lights in some region could be equipped with these sensors, then this would create a testbed not available anywhere else in the world.

Currently, the Ministry of Internal Affairs and Communications shares the personal information of volunteer visitors to Japan with hotels and cultural facilities as part of its "IoT Hospitality Cloud Business" initiative. We are performing demonstration trials in which the information is used to provide various services, and in FY2016 the number of participating tourists reached approximately 2,000. However, a number of restrictive and technical issues came to light. Unless we proactively engage in characteristic projects like this, there will be little point in us repeating the work of studies that are already being performed in other countries. In the future, we hope to discuss the specific details of the testbed in more depth, and gather opinions from many other fields of industry.

4. Future initiatives

Through six study group discussions, we have carried out an analysis of the current situation and the tasks to be performed in order to realize a connected car society. The Ministry of Internal Affairs and Communications also plans to promote efforts toward realizing a connected car society based on the points raised in this study. On the other hand, connected cars represent a new field that combines automobiles and communication, and the stakeholders involved in this technology are far more diverse. Since we have to trust our cars with our lives, it is not sufficient to pursue the idea of a "best effort" as in other fields. Instead, we must build systems that reliably ensure the safety of drivers and pedestrians. In this sense, it will become necessary to promote the development of technology while checking that the technical requirements match the actual situation of road users and their needs. The government as a whole will go ahead with full-scale field demonstration tests with the aim of realizing a connected car society.