SIP-adus: An Update on Japanese Initiatives for Automated Driving

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Abstract This is a report on the latest SIP-adus activities. SIP-adus is a five-year research program on connected and automated driving led by the Japanese government that began in 2014. Beginning in 2016, the project prioritized five themes (Dynamic Map, human-machine interfaces (HMI), cyber security, pedestrian collision reduction, and next-generation transport). Large-scale field operational tests started in October 2017 around Tokyo area in order to integrate and evaluate achievements. The tests are open to global entities, and more than 20 entities have participated to date.

Keywords Automated driving · Automated vehicles · Connected vehicles
Dynamic map · Human factors · Field operational test · Cyber security
SIP-adus · Japan

1 Overview of the SIP-Adus Program

The Japanese government's Cross-Ministerial Strategic Innovation Promotion Program, called SIP, was started in 2014 as a five-year project. SIP aims to realize science, technology and innovation through basic research, application research and commercialization, with cross-ministerial cooperation. The project for automated driving systems for universal service (adus) was chosen by SIP as one of 11 research themes [1, 2].

The governmental framework for the promotion of connected and automated driving systems includes four relevant ministries and agencies under the leadership

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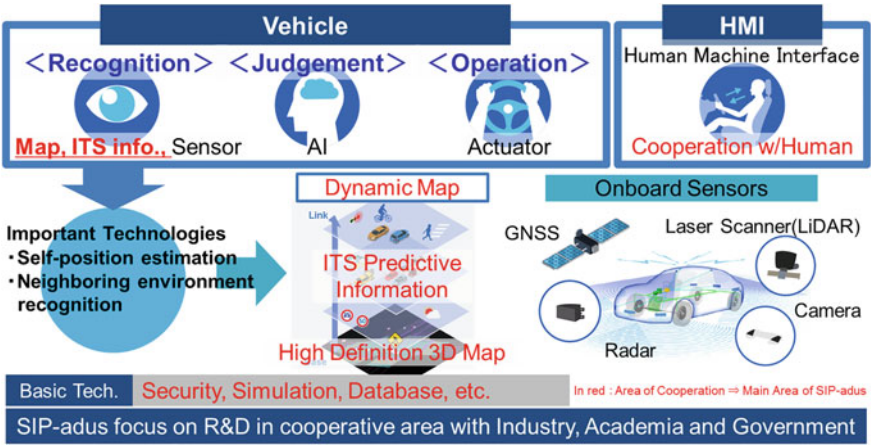

Fig. 1 Technologies for automated driving systems and SIP-adus focus areas

of the Cabinet Secretariat and the Cabinet Office. The responsibilities of the Cabinet Office are comprehensive planning and coordination function for R&D promotion on automated driving systems. Connected and automated driving systems, which provide benefits to our society, require collaborative efforts among government, industry and academia.

When starting SIP-adus, reducing the number of traffic fatalities was set as the goal with the highest priority. Automated driving systems are thought to have major potential for reducing traffic collisions. The second goal was to realize and spread automated driving systems as soon as possible. The third goal was to realize a next-generation urban transport system in time for the 2020 Tokyo Olympic and Paralympic Games.

For automated driving systems, it is necessary to develop various technologies, such as high performance on-board sensors like cameras or radars for recognition and artificial intelligence for judgment. Automakers are competing to develop these technologies now. In SIP-adus, it is challenging to cover all relevant themes with the limited resources available. Therefore, among all themes, the subjects in red shown in Fig. 1 were selected and classified as cooperative field technologies. Beginning in 2016, the project prioritized five themes (Dynamic Map, HMI, cyber security, pedestrian collision reduction and next generation transport). These activities are being conducted in cooperation with industry and academia.

2 Progress of SIP-Adus in the Focus Areas

In this chapter, progress in the five focus areas is reported.

2.1 Dynamic Map

Figure 2 shows a concept of Dynamic Map. Dynamic Map consists of a highly accurate 3D map and dynamic data. It is conceptually composed of four layers: static data, semi-static data, semi-dynamic data and dynamic data. This Dynamic Map database is thought to be useful not only for automated driving vehicles, but also for all other vehicles and drivers on the road.

As Dynamic Map data should be fresh, the ease with which data can be updated is important. Also, scalability, low cost and security are required. Since it is a large burden for auto makers and map suppliers to prepare their own maps independently, Dynamic Map was determined to be an area of collaborative interest, and Dynamic Map database is to be established with government and private sector cooperation.

In the future, almost all vehicles will be equipped with sensors, such as cameras and radars, and data communication modules. Probe data will help update map data, which will decrease the cost of Dynamic Map (Fig. 3).

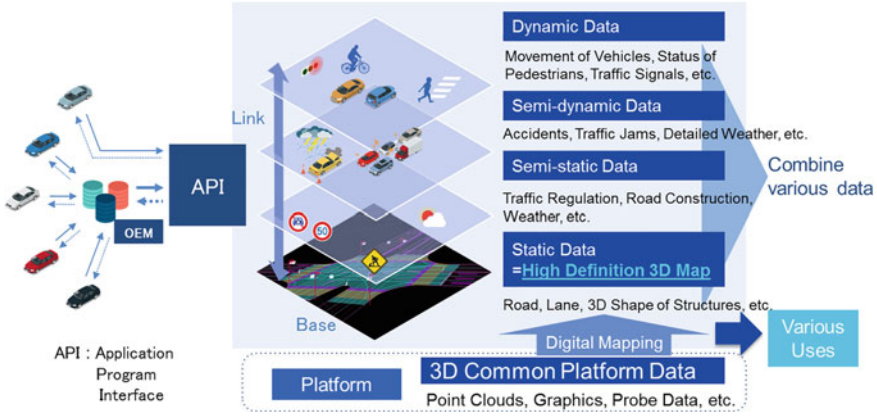

Fig. 2 The concept of dynamic map

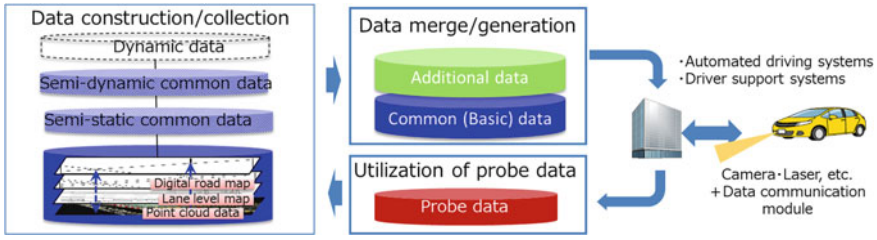

Fig. 3 The data flow of dynamic map

As the result of two years of the SIP activity, Dynamic Map Planning Co. Ltd (DMP) was established in 2016. Six map companies and nine automakers invested in the company.

DMP is now developing the methodologies of creating and maintaining a high-precision 3D map data for automated driving systems. It is also conducting a feasibility study on the business prospects of Dynamic Map data providers.

In June 2017, the planning phase was completed, and DMP became a business enterprise [3].

2.2 Cyber Security

Utilization of wireless communication such as Dynamic Map and vehicle-to-x (V2X) technology makes cyber security a critical issue.

In order to enhance cyber security performance, SIP-adus tries to elicit security requirements by building common models based on threat analysis. Validation/evaluation methodologies and criteria for vehicle level cyber security are targeted for development (Fig. 4).

2.3 Human Machine Interface

Regarding human machine interfaces, there are three important research themes to be studied.

The first is to investigate the effects of prior system information on drivers' behavior when using automated driving systems [4].

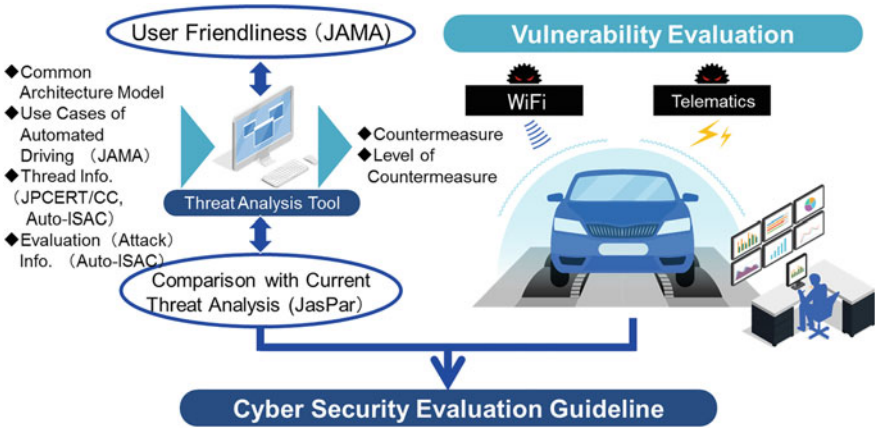

Fig. 4 The approach on cyber security

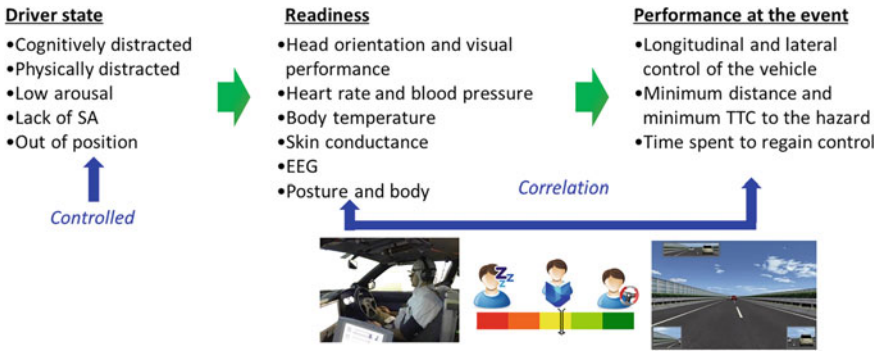

Fig. 5 HMI research

The second is to investigate the effects of a driver state on his/her behaviors when transitioning from automated driving to manual driving (Fig. 5) [5].

The third is to investigate effective ways to functionalize automated driving vehicles to communicate with other road users under various traffic scenarios [6].

2.4 Pedestrian Collision Reduction

Pedestrians and cyclists account for approximately half of traffic fatalities in Japan.

In order to realize a direct vehicle-to-pedestrian (V2P) communication system that can alert pedestrians or drivers in the appropriate situation and at the correct timing, the key technologies required for a pedestrian terminal, such as 700 MHz-band communication and high-precision positioning, are being developed [7].

A 79 GHz-band infrastructure radar for pedestrian detection at intersections is also under development (Fig. 6).

2.5 Next Generation Transport

For the realization of automated driving systems on general roads, it is crucial to have a system that helps vehicles recognize traffic signal information in real time.

The Public Transportation Priority System (PTPS) is one application that is effective with traffic signal control [8].

Other real-time traffic information, such as traffic congestion, bus locations and dynamic connection guidance, are useful for smooth and safe transportation. A traffic information database is to be developed based on Dynamic Map (Fig. 7) [9, 10].

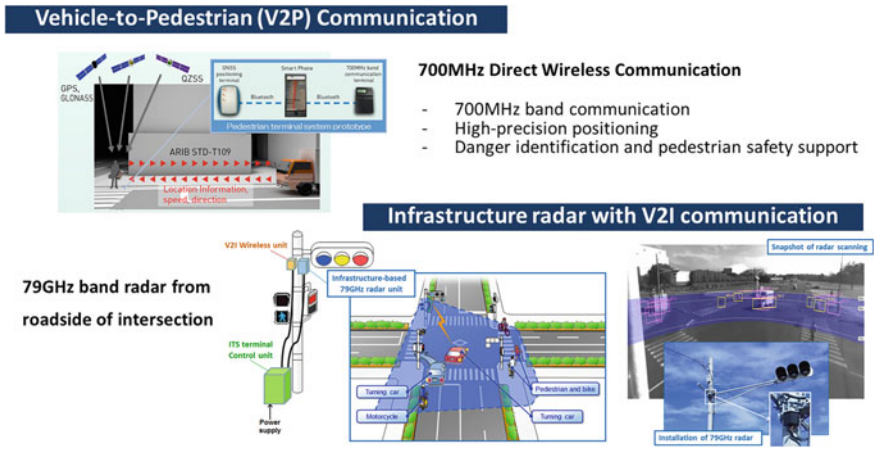

Fig. 6 Pedestrian collision reduction

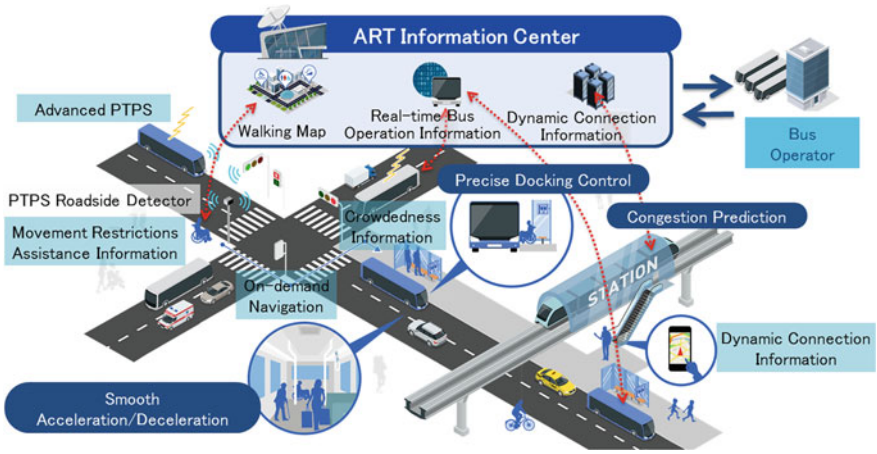

Fig. 7 Next generation transport

3 Outline of the Field Operational Tests (FOT)

Large-scale field operational tests began in Japan in October 2017. They will last until March 2019.

The main purpose of the FOT is the validation of automated driving system technologies under real environments on public roads.

Another purpose is to enhance international cooperation and harmonization. SIP-adus welcomes open discussions with every stakeholder from around the world. Currently, over 20 entities, including global automakers and suppliers, have joined (Fig. 8) [11].

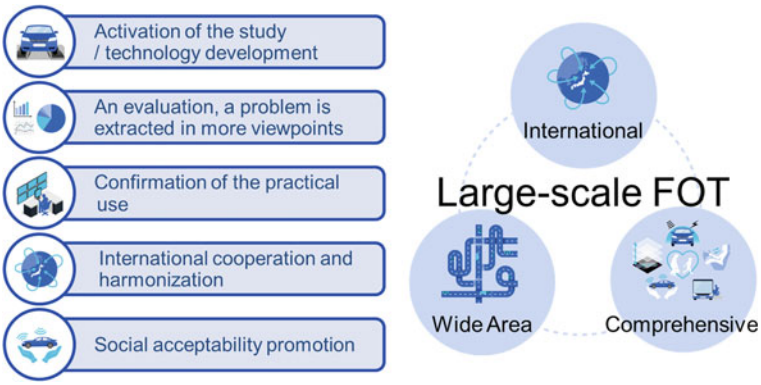

Fig. 8 Field operational tests by SIP-adus

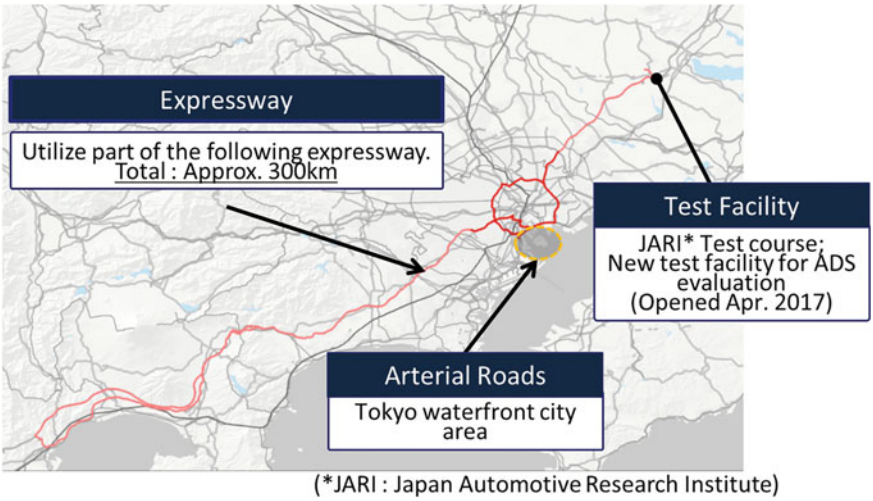

Fig. 9 FOT test sites

3.1 Test Sites

The test sites shown in Fig. 9 are routes that total about 300 km, including part of the Metropolitan expressway, arterial roads in the Tokyo waterfront city area, and a newly developed test facility belonging to the Japan Automobile Research Institute.

While SIP-adus prepares these test fields, participants need to prepare test vehicles and test drivers.

3.2 *Testing Activities in Focus Areas*

3.2.1 Dynamic Map

SIP-adus provides the Dynamic Map data to the participants. The participants are expected to install this data in their own vehicles and evaluate it during use on actual public roads.

The objectives are to validate high-resolution map data, to validate data collection and distribution methods, and to verify the utility of semi-dynamic map information (Fig. 10) [12].

3.2.2 HMI

The main theme of HMI FOT is to collect and analyze driver status data, to define the status of drivers' readiness to take over driving, and to verify HMI methods and devices.

During this FOT, measurements, data collection and analyses of driver status under actual driving environments through continuous long drives are being conducted.

3.2.3 Cyber Security

Regarding cyber security, the objectives are to validate the evaluation method for attacks from outside a car and to verify the defense functions of automated driving vehicles.

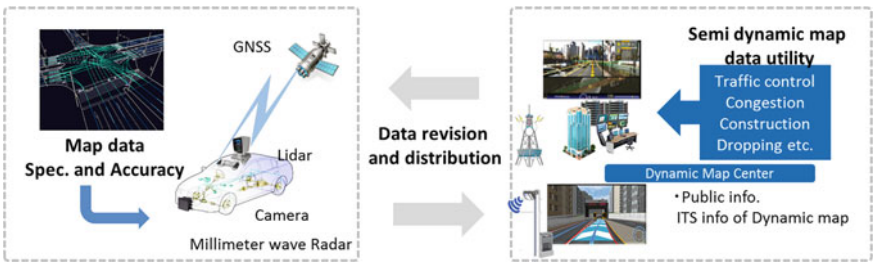

Fig. 10 Dynamic map validation in the FOT

4 International Cooperation and Harmonization

Since the 1880s, automobiles have changed our lives and provided multiple benefits to our society. But in the early stages of motorization, there was a great deal of confusion, and terrible traffic collisions occurred on the roads. In the 130 years of automobile history, a sophisticated automobile society has been established by creating traffic rules and regulations, and standardization made automobiles a commodity.

When automated driving vehicles enter the market, similar confusion and traffic collisions might occur. In order to maintain the safety and social order, established by our forerunners, harmonization and standardization should be promoted more vigorously. Automated and connected vehicles should be built on so-called common platforms.

SIP-adus set six themes as our main international collaborative themes, including Dynamic Map, connected vehicles, cyber security, impact assessments, human factors and next generation transport. Each theme is extremely complicated and requires harmonization. SIP holds an SIP-adus workshop every year to facilitate discussions on these themes, in addition to the EU-US-Japan trilateral framework of ITS cooperation and ISO.

5 Conclusion

SIP-adus is a five-year research program on connected and automated driving led by the Japanese government that was begun in 2014. Among relevant technical issues, cooperative field technologies were selected as the research themes of SIP-adus. In 2016, the project prioritized five themes (Dynamic Map, HMI, cyber security, pedestrian collision reduction and next generation transport). Large-scale field operational tests started in October 2017 to integrate and evaluate the achievements made so far. The tests are open to global entities and will provide opportunities to share meaningful results and to encourage mutual cooperation for harmonization on specifications and frameworks for connected and automated vehicle operations in the future.

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