



Japan's SIP-Adus Program on Road Vehicle Automation

Ryota Shirato¹(✉) and Seigo Kuzumaki²

¹ Nissan Motor Company, 560-2, Okatsukoku, Atsugi 243-0192, Japan
r-shirato@mail.nissan.co.jp

² Toyota Motor Corporation, 1, Toyota-Cho, Toyota 471-8572, Japan
seigo_kuzumaki@mail.toyota.co.jp

Abstract. SIP, the Cross-ministerial Strategic Innovation Promotion program, was started in 2014 with 11 research projects, and those projects are proceeded by initiative of Council for Science, Technology and Innovation of Japanese government. SIP-adus, automated driving system for universal service, is one of the SIP projects and aims to realize innovation of the Automated Driving System through fundamental research to practical application and commercialization. The second phase started from 2018 and is planning Field Operational Test at Tokyo waterfront area in 2020. This paper introduces Society 5.0, Japan's proposal in the 5th Science and Technology Basic Plan, and an overview of the 1st and 2nd phase of SIP-adus and its challenges and contributions.

Keywords: Automated driving · Automated vehicles · Connected vehicles · Dynamic map · Field operational test · Traffic environmental information framework · SIP-adus · Japan

1 Introduction: Society 5.0

Japan has its particular challenges for digital transportation of manufacturing. Society 5.0 was proposed in the 5th Science and Technology Basic Plan as a future society that Japan should aspire to. It follows the hunting society, agricultural society, industrial society, and information society. Society 5.0 achieves a high degree of data convergence between cyberspace (virtual space) and physical space (real space). It leads economic advancement and solutions of social problems, which provides products and services to the people that need them at the time they are needed. Finally, a human-centered society in which anyone can enjoy a high quality of life with full of vigor will be realized (Fig. 1) [1]. In Society 5.0, new value can be generated through AI analysis of big data including sensor data from automobiles, real-time information on the weather, traffic, accommodations, food and drink, and personal history.

It is expected to optimally plan for travel, reduction of congestion and traffic accident, smooth transfer, and movement support for the elderly and physically challenged through the use of automated driving technology. Furthermore, these solutions will help reduction of CO₂ emissions by public transportation (Fig. 2). SIP-adus aims to realize that innovative future society.

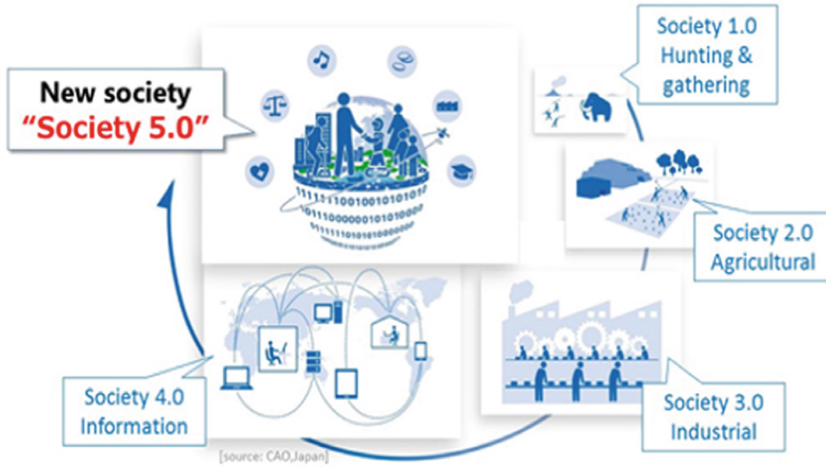


Fig. 1. Society 5.0

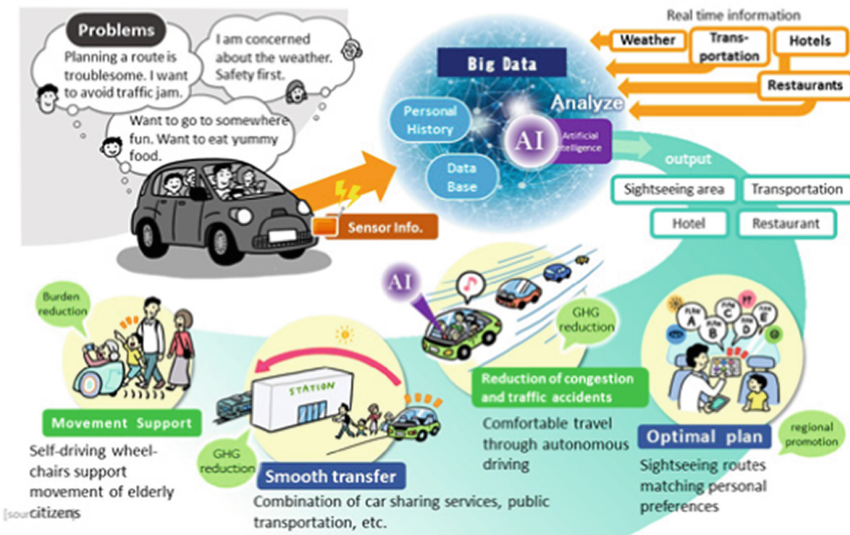


Fig. 2. Expected solutions of Society 5.0

2 Outline of SIP

SIP was started in 2014, and planned as 5 years project. It aims to realize Science, Technology and Innovation from fundamental research to practical and commercialization by cross-ministerial cooperation. By initiative of CSTI, Council for Science, Technology and Innovation, SIP program are proceeded. CSTI appointed the Program

Director and allocated the budget for each research theme. And it promotes the enhanced cross-ministerial cooperation and industry-academia-government collaboration (Fig. 3).



Fig. 3. Outline of SIP

SIP has the following features.

- Intensive R&D program
 - Promote 5-years R&D
 - 1st phase: FY2014–FY2018
 - 2nd phase: FY2018–FY2022
 - From fundamental research to practical and commercialization
- Promote cross-sector collaboration
 - Enhancing cross-ministerial cooperation
 - Promoting industry-academia-government collaboration
- Leadership and total Budget
 - CSTI appointed Program Directors and allocates the budget for each research theme.

SIP started with 11 research projects in the area of Energy, Next-generation Infrastructures and Local Resources. The theme of Automated Driving System was selected from the beginning, and its objective is developing new system for more safe and convenient transportation. [2]

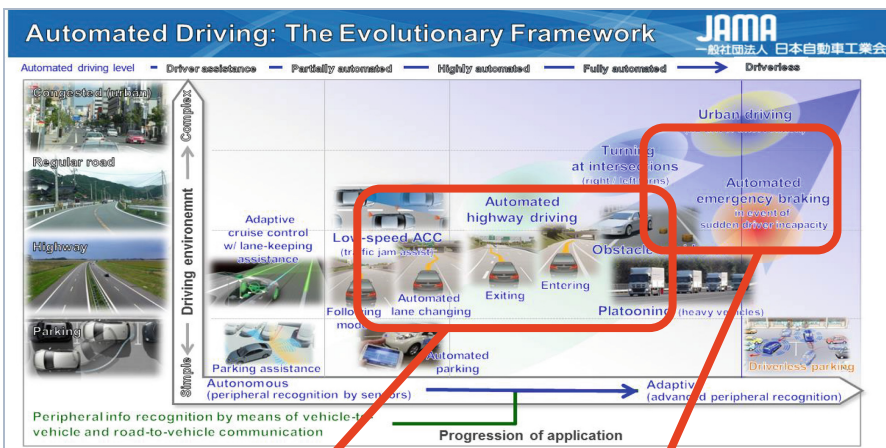
3 1st Phase of SIP-Adus (FY2014–FY2018)

3.1 Goal and Deployment Milestone

When starting up SIP-adus, it had a goal of reducing the number of traffic accident fatalities as the highest-priority. It also had the secondary goal of hastening the implementation of an automated driving system. Third goal was to realize a next-generation urban traffic system for 2020.

Figure 4 shows the JAMA, Japan Automobile Manufacture Association’s, roadmap for the automated driving system. The longitudinal axis shows an application of automated driving systems, from simple areas such as highways to complex areas like general roads. The horizontal axis means a progress of systems from autonomous vehicle to connected automated vehicle with ITS.

SIP-adus supported to realize this scenario from the government point of view.



Realization of Level 2 on highway by 2020

Prioritization for next step Level 2 on regular road

Fig. 4. JAMA’s automated driving system roadmap.

3.2 Main Technology Domain

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. In SIP-adus, it was difficult to cover all relevant themes with the limited resources available. Therefore, it was discussed to classify the technology in cooperative field from all themes.

Figure 5 shows the main technology domain of 1st phase of SIP-adus. The letters in red indicate the cooperative themes, e.g. dynamic map, HMI, cyber security, and simulation.

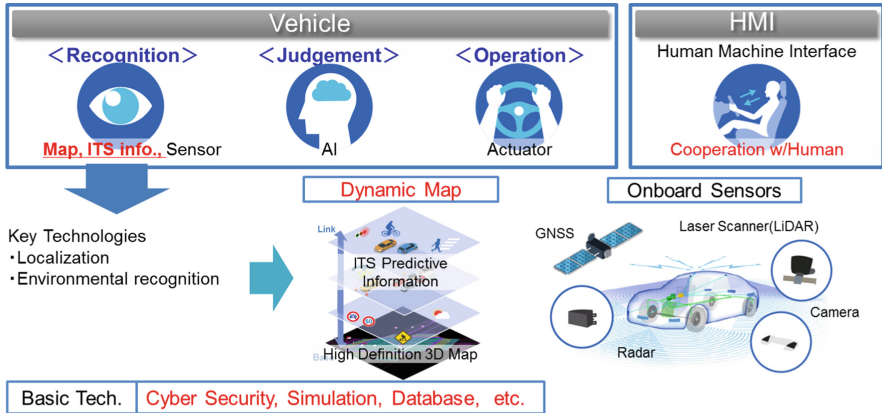


Fig. 5. Main technology domain of 1st phase of SIP-adus.

The automobile is an international product, so international harmonization and standardization is also very important. [3]

3.3 Output of 1st Phase of SIP-Adus

The aim of SIP is to realize innovation through fundamental research to practical application and commercialization by cross-ministerial cooperation and industry-academia-government collaboration. Healthy competition and cross-sectional cooperation are necessary for automated driving realization. So SIP-adus was tackling the issues with the R&D in cooperative field in SIP-adus.

One of the major output from first phase was digital infrastructure. What are necessary features for Automated Driving was discussed and the sample of precise 3D map data was created. More features are better, but increase cost.

As the result, Dynamic Map Planning, DMP, was established in 2016. Six map companies and nine automakers invested in the company. DMP was developing the methodologies of creating and maintaining a high-precision 3D map data for automated driving systems. In June 2017, the planning phase was completed, and DMP became a business enterprise, and name of DMP was changed to Dynamic Map Platform (Fig. 6).

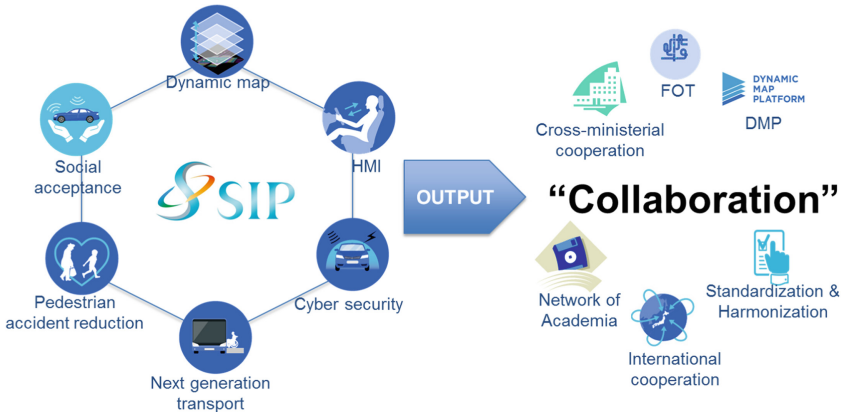
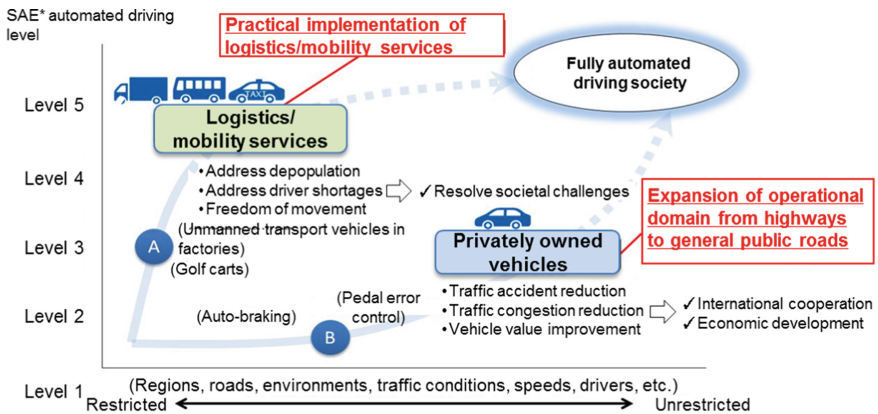


Fig. 6. Output of 1st phase of SIP-adus.

4 2nd Phase of SIP-Adus (FY2018–FY2022)

4.1 Overview

There are two possible approaches for automated driving development as shown in Fig. 7.



*SAE (Society of Automotive Engineers): Standardization body in the U.S.

Fig. 7. Approaches for automated driving development.

The vertical axis is the level of automation according to the SAE definition, and the horizontal axis indicates the operational design domain (ODD). Left is a restricted condition, and the further right, the less restricted.

In its first phase, SIP-adus focused on the development of automated driving on highway for privately owned vehicles, so the second phase has to expand the operational domain from highway to public roads. Also, regarding logistic and mobility services, it is critical to implement automated driving service for solving social issues like mobility in rural area and shortage of truck and bus drivers.

SIP-adus aims to promote R&D overlooking from fundamental research to practical application and commercialization, so stakeholders of commercialization participate in the R&D phase. And it is also expected that mobility services will be commercialized smoothly at the end of the project.

The second phase has a strategy of developing milestones. Specifically, investment and business planning by private operators will be promoted by:

- 1) Taking full advantage of the Olympic and Paralympic Games Tokyo occasion
- 2) Conducting field operational tests (FOT) based on the plans of business operators and local government

4.2 Four Pillars of 2nd SIP-Adus

The second phase is composed of four pillars. First, FOT are created in order to supply opportunity for open discussion. For realization of automated driving systems, it is said that there are three barriers to overcome, which are technology, law and social acceptance. Regarding regulatory reform and rulemaking, all Japanese ministries are making efforts to solve those issues. So SIP-adus focuses on development of core technology and fostering of social acceptance as second and third pillars. The fourth pillar is international cooperation. SIP-adus aims to promote the joint research with overseas research institutions (Fig. 8).

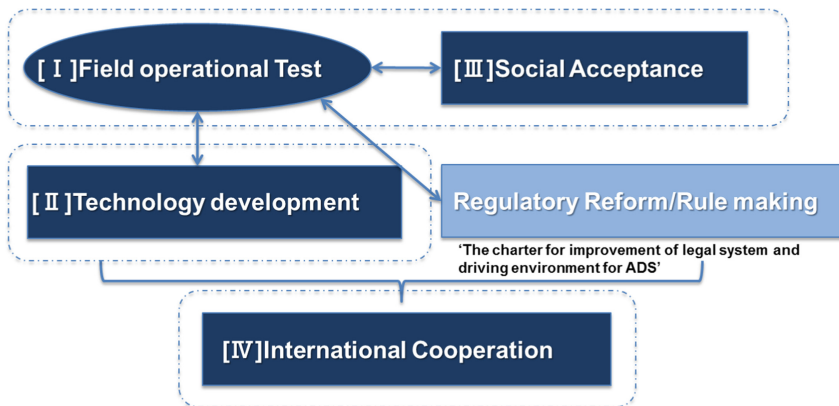


Fig. 8. Four pillars of 2nd SIP-adus

4.3 Major Activities

4.3.1 Traffic Environmental Information Framework

In the first phase of SIP, a basic initiative of dynamic map, and developing 3D precise static map data were established. In the second phase, it aims to develop and operate dynamic traffic data, such as traffic light information and merging area traffic information, and also planning to do Field Operational Testing, FOT, in the Tokyo waterfront area. Finally, it is expected to realize a cooperative automated driving society, and new data business creation (Fig. 9).

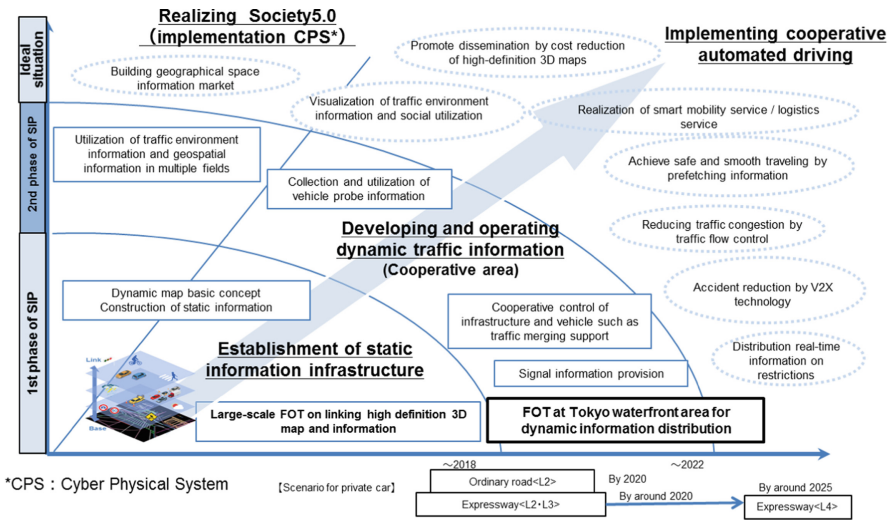


Fig. 9. Traffic environmental information framework

4.3.2 FOTs (Tokyo Waterfront City–Haneda Area)

FOTs will start in autumn 2019 in the Tokyo waterfront city area (general roads and Metropolitan Expressway in the Tokyo Waterfront City area/Haneda area) in cooperation with Japan Automobile Manufacturers Association. SIP-adus aims to increase public acceptance by involving local government, the general public, etc. (Fig. 10).

In Tokyo waterfront city:

Signal information from about 30 traffic lights is provided by DSRC. Vehicles are allowed to pass through intersections safely and smoothly based on the signal display and change timing information even in environments where recognition is difficult using in-vehicle cameras.

On the highway:

Providing vehicle information on the main lane from the road side for merging assistance. The speed and timing to enter the main lane are automatically adjusted to ensure safe merging.

In Haneda area:

The next generation Advanced Rapid Transit will be implemented on public roads by using automated driving technology in mixed traffic flow.

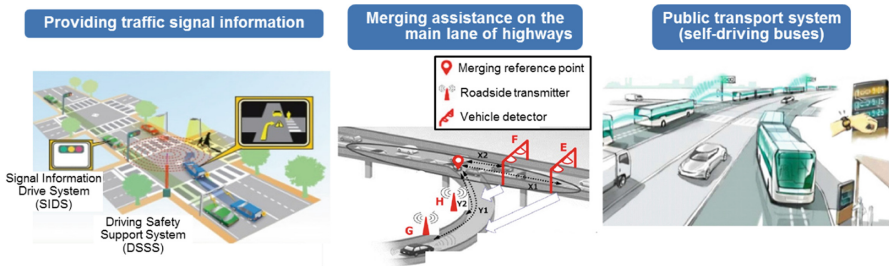


Fig. 10. FOTs (Tokyo waterfront city–Haneda area)

4.3.3 FOTs (Local Transportation)

In Japan, the progress of depopulation and aging in rural areas is a serious social issue. In rural area, SIP-adus plans FOT using simple and inexpensive automated vehicle for evaluation of social acceptance.

Long-term FOTs will be implemented in underpopulated areas, local communities, etc. through collaboration with businesses and local government to validate the effectiveness and business feasibility of automated driving in terms of logistics and mobility services (Fig. 11).



Fig. 11. FOTs (local transportation)

4.3.4 Virtual Environment for Safety Evaluation

SIP-adus will start the development of safety assessment methodology with JAMA in the second phase. Simulation tools for assessing the safety performance of automated driving in various traffic environments will be established. It is necessary for safety assessments to mix actual long-term driving tests and simulation.

4.3.5 Networking of Academia

SIP-adus is working to strengthen the network of academia. Mobility Innovation Collaborative Research Organization, The University of Tokyo, established the 'Mobility innovation promoting council' with 17 domestic universities and 3 research institutes. They will promote collaboration and information sharing. SIP-adus asked them to facilitate collaborative research with overseas entities.

5 Summary

SIP-adus is a five-year research program on connected and automated driving led by the Japanese government that first begun in 2014. Among relevant technical issues, cooperative field technologies were selected as the research themes of the first phase of SIP-adus. In the second phase that started in 2018, it expanded its operational domain from highways to public roads. Also, regarding logistic and mobility services, it is critical to implement automated driving service for solving social issues like mobility in rural area and shortage of truck and bus drivers. Field Operational Test are planned at Tokyo waterfront area for 2020. The network of academia will be strengthened and facilitate collaborative research with overseas entities.

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