Automated Driving Activities in Japan

Takumi Yamamoto

Abstract Industry, government, and academia are collaborating on various projects to develop automated driving technologies in Japan. Major automobile manufacturers are actively developing automated driving vehicles that incorporate these technologies. Driving demonstrations were conducted at CEATEC Japan in October 2013, and at the ITS World Congress, also in 2013. Some automobile manufacturers have even announced that vehicles equipped with automated driving features will enter the market around the year 2020. In the light of these developments, the Ministry of Land, Infrastructure, Transport and Tourism established an Autopilot System Study Group, which organized the issues, studied the policies needed to implement automated driving, and prepared a roadmap between June 2012 and August 2013. On October 8, 2013, the study group, released an Interim Report. In 2014, the Japanese government announced the "Public-Private ITS Initiatives and Roadmap" and established a new Cross-ministerial Strategic Innovation Promotion Program (SIP) that included an Automated Driving Systems project. Based on the schedule established in the roadmap, the government intends to rapidly develop and implement both the road and vehicle aspects of the project with collaboration between the public and private sectors.

Keywords Automated driving · Highway driving · Japan

1 Progress of Automated Driving Projects in Japan

A variety of activities related to automated driving are underway in Japan (Fig. 1).

In 1996, the Advanced Cruise-Assist Highway Systems (AHS) Research Association demonstrated convoy driving using lane markers.

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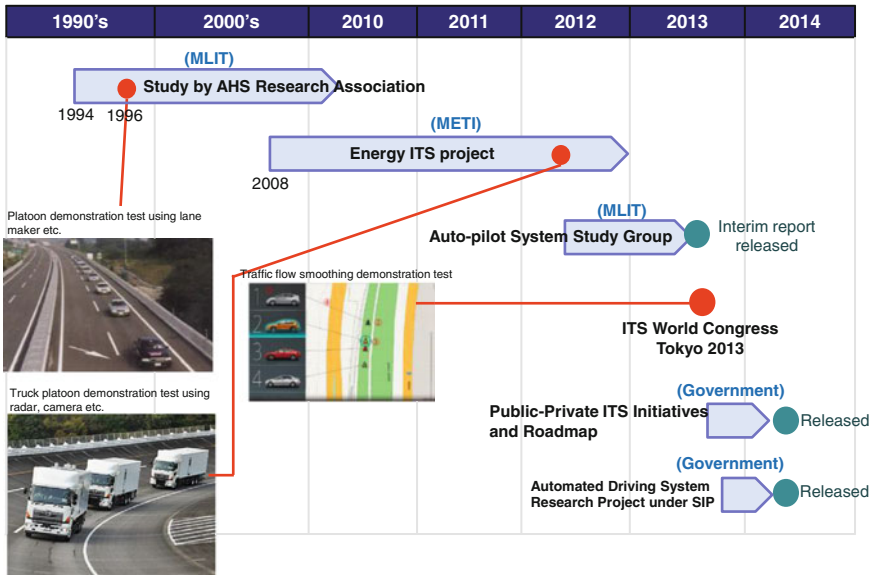

Fig. 1 Progress of automated driving projects in Japan

In 2008, as part of the Energy ITS Project, the Ministry of Economy, Trade and Industry (2008–2012), demonstrated truck convoy driving using cameras, radar, and a 5.8 GHz vehicle-to-vehicle communications system.

In 2013, the Autopilot System Study Group of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) released an interim report.

In 2014, the Japanese government announced the "Public-Private ITS Initiatives and Roadmap" and established a new Cross-ministerial Strategic Innovation Promotion Program (SIP) that included an Automated Driving Systems project in order to actively and strategically promote automated driving.

2 Autopilot System Study Group

The Autopilot System Study Group was set up in 2012 to study automated driving on expressways. The Study Group is under the guidance of the parliamentary secretary for the Ministry of Land, Infrastructure, Transport and Tourism. Its members include university professors and representatives of automobile manufacturers and other entities.

The Autopilot System Study Group refined the concept of automated driving and compiled information that must be studied in order to make autopilot systems a reality. The Study Group released an Interim Report in August 2013.

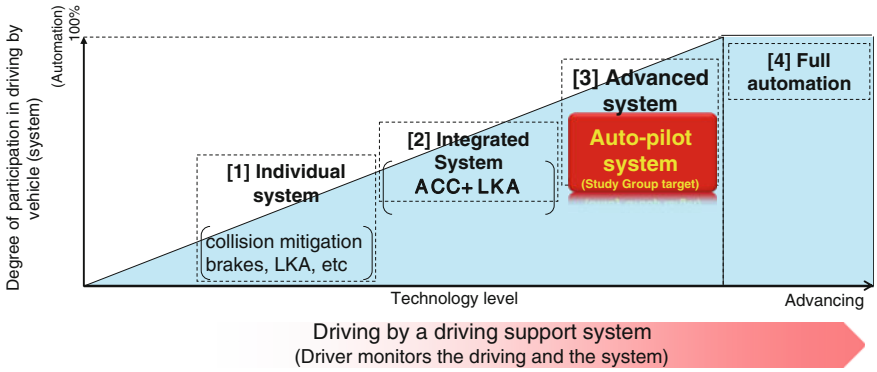

Fig. 2 Immediate target for autopilot systems

2.1 Immediate Target for Autopilot Systems

The Interim Report of the Autopilot System Study Group divided automated driving into four levels according to the degree of participation in driving by the automobile system (Fig. 2). It defined "driving with the use of integrated and advanced driving support systems" as Levels 2 and 3 and "fully automated driving" as Level 4.

Level 2 products that incorporate Adaptive Cruise Control (ACC), Lane Keeping Assistance (LKA), and other technologies have already entered the market. For this reason, the immediate target is to achieve Level 3, advanced autopilot driving systems on expressways.

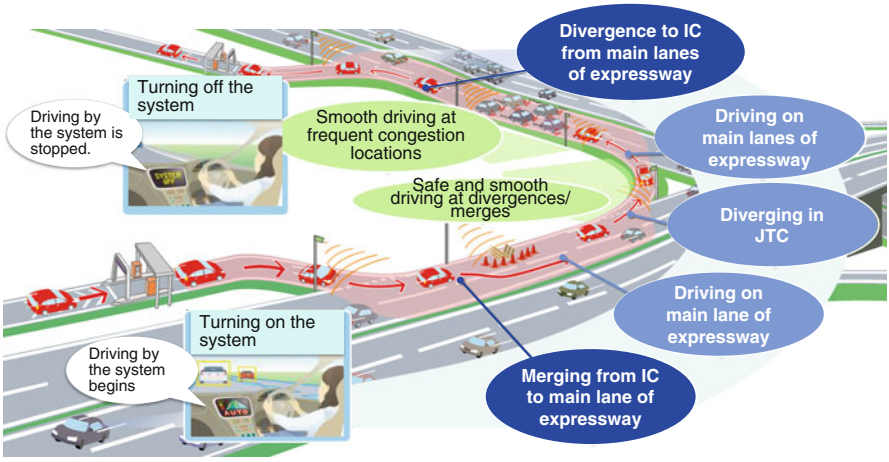

Fig. 3 Autopilot system to be achieved

2.2 Operation of Autopilot System

The objective of the Autopilot System Study Group is an autopilot system for vehicles entering the expressway, driving in the through lanes, passing junctions and other expressway features, and then exiting the expressway (Fig. 3).

While the autopilot system is operating, drivers can expect to safely and smoothly travel past merging and diverging lanes and smoothly transit through congested sections.

2.3 Stage of Development of Autopilot System

Vehicle-based driving support technologies must be developed in three steps (Fig. 4).

Step 1 is continuous driving in a single lane. Driving support systems such as Adaptive Cruise Control (ACC) and Lane Keeping Assistance (LKA) are already in actual use. In sections where the driving environment is relatively stable, the combination of these two systems make possible driving assistance in a single lane. Such systems, however, cannot handle sharp curves, adverse weather conditions, etc. For this reason, detailed data about the road structure must be gathered and advanced vehicle positioning technology developed before continuous driving in a single lane can be implemented.

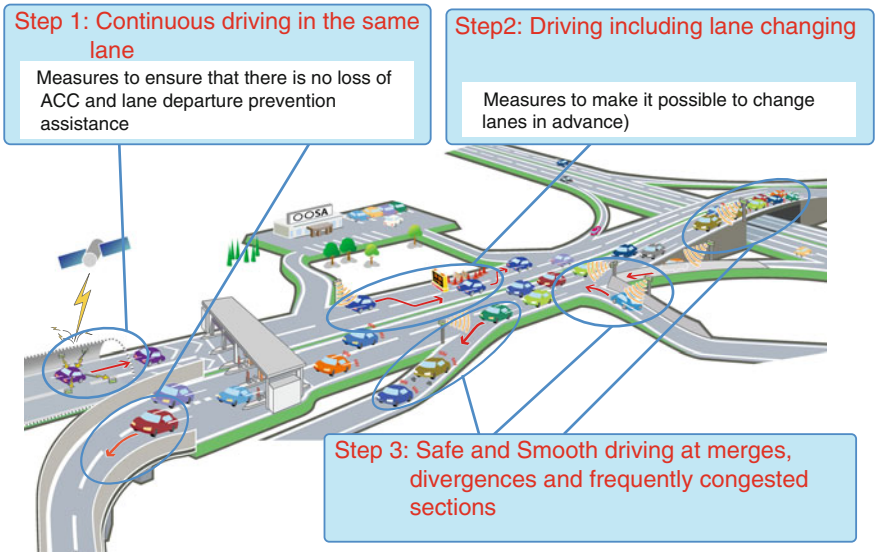

Fig. 4 Stages of autopilot system development

Step 2 is driving that includes lane changes. On expressways, vehicles using automated driving systems will often need to change lanes, such as when lanes are closed because of road construction or a traffic accident. A vehicle using an automated driving system must be able to automatically detect obstacles in the lane, or obtain information on lane closures by means of road-to-vehicle communications or vehicle-to-vehicle communications, enabling the vehicle to change lanes.

Step 3 is optimal driving at merging and diverging locations, locations with frequent congestion, etc. In some cases, a vehicle operating independently may be able to safely and smoothly continue using its automated driving system at merging and diverging locations and locations with frequent congestion. In such cases, the roadside system will provide detailed information to the vehicle, such as information about approaching vehicles in the through lanes, which the vehicle cannot easily detect at merging and diverging locations, and information on the ideal lane to use in congested sectors. This will enable continuous automated driving at merging and diverging locations and locations with frequent congestion.

3 ITS World Congress Tokyo Demonstration "ITS Green Safety"

The Japanese government and related institutions presented five demonstrations under the title of "ITS Green Safety" at the ITS World Congress held in Tokyo in October 2013 (Fig. 5).

Fig. 5 Demonstration of ITS green safety at ITS world congress in Tokyo

One of these demonstrations was entitled "Smartway with ACC/CACC," which is designed to ease congestion at sag locations on expressways using roadside units, Adaptive Cruise Control (ACC), and Cooperative Adaptive Cruise Control (CACC).

60 % of the congestion on Japanese expressways starts at sags where the road grade changes. At sags where the road grade increases, driving speed decreases before the driver is aware of this fact. The drivers behind the vehicle brake, resulting in congestion.

Both road and vehicle technologies are used to correct the decrease in speed at sag locations. An ITS Spot unit installed by the side of the road provides information about the optimum driving speed and following distance to the cars on the road. At the same time, technologies inside the vehicles, such as ACC and CACC, maintain the proper following distance and move the vehicles to less crowded lanes. The result is optimal traffic flow.

According to computer simulations, if 30 % of the vehicles are equipped with ACC, the congestion at sag locations decreases by 50 %.

4 The Latest Government-Led Efforts to Achieve Automated Driving

The entire Japanese government is committed to the task of achieving automated driving.

The four relevant government ministries and agencies are working together to promote ITS. The ITS roadmap and the research and development plan were formulated by all relevant government ministries and agencies (Fig. 6).

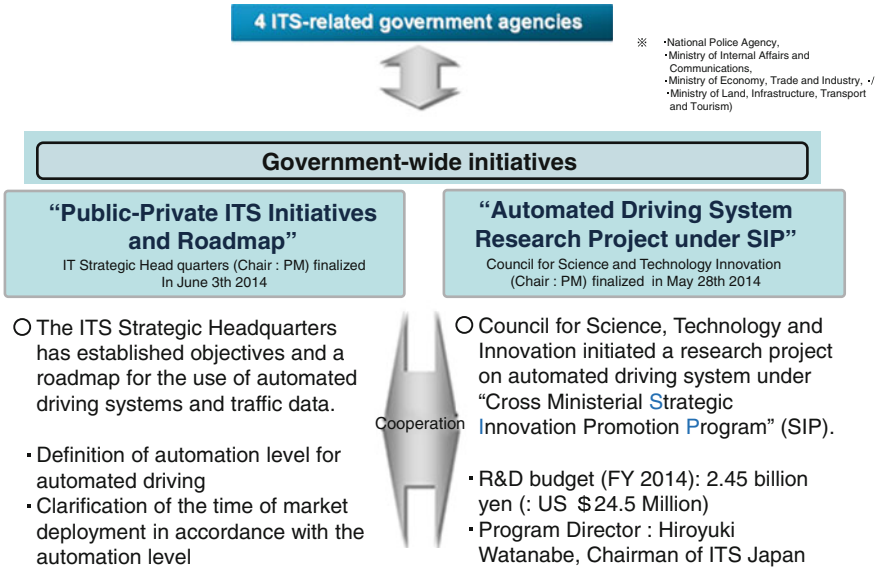

Fig. 6 Latest government-led efforts to implement automated driving

In June 2014, the IT Strategic Headquarters released the "Public-Private ITS Initiatives and Roadmap" consisting of strategies and a roadmap for automated driving systems and the use of traffic data.

In addition, the Council for Science and Technology Policy established a new Cross-ministerial Strategic Innovation Promotion Program (SIP) and selected ten projects that should be promoted on a priority basis. One of these was "Automated Driving Systems." A Research and Development Plan was formulated in May 2014.

4.1 Public-Private ITS Initiatives and Roadmap: Automated Driving Levels and Expected Time of Commercial Deployment

The Public-Private ITS Initiatives and Roadmap define the levels of the automated driving system and when each level is expected to become commercially available (Table 1).

In Japan, the development of a driving safety support system and automated driving system has been divided into five stages. The information provision system and the Level 1 system are already available as commercial products.

At Level 2, the vehicle performs two operations (selected from among acceleration, steering, and control) at the same time. In the case of steering to avoid a collision, for example, the objective is commercial deployment in the mid-2010s.

At Level 3, except in the case of an emergency, the vehicle performs all three operations: acceleration, steering, and control. Driver control is not required even at merging locations. The objective for Level 3 is commercial deployment in the first half of the 2020s.

Finally, at Level 4, the driver does not intervene in the driving process at all. Study is underway with the goal of beginning trials in the second half of the 2020s. However, a great many problems remain to be resolved, so the target period may be revised.

For reference purposes, the far left column lists the levels for automated driving as defined by the U.S. National Highway Traffic Safety Administration (NHTSA). The definitions used in Japan are fundamentally the same as those used by the NHTSA.

4.2 Cross-Ministerial Strategic Innovation Promotion Program (SIP)

The Council for Science, Technology and Innovation established a new Cross-ministerial Strategic Innovation Promotion Program (SIP) and selected ten projects that should be promoted on a priority basis. One of these projects was "Automated Driving Systems" (see Table 2).

Table 1 Automated driving levels and expected time of commercial deployment

(Reference) NHTSA definition	Level	Summary	Technologies thought to be needed for achievement	Expected time of market deployment
Level 0 (No-automation)	Provision of information	Warnings to driver	–	–
Level 1 (Function-specific automation)	**Level 1** (Single function)	One operation (Acceleration, steering or control) is performed by the vehicle	–	–
Level 2 (Combined function automation)	**Level 2** (More complex system)	Multiple operations (From among acceleration, steering and control) are performed at the same time by the vehicle	Tracking/following system	Mid-2010s
			Steering for collision avoidance	Around 2017
			Automated driving in multiple lanes etc.	
Level 3 (Limited self-driving automation)	**Level 3** (Advanced system)	All operations (Acceleration, steering and control) are performed by the vehicle (Emergency response: driver)	Automated merging etc.	First half of 2020s
Level 4 (Full self-driving automation)	**Level 4** (Fully automated driving)	All operations (Acceleration, steering and control) are performed by the vehicle (With no assistance from the driver)	Fully automated driving	Second half of 2020s[a]

[a]Assumed period of trial use. However, as many factors are still unclear, the period will be revised as needed

Table 2 Strategic innovation promotion program

Priority policy issues	Prospective subject	Description
Energy	Innovative combustion technology	Improving fuel efficiency of automobile engines
	Next-generation power electronics	Integrating new semiconductor materials into highly efficient power electronics system
	Innovative structural materials	Developing ultra-strong and -light materials such as magnesium-, titanium-alloys and carbon fibers
	Energy carrier	Promoting R&D to contribute to the efficient and cost-effective technologies for utilizing hydrogen
	Next-generation ocean resources development technologies	Establishing technologies for efficiently exploring submarine hydrothermal polymetallic ore
Next-generation infrastructures	**Automated Driving System**	**Developing new transportation system including technologies for avoiding accidents and alleviating congestion**
	Technologies for maintenance/upgrading/management of infrastructures	Developing low-cost operation and maintenance system and long life materials for infrastructures
	Reinforcement of resilient function for preventing and mitigating disasters	Developing technologies for observation, forecast and prediction of natural disasters
Local resources	Technologies for creating next-generation agriculture, forestry and fisheries	Realizing evolutionary high-yield and high-profit models by utilization of advanced IT etc.
	Innovative design/manufacturing technologies	Establishing new styles of innovations arising from regions using new technologies such as Additive Manufacturing

The project has three objectives. The first is to reduce traffic accidents. The second is to create and deploy an automated driving system. The third is dramatic progress in automated driving technologies before the Tokyo Olympics and Paralympics in 2020.

One of Japan's national goals is to reduce accident fatalities from approximately 4400 in 2013 to 2500. Automated driving systems are being developed not simply because it is an exciting field of research but because they clearly can help improve traffic safety in Japan. To this end, the times for commercial deployment of each level have been established. Moreover, the Olympics and Paralympics will be held in Tokyo in the year 2020, and study is underway to develop by that time a next-generation urban transport system that includes automated driving.

Hiroyuki Watanabe, the Chairman of ITS Japan, the Program Director for the SIP Automated Driving System project is taking the lead in promoting the project.

In addition, a Research and Development Plan and an exit strategy have been formulated by the public and private sectors based on their respective positions.

The budget for research and development in FY 2014 is 2.45 billion yen.

4.3 Research and Development Topics Covered by SIP Research Project

Four categories of research and development are being pursued under SIP.

The first category of research is the development and verification of an automated driving system. This involves the development of vehicle technologies, including the following.

1. A dynamic map
2. Technologies for generating prediction data
3. Enhancement of sensing capability

System security and human-machine interface, or HMI, technologies also must be developed.

The second category is basic technologies for reducing traffic accident fatalities and reducing traffic congestion.

The third category is fostering international cooperation by establishing an open international research center and studying social acceptance.

The fourth and final category is the study of the deployment of next-generation urban transport systems.

The red broken-line circles in Fig. 7 highlight areas targeted by SIP. These are areas in which the automobile manufacturers will cooperate with one another. The light blue area in the center of the slide shows the area of competition among automobile manufactures, which is not covered by SIP.

4.4 SIP Implementation Structure

The Cross-ministerial Strategic Innovation Promotion Program is promoted by a Steering Committee consisting of three working groups with tasks as follows:

System Implementation Working Group

- Develop for map data technologies
- Develop simulation technologies for assessing systems
- Study the roles of the driver and the automated driving system
- Study ways to assist pedestrian movement

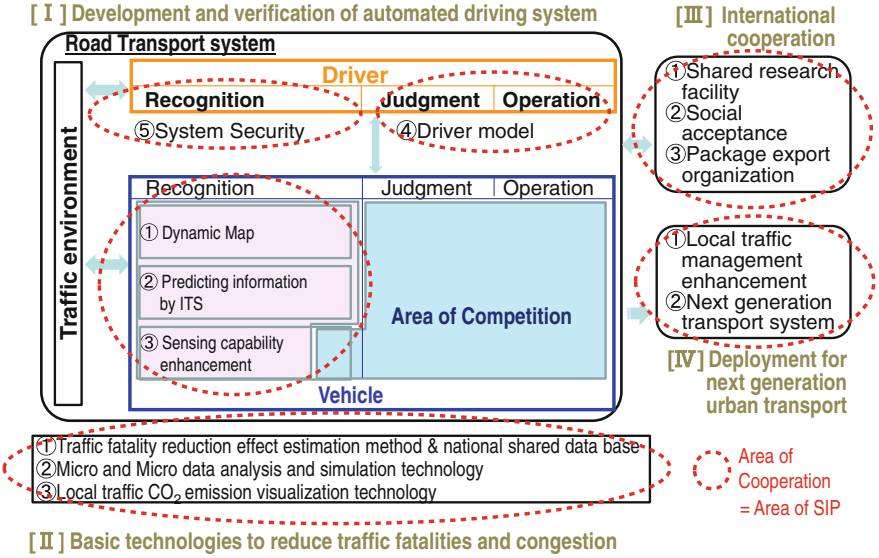

Fig. 7 SIP research and development topics

International Cooperation Working Group

- Build an organization for international cooperation
- Establish an open international research and development environment
- Foster social acceptance of automated driving systems

Next-generation Urban Transportation Working Group

- Develop advanced methods for managing local transport systems
- Develop next-generation public road transport systems
- Develop systems to assist pedestrians and vulnerable road users

The Steering Committee consists of scholars and representatives from relevant government ministries and agencies, Japanese major five automobile manufacturers (TOYOTA, HONDA, NISSAN, MAZDA, SUBARU), and automobile-related organizations.

5 Future Efforts

Based on the schedule established in the roadmap, the government intends to rapidly develop and implement both the road and vehicle aspects of the project with collaboration between the public and private sectors.

Moreover, in view of the rapid development of automated driving technology in recent years, the government will regularly review systems implementation and front-load objectives in accordance with the Autopilot System Study Group's work and the roadmap in order to promote the steady and speedy development and implementation of autopilot systems.

With the 2020 Tokyo Olympics and Paralympics as a milestone, the government will continue to study the issues in collaboration with industry and academia.

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