Automated Driving System

Freedom of Mobility and Safety through Automated Driving Systems and Advanced Infrastructure

The Automated Driving System is a technology that makes use of real-time information from vehicles, people, and roads. The ultimate goal of this program is to eliminate traffic fatalities. In the near future, developments in safety technologies and local traffic management systems will guarantee for the first time that every person across the world can enjoy freedom of mobility and safety. Reducing traffic accidents is a common concern around the world. The Automated Driving System program seeks to lead the world in developing a next-generation transportation system as social infrastructure for tomorrow.

Program Director

Seigo Kuzumaki

Toyota Motor Corporation
Advanced R&D and Engineering Company
Executive General Manager

Profile

Mr. Kuzumaki received a master's degree in aeronautical engineering from Kyoto University in 1985. The same year, he joined Toyota Motor Corporation in the Body Design Department. In 2003, he began working in technology planning and technical development as the vehicle safety function supervisor in the Vehicle Technology Development Department at Toyota. He has served in his present post since 2017. Following his appointment as Sub-PD for the SIP Automated Driving System program for two years from 2014, he was appointed PD in 2016

Research and Development Topics

1. Develop/verify automated driving systems

- Research into commercialization and conduct field operational tests for the rapid deployment of automated driving systems
  - ✓Improve digital map information
  - ✓Develop technology to generate predictive informationusing ITS
  - ✓Develop technology to improve sensing capabilities
  - ✓Develop HMI technology for drivers and automated driving systems
  - ✓Develop technology to system security

2. Advance basic technologies to reduce traffic fatalities and congestion

- Develop technologies for estimating the impact on reducing traffic fatalities; create a common national database
- Develop micro/macro data analysis and simulation technologies
- Visualize CO_2 emissions from regional traffic

3. Promote international cooperation

- Prepare an internationally open R&D environment; promote international standardization
- Identify six key areas*1 for international cooperation and engage in strategic coordination
- Promote public acceptance of automated driving

4. Deploy next-generation urban transportation

- Improve regional traffic management
- Develop a next-generation transportation system, improve and promote accessibility

5. Conduct large-scale field operational tests

- Identify five key issues*2 for accelerating practical application of automated driving systems and conduct large-scale field operational tests
- Integrate R&D measures and uncover institutional and other issues

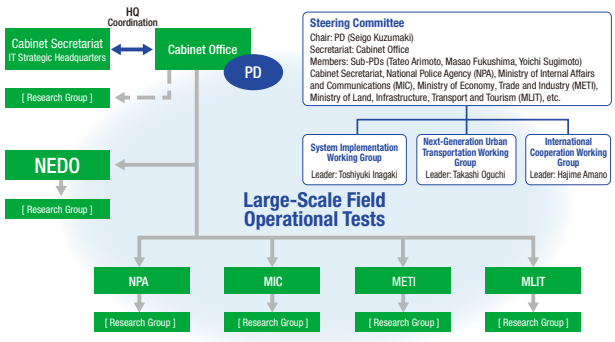
6. Other

- Strengthen industry-academia partnerships, and coordinate with other SIP programs
- Exercise leadership related to Society 5.0 initiatives

*1 Six areas of high interest in international discussions:Dynamic Maps, Connected Vehicles, Human Factors, Security, Impact Assessment, Next-generation Transport

*2 Key issues addressed by the SIP Automated Driving System program: Dynamic Maps, HMI, Information Security, Pedestrian Accident Reduction, Next-generation Urban Transportation

Implementation Structure



The program leverages the government's existing framework for promoting Intelligent Transport Systems (ITS), taking direct charge of research fields under the jurisdiction of various ministries and agencies. In this manner, the government aims to accelerate the promotion of policies and spend budgets efficiently.

Deployment Milestones

☑ Accomplish national goals (reduce traffic fatalities, etc.)

Build a technological foundation for traffic safety policies that encompass vehicles, citizens, and infrastructure as needed to accomplish the national goals of reducing traffic fatalities, etc.

☑ Realize and diffuse automated driving systems

Using ITS-based predictive information, advance R&D in cooperative fields and secure necessary technologies to commercialize SAE Level 2 automated driving systems (utilizing signal, traffic congestion and other infrastructure information) by 2017, SAE Level 3 by 2020 and SAE Level 4 by 2025. Also, through these achievements, create new industries that extend beyond the framework of the current automotive industry.

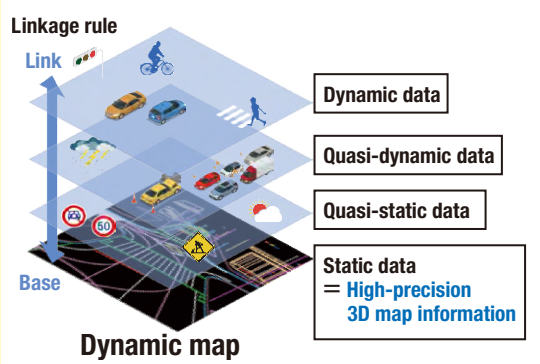
☑ Engage in collaborative development with the Tokyo Metropolitan Government, setting the 2020 Tokyo Olympics/Paralympics as a milestone

Work toward the 2020 Tokyo Olympics/Paralympics as a milestone for introducing a next-generation public transportation system (Advanced Rapid Transit; ART) that both promotes the city of Tokyo and addresses Japan's aging population, contributing value for future generations.

Progress to Date

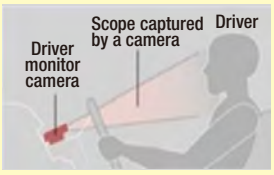
❶ Dynamic map

- Achieving the functions to link and distribute the dynamic map data for an advanced automated driving system on limited highways; coordinating the specifications of dynamic maps for general roads, and establishing the system to develop Dynamic maps.
- **Dynamic Map Platform Co., Ltd. (DMP) was established in June 2017.** Six surveying/map companies and 10 automakers in Japan invested in DMP.
- Achieving commercialization through international coordination by promoting standardization based on Japan's proposals (that were approved as proposals to ISO/TC204/WG3) and communicating with organizations that promote establishment of de-facto standards of digital maps outside Japan (e.g., OADF)



❷ HMI

- **Establishing an index of the driver's condition** and determining the correlation with the time required for TOR* by **gathering data on public roads, developing a database, and sharing results** with participants in tests including manufacturers outside Japan
- Formulating the HMI guidelines to achieve advanced automated driving (Level 3) and working on ISO/TC22/SC39 in cooperation with the Society of Automotive Engineers of Japan, Inc. and Japan Automobile Manufacturers Association, Inc.

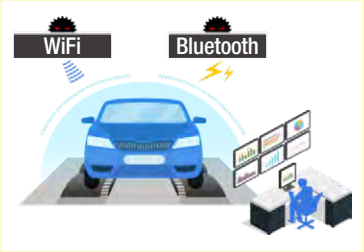


●Research on HMI measurement techniques and indices

*Take Over Request

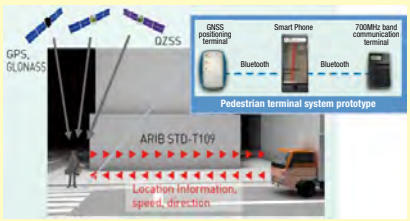
❸ Cyber-security

- Developing evaluation guidelines; verifying the validity and effectiveness of the guidelines through field operational tests based on the guidelines
- Establishing organizations for evaluating the security of automated driving



❹ Pedestrian accident reduction

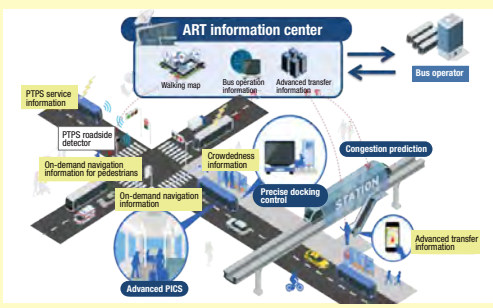
Communication devices between pedestrians and vehicles as well as high-accuracy pedestrian positioning and pedestrian behavior estimation technologies were developed. Their effectiveness was confirmed in complicated traffic environments.



●(V2P equipped smartphone, 79GHz millimeter-wave radar)

❺ Next-generation transport

- Achieving precise docking control at bus stops (precision: 4 cm ± 2 cm) and smooth acceleration/deceleration control as the ART* control function
- Achieving on-time operation by **advanced PTPS**** and **ART information center function**; achieving traffic information distribution services for ART users



* Advanced Rapid Transit ** Public Transportation Priority Systems

Program Director **Seigo Kuzumaki** Interview

Large-scale Testing on Public Roads in 2017! Automated Driving System Closer to Becoming a Reality

Automated driving systems are one area of research closest to becoming a reality for Society 5.0, an integration of cyberspace and physical space. Under Society 5.0, social transportation will be safe, comfortable, and convenient thanks to the harmonization of vehicle and traffic systems between which various pieces of data flit about. Today, we are closer than ever to seeing this society become a reality.

Program Director (PD) Seigo Kuzumaki says confidently, "Our work is progressing almost as planned. In October 2017, we started large-scale testing of automated driving systems on public roads."*1

The SIP Automated Driving System program is managed under an existing public-private framework to further Japan's Intelligent Transport Systems (ITS). At present, this program is conducting research and development toward the practical application of automated driving systems. While the program has addressed a wide range of topics related to automated driving technologies, these topics have been largely consolidated into five key issues.*2

Using Quasi-dynamic Information to Achieve an Automated Driving System by the Year 2020

The rapid evolution of automated driving technology over the past two years backs up Mr. Kuzumaki's statements. Sensors have become more precise, while software and HMI technologies have advanced to a significant degree. Despite the difficulties involved, driver support technology (e.g. automated freeway merging/exiting) is now close to becoming a reality.

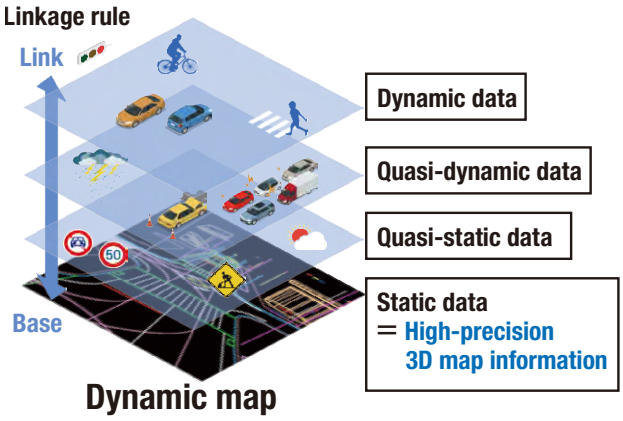
However, Kuzumaki says, "On-board sensor technology by itself is not enough to achieve an automated driving system. You need self-positioning technologies that coordinate with extremely precise 3D map information. You also need technologies that use traffic regulation information and position information for nearby vehicles to recognize the surrounding environment. In this program, we are trying to achieve this level of sophistication through the technologies of dynamic maps, HMI, security, and databases. Here, we are working on a collaborative basis for technologies that would present challenges for auto makers working on their own. The Japanese automobile industry faces stiff technological competition with the United States and Europe. One distinctive aspect about the SIP is that the program engages in focused cooperative research and development for certain fields, while allowing for free private-sector competition in others.

The ultimate aim is to realize a highly advanced automated driving system. Mr. Kuzumaki states definitively, "We will achieve a highly advanced (SAE Level 2) automated driving system by the year 2020, as a step toward an SAE Level 3 system." One more major target of this program is to achieve a national goal of reducing traffic fatalities to fewer than 2,500 by the year 2020 (compared to 3,694 fatalities in 2017). Other targets include reducing traffic congestion and creating a public bus system more accessible to the elderly and people who face restrictions in transportation.

Establishment of Dynamic Map Platform Co., Ltd. to offer dynamic maps commercially

"We have focused much of our efforts on building dynamic maps," says Mr. Kuzumaki. A dynamic map is one that links constantly changing dynamic data (dynamic information, quasi-dynamic information, and quasi-static information) onto a high-precision 3D map (basic map: static information).

Conceptually speaking, signal information, information about vehicles and pedestrians in the surrounding area, and other dynamic information is updated without a time lag, reflected on a display panel and in operations of an automobile. Quasi-dynamic information including information about accidents, congestion, and local weather, quasi-static information such as information about planned traffic regulations, planned road construction, and area weather, and static information including information



*1 Mr. Kuzumaki was named PD in April 2016
*2 Dynamic Map, HMI, Information Security, Pedestrian Accident Reduction, Next-generation Urban Transportation

Automated Driving System

about road surfaces, lanes, 3D structures, etc. are updated based on different time units each time. The automatically controlled vehicle will acquire updated information in real time, using this data for driving control as needed.

Mr. Kuzumaki notes, “In FY2017, field operational tests were conducted on public roads with the participation of 22 entities including automakers, auto parts manufacturers, universities, and organizations outside Japan. These entities agreed on the specifications of the high-precision 3D maps. In FY2018, efforts are being made to verify technologies to link and distribute traffic information such as traffic regulation information for each lane on expressways through industry-government cooperation. At the same time, SIP has been working to expand applications for dynamic maps and establish international standards for dynamic map specifications.”

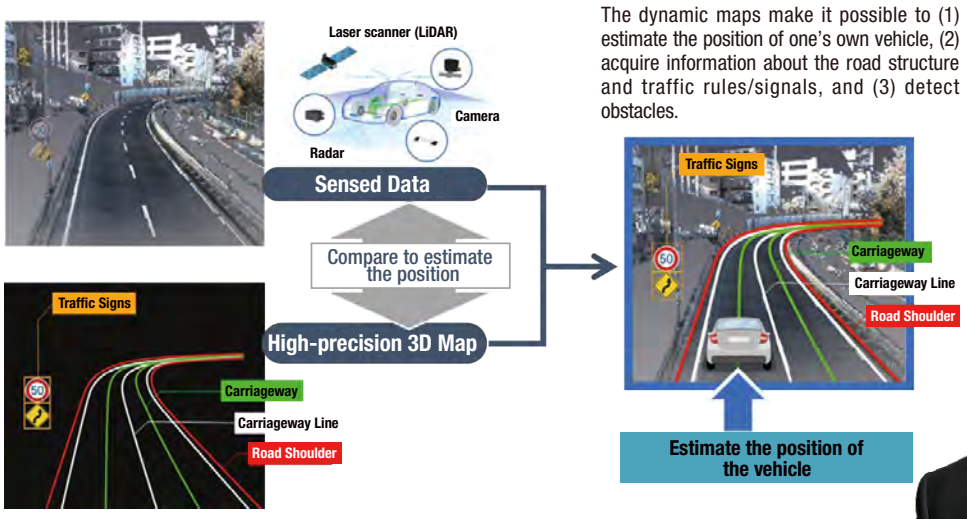
Regarding the developments in the private sector based on the results of these activities, Dynamic Map Platform Co., Ltd. (DMP) was established in June 2017. DMP announced that it will start commercial distribution of dynamic maps for all the expressways in Japan (about 30,000 km) by the end of FY2018. As the high-precision 3D maps (which are indispensable for automated driving on expressways) are set to be improved, development in competitive fields led by automakers will also be accelerated. Level 3 automated driving on expressways is expected to be implemented by 2020.

Automated Driving Research to Give Concrete Example of How “Society 5.0” Grows

The government’s 5th Science and Technology Basic Plan, adopted by Cabinet decision in January 2016, details Society 5.0, a first-of-its-kind model for a future super-smart society. Automated driving systems are one area of research closest to becoming a reality under this model. Mr. Kuzumaki, director for this program, draws a specific picture for automated driving systems.

“Automated driving systems will collect a variety real-time information related to the surrounding physical spaces. The system will store, analyze, and process this information in cyberspace. We believe this data should be used for basic technology shared across different fields of specialization. Technologies capable of extracting pedestrian information or other specific data from the vast amount of data available may then use this data as part of an artificial intelligence network.” Mr. Kuzumaki is eager to use traffic information as an initial gateway to achieving Society 5.0.

Besides making road transportation safer and more secure, the Automated Driving System program also intends contribute to social value in a number of other ways, including providing support to traffic regulators and resolving the lack of drivers in rural areas. The basic goal of this program is to strengthen the competitive capacity of Japan’s auto industry, expanding the market for related industries and boosting industrial value in the nation. The Automated Driving System program will continue to advance research and development in support of these goals..



The dynamic maps make it possible to (1) estimate the position of one’s own vehicle, (2) acquire information about the road structure and traffic rules/signals, and (3) detect obstacles.

A data integration platform for achieving Society 5.0 has been built by implementing dynamic maps.
We will upgrade the technology level to Level 3 automated driving on expressways by 2020.