SIP Automated Driving System

— *SIP Automated Driving for Universal Service (SIP-adus)* —

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1. Introduction

In the 2014 fiscal year, a Cross-Ministerial Strategic Innovation Promotion Program was established as one of the flagship functional enhancements of the Council for Science, Technology and Innovation. In this program, the Council for Science, Technology and Innovation selects issues that are indispensable to society and have an important bearing on Japan's economic and industrial competitiveness, and engages with these issues at every stage from basic research to practical implementation and commercialization by crossing the boundaries between different disciplines and government departments. Ten themes were selected for the 2014 business year, including automated driving systems, and ¥50 billion was earmarked by the cabinet office as expenses to promote innovative creativity in science and technology.

A program director (PD) was appointed to address any issues that arose, and research and development is being promoted based on the assessments and advice of a governing board consisting of expert members of the Council for Science, Technology and Innovation. In the SIP automated driving system (SIP-adus), a promotion committee was established under the supervision of PD Hiroyuki Watanabe of Toyota Motor Corporation. This committee includes members from various bodies such as the Cabinet Secretariat, National Police Agency, Ministry of Internal Affairs and Communications, Ministry of Economy, Trade and Industry, the road and vehicle departments of the Ministry of Land, Infrastructure, Transport and Tourism and other public and private organizations centered on the motor industry, together with journalists and experts from universities and research organizations, and is promoting discussions and research on issues related to the realization of automated driving systems that need to be addressed at a national level.

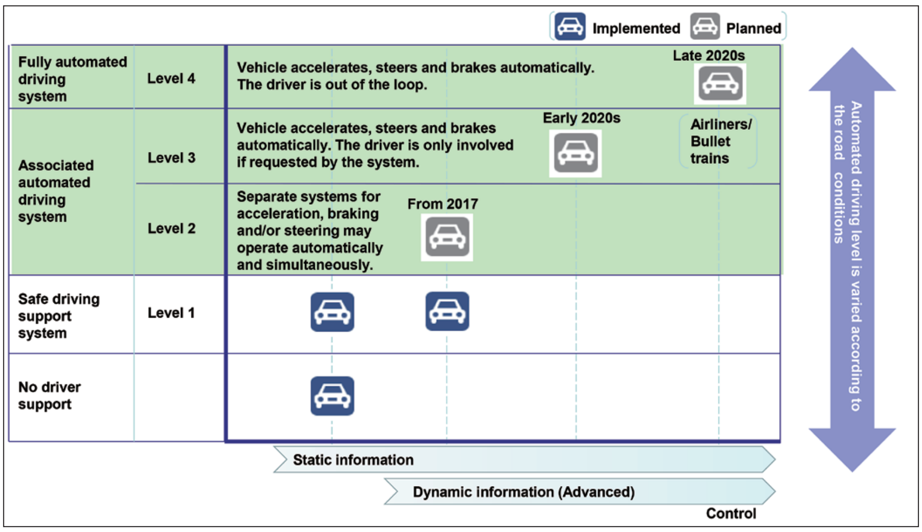
2. The aims and exit strategy of SIP-adus

When starting up SIP-adus, reducing the number of traffic accident fatalities was set as the highest-priority after a discussion of Japan's reasons for promoting automated driving systems. This is because while Japan would fail to meet the national target of becoming the world's safest country with less than 2500 fatalities occurring within 24 hours of a traffic accident per year by 2018, it is expected that automated driving systems will have greater potential for reducing traffic accidents by supporting drivers and avoiding danger.

In addition to this sort of social significance, it is also of great industrial significance in that it will create new services and industries by making Japan's motor industry more competitive and expanding the markets of related industries. It also has the secondary goal of hastening the implementation of an automated driving system.

There is also a third goal, which is related to another core purpose of SIP: to realize a next-generation urban traffic system in time for the 2020 Tokyo Olympic and Paralympic Games by engaging at all levels from basic research to practical implementation and commercialization.

Figure 1: Definitions of automated driving levels

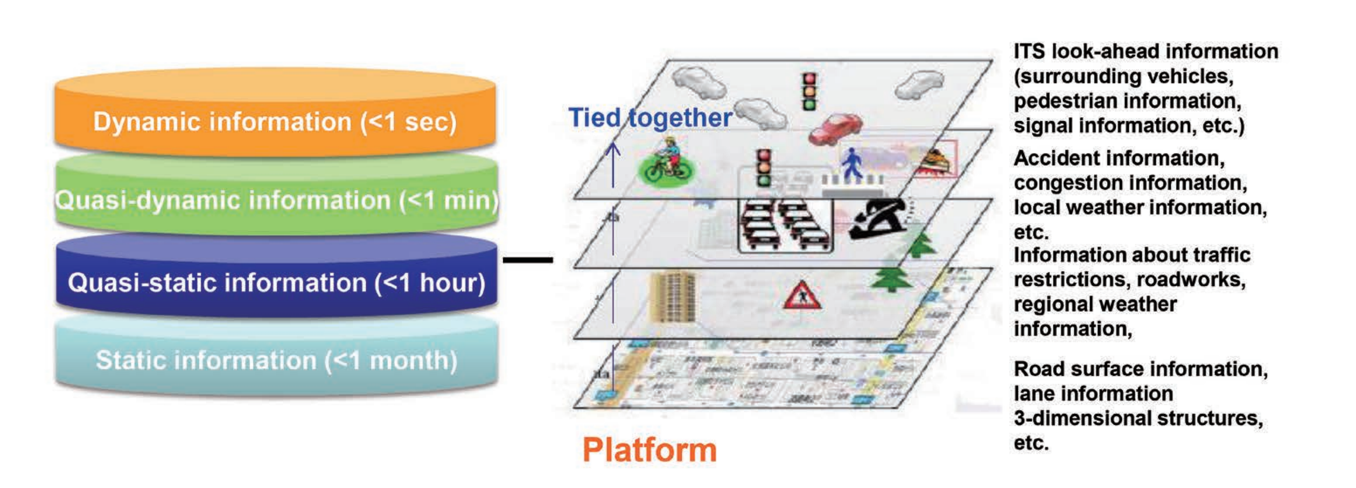


3. Definition of automated driving levels

When discussing automated driving systems, people often have totally different images of what they entail. On hearing the words "automated driving", some people might think of driverless cars, while others might think of cars equipped with technology that is already commercially available, such as the combination of Lane Keep Assist (LKA), Adaptive Cruise Control (ACC) and Pre-Crash Safety Systems (PCS).

For this reason, definitions of automated driving levels are currently under discussion at organizations such as the NHTSA and OICA. Since

Figure 2: Dynamic map



these discussions had only just begun when SIP-adus started, we defined four levels based on the NHTSA definitions. A characteristic of our definitions is that the automated driving level changes from one moment to the next according to the driver's intentions and the driving conditions. However, our level definitions are not set in stone, and are liable to be amended after further international discussions.

4. Scope of research and development area

Based on various announcements made by Google and car manufacturers about the development of automated driving systems, it can be seen that the core technologies of automated driving systems are intelligent technologies consisting of so-called on-board systems like vehicle sensors and control techniques. This raises the issue of deciding which areas should be tackled cooperatively by national projects, and which would be better left to private-sector competition.

Even only with on-board systems like the abovementioned combination of LKA+ACC+PCS, cars are still capable of automated driving to quite a considerable level. However, to cope with more complex environments and ensure greater safety, the limitations of on-board systems need to be complemented by using accurate maps and look-ahead information obtained from ITS. These are thought to be issues that need cooperative engagement between related parties including the government, rather than by individual motor companies.

Also, as vehicles become more intelligent and their interactions with drivers become more complex, users are more likely to be confused and meet with accidents if every company implements a different human-machine interface (HMI). It is therefore also necessary to create industry-wide guidelines for HMI.

Furthermore, when we reach the era of "connected" vehicles where ITS and communication technology is used to acquire information about traffic congestion or about other vehicles, information security will also become a major concern. Malicious cyber attacks may pose threats not only to vehicle safety but also to people’s trust in the traffic systems themselves. Therefore, information security is also an important concern requiring mutual cooperation between industry and Japan as a whole.

In addition to these challenges, it was decided that work on SIP-adus should include the development of an accident database and a methodology for simulating the effectiveness of traffic accident reduction as a national platform for the reduction of traffic fatalities and road congestion.

Furthermore, based on the idea that vehicles are global commodities requiring global cooperation, we have tried from the very beginning to communicate with overseas researchers in order to promote social acceptance of automated driving systems.

For the 2020 Tokyo Olympics and Paralympics, we are also cooperating with Tokyo in order to establish a next-generation urban transportation system and improved accessibility.

5. Technology and communication requirements of automatic driving systems

For automated driving, a vehicle must be able to estimate its own position accurately and determine the path of the road upon which it is driving. To achieve this, it is necessary to develop not only on-board sensors such as cameras and radars, but also precise maps and geolocation systems. Also, driving with on-board sensors alone is a bit like driving in complete darkness with just the headlights on, which is not as safe and may even be impossible in severe weather conditions or driving environments. This is complemented by making effective use of technologies such as ITS and GPS.

In other words, an automated driving system cannot be implemented with a single sensor, but can be implemented using diverse information from different complementary systems.

The precise maps needed for this purpose are nothing like the sort of maps used for ordinary car navigation systems. First of all, for automated driving, a vehicle must know how much space there is on the road for it to run on. Although it is of course possible to navigate with the white lines on the road, a vehicle must be able to determine where it can go to avoid obstacles such as parked cars or fallen objects in the road, or to avoid collisions with oncoming vehicles. For this purpose, three-dimensional road profile information is needed in order to distinguish between the curb and the roadside. It is also necessary to have other information such as lane closures and the locations of road works.

In addition to this static and quasi-static information, it is also necessary to have time-varying dynamic information. This includes quasi-dynamic information such as accident information, traffic information, and weather information including the extent of flooding and the like. An important source of dynamic information to complement the information from on-board sensors is ITS look-ahead information obtained by vehicle-to-vehicle, vehicle-to-infrastructure and vehicle-to-pedestrian communication. This information should be accurately linked to positions on the map. A database that includes all this static, quasi-static, quasi-dynamic and dynamic information is called a dynamic map. A dynamic map is a useful source of data not just for automated driving systems but for all vehicles, and is regarded as indispensable for vehicles to drive safely and comfortably.

Also, the three-dimensional road data profile is not only applicable to automated driving systems, but is also very useful for applications such as the maintenance of social infrastructure, disaster prevention/mitigation, and personal navigation. This means it will help to reduce the cost of producing precise maps, and will provide diverse information services in the future. In the SIP-adus project, we are willing to spearhead the construction of this database.

6. Using communication systems to reduce traffic fatalities

Finally, I will discuss how communication systems can be expected to reduce the number of traffic fatalities. As mentioned above, no matter how advanced the on-board sensors are, since they are mounted on a vehicle there will inevitably be blind spots at intersections or junctions with poor visibility. Currently, about half of all traffic fatalities in Japan occur at or near intersections. To reduce these accidents it is necessary to use not only on-board sensors but also ITS look-ahead information from sources such as vehicle-to-vehicle, vehicle-to-infrastructure and vehicle-to-pedestrian communication.

Meanwhile, there are still many other problems to be solved. In the SIP-adus project, we are establishing protocols for vehicle-to-vehicle and vehicle-to-infrastructure communication, we are developing systems that use direct communication via dedicated terminals and communication via mobile phone networks, and we are working on the development of a 79 GHz high-resolution radar that can detect obstacles such as people and other vehicles.

Details of these efforts will be described later by the people responsible for each initiative.

7. Concluding remarks

All the interested parties are currently engaged in research and development to implement an automated driving system, but our goal is to realize a next-generation traffic system where accidents are a thing of the past. To reduce the number of accidents, it is still necessary to treat people, vehicles and traffic environments as a single ensemble.

We are not aiming to build a future where humans have nothing to do, but we hope that our efforts will soon provide people around the world with safe, stress-free transport by complementing with people, vehicles and traffic environments.

Figure 3: Using base map data