6 Promoting International Cooperation

(1) International Cooperation and Activities for Standardization

Overview

Manabu Umeda (The University of Tokyo)

Automated driving technologies have been improved dramatically, and various activities are being addressed throughout the world. In this circumstance, it is crucial for Japan to take the initiative in standardization and regulatory activities, and to contribute to international harmonization, in order to keep the international competitiveness for the automotive manufacturers and related industries.

In the second phase of SIP-adus, enhancing international cooperation is one of the four major activity pillars. Seven focus international cooperation themes have been identified, and an international cooperation theme leader has been assigned in each research theme. Addition to that, an international cooperation framework featuring collaborative research coordinator who promotes international cooperation activities, has been established. Currently, joint research activities with the German Federal Ministry of Education and Research, and cooperation activities with research projects in the EU Framework Programme for Research and Innovation etc., have been progressing. We are also making the SIP-adus research outcomes known to other countries through events such as SIP-adus Workshops, as well as carrying out the investigative research activities. At the same time, we are coordinating with the relevant standardization bodies about international standardization activities and contributing standardization from both the “de jure” and “de facto” standards perspectives.

1 Background

Automated driving technologies has been improved dramatically with the participation of various industries, including companies in the information services and startups in addition to current automobile manufacturers. Automobile manufacturers are actively producing and selling cars both in Japan and other global markets. Various activities such as automotive technologies development, infrastructure, standardization, legislative issues, and field operational tests (FOTs) are being addressed throughout the world .

As the automotive industry plays a crucial role in Japan, in order to maintain the international competitiveness of automobile industries and its related businesses, it is necessary to take the initiative in standardization and regulatory activities, and to work toward international harmonization. Consequently, the strengthening of international cooperation has been defined as one of the four major activity pillars of the second phase of SIP-adus, and information on its research outcomes is actively communicated to other countries. Furthermore, investigative research and other activities necessary to strengthen international cooperation are addressed for the purpose of providing open research and development that will induce active discussions, as well as creating opportunities for social implementations.

At present, offerings of joint research through the frameworks of Japan–Germany cooperation and of EU funded projects are received, and we are supporting joint research activities on automated driving between Japanese universities & research institutes and research institutes in Europe or US, through providing workshops to explore joint research themes, and additional calls for submissions in the second phase of SIP-adus.

2 International Cooperation Framework and Focus Themes

At SIP-adus, the seven focus themes described in sections 2.1 to 2.7 have been identified by enhancing the international cooperation activities addressed in the first phase of SIP, and theme leaders responsible for promoting international cooperation activities in each research fields have been assigned. Furthermore, in order to promote international cooperation activities, a collaborative research coordinator who supports and coordinates international cooperation activities as the main window person in SIP-adus has been designated under the Steering Committee of SIP-adus, and the framework shown in Fig. 1 has been established.

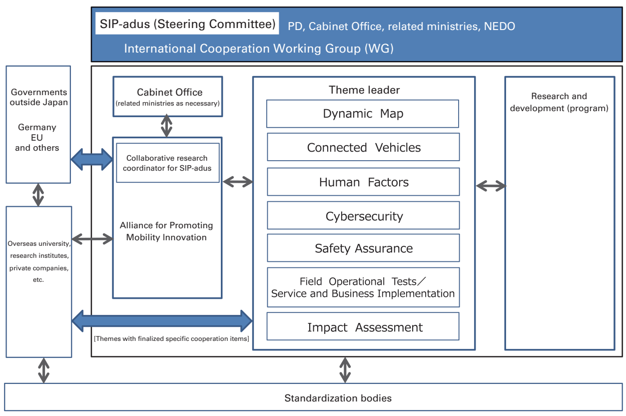

Fig. 1: SIP-adus Framework for International Cooperation Activities

2.1. Dynamic Map

Digital map databases with a layered structure built on graph network representation of roads will be expanded widely including highly detailed description of the road structure and its surrounding environment. The databases will be dynamically linked to real time information from an integrated sensor systems onboard the vehicles and semi-real time information from V2X communications. The development of such databases is only possible through collaboration across industry sectors and public agencies.

2.2. Human Factors

The shift between levels of automation will depend on the driving environment and the driver's condition along the trip. It is important to design automated vehicle systems to effectively communicate with the driver, so that the situational awareness of the driver is maintained and the transition between the levels of automation is properly performed.

2.3. Safety Assurance

How safety is assured is an extremely critical aspect of implementing automated driving technologies into the society. Reliable and efficient test methods will be required in order to assure the safety for automated driving. Ensuring the safety of complex electronic systems and software requires virtual testing environments in cyberspace. Various evaluation methods for validation, modeling, and simulation are under development.

2.4. Connected Vehicles

High levels of automation require a larger range of observation of the driving environment. The deployment of connected vehicle technology will be advantageous to automated driving systems. Proximity will be sensed by integrated sensors onboard the vehicle, and physically blind vehicles will be notified through vehicle to vehicle (V2V) communication. Furthermore, providing traffic signal and other infrastructure information to automated vehicles through vehicle to infrastructure (V2I) communication facilitates the realization of smoother and safer automated driving.

2.5. Cybersecurity

A connected car is a car that has become capable of providing various services, which enhance its convenience and safety, through DSRC and cellular communication. However, a connected car is also at risk from cyberattacks, and new types of cyberattacks are regularly reported at international conferences such as BlackHat in the field of vehicle cyber security. Cybersecurity measures will have to continue to be reinforced to keep systems secure in the future. Therefore, it is essential to share information and promote collaboration among industry and government across the conventional boundaries between sectors.

2.6. Impact Assessment

Demonstrating the economic and social benefits provided by automated driving technologies and understanding its latent risks will be essential for automated driving technologies to be widely accepted in public. Considering the level of automated driving technologies and its dissemination status, having an open discussion for its effects and latent risks by automated driving technologies is necessary, through guiding the analysis and quantitative effects of the impact of automated driving with respect to reducing traffic accidents, decreasing CO2 emissions, and mitigating traffic congestion, defining its long-term vision in Japan.

2.7. Service and Business Implementations

In the central districts of large cities with high-density travel demand, a pedestrian-centered multimodal transportation network is anticipated to offer efficient and sustainable mobility. Innovative transportation systems featuring automated driving technologies and on-demand operation will reduce travel time while making trips comfortable for passengers, and enhance efficiency for operators. In contrast, small size vehicles with enhanced driver assistance for personal use are also anticipated to provide aged or vulnerable road users and to encourage them to actively engage in social activities.

Various activities regarding new mobility services and mobility innovation by utilizing automated driving technologies, are being carried out worldwide.

3 Major International Cooperation Activities

3.1. Networking

The international cooperation theme leaders for SIP-adus participate in international conferences such as ITS World Congress, Transportation Research Board (TRB) in US, or EU-CAD in Europe, to maintain and consolidate their expert network through information exchange with overseas specialists. In addition, a collaborative research coordinator has connections with government organizations such as the U.S. Department of Transportation (USDOT) and the Directorate-General for Research and Innovation (DG-RTD) of the European Commission, and these connections contribute to establish a new research network by introducing specialists or research project leaders through those government organizations based on requests from each experts.

3.2. Japan–Germany and Japan–EU Cooperation Activities

Japan-Germany cooperation activities have been carried out between the Japanese Cabinet Office and the German Federal Ministry of Education and Research, based on the Joint statement to enable scientific exchange in automated driving and to identify areas for potential research and development activities on Science, Technology, and Innovation. As a result, it was agreed to start joint research activities in the two fields of "Human Factors" and "Impact Assessment" in 2019, and a further joint research activities in the fields of "Safety Assurance" and "Cybersecurity" were agreed in 2020.

With respect to Japan–EU cooperation activities, an agreement to study cooperation opportunities between the two existing projects, the Horizon 2020 in EU Framework Programme for Research and Innovation and the SIP-adus research project, was reached with the Directorate-General for Research and Innovation (DG-RTD) of the European Commission, and potential cooperation has been studied. As of June 2021, cooperation activities under the Horizon 2020 framework are being carried out in three projects.

3.3. SIP-adus Workshop

The SIP-adus Workshop have been held since the first phase of SIP as an international conference, in order to enhance Japanese initiatives in the context of automated driving research and development, to promote the technologies developed in Japan, and to contribute harmonization for international standardization. It has been held annually in November since 2014, and the Workshop is now recognized as an international conference on automated driving researches hosted by Japan.

The Workshop is composed of plenary sessions open to the public and breakout sessions that aim for deeper discussions between invited specialists, and each session is composed of the focus international research themes. The Workshop was held over three days at the Tokyo International Exchange Center in 2018 and 2019. Due to the COVID-19 pandemic, the SIP-adus Workshop 2020 changed a format to a web-based conference, and it was held with the SIP-adus Status Report Meeting.

3.4. Deploying a Large-Scale Field Operational Test Environment

Large-scale FOTs have been conducted in the Tokyo Waterfront City area encompassing the Tokyo waterfront subcenter area, the Haneda Airport area, and the Metropolitan Expressway that connects Haneda Airport and the Waterfront City area. The purpose of this FOT was to find solutions to technical issues for application of infrastructure cooperative data, such as merging lane assistance, traffic jam information, and traffic signal information, as well as to encourage the development of automated vehicles, enhance international cooperation and standardization, foster public acceptance, and promote advanced technologies.

Deploying a globally open test environment to conduct the FOTs in the Tokyo waterfront area enabled automobile manufacturers and suppliers from outside Japan to participate in the FOTs. Basic technologies for the realization of automated driving were validated in the real traffic environment on public roads.

3.5 Activities for International Standardization

SIP-adus is strengthening collaborations with standardization bodies to bring products and services into global markets smoothly and quickly. We are working with organizations such as the Japan Automobile Manufacturers Association (JAMA) and the Society of Automotive Engineers of Japan (JSAE), as well as the Japan Auto Parts Industries Association (JAPIA), the Japan Electronics and Information Technology Industries Association (JEITA), the UTMS Society of Japan, the Association of Radio Industries and Businesses (ARIB), and the ITS Info-communications Forum (ITS Forum) to promote standardization based on both “de jure” standards in ISO, IEC, and ITU etc., and “de facto” standards through cooperation with global industry standardization bodies.

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6 Promoting International Cooperation

(1) International Cooperation and Activities for International Standardization

SIP-adus Workshop

Takahiro Tanaka and Akira Ikeda (New Energy and Industrial Technology Development Organization)

The SIP-adus Workshop is an international conference held by SIP-adus since the first phase of SIP was started in 2014. Counting the seventh in 2020, this series of conferences hosted by Japan is gaining recognition as one of the world's major international events in the field of automated driving. The SIP-adus Workshop is more than just an event. This is a forum to enrich international networks by gathering many automated driving specialists in both fields of the research and development and the implementation of businesses from around the world and exchanging their knowledge and expertise. It has always evolved in gaining momentum. The Eighth edition, SIP-adus Workshop 2021, will be held in November of that same year. Focusing on the results of SIP-adus research and development, as well as social implementation efforts, it will feature various discussions and exchanges of views and offer an opportunity to communicate information with one another on automated driving at an international level, and therefore contribute to the SIP-adus international cooperation activities. This report also gives an overview of the SIP-adus Workshop carried out during the first phase of SIP of which the report did not cover it.

1 Purpose and Overview

SIP-Automated Driving for Universal Services is promoting to strengthen international cooperation as one of the four pillars of its activities. The first SIP-adus Workshop was held in 2014, when the first phase of SIP commenced. The conference was organized for the purposes of clearly establishing Japan's global role through the exchange of information with Europe, the U.S. and other nations, and the active communication aiming for international standardization initiated by Japan, based on globally shared and discussed issues about automated driving. Since 2014, the workshop has been annually carried out in autumn, and gained international recognition as a Japanese-organized international conference, where many specialists from both Japan and around the world come together to enjoy discussions and exchange ideas in their respective fields.

The Workshop is opened with a welcome speech by a Minister of State and keynote speeches by European and American government representatives, as well as by the Program Director. These are followed by plenary sessions in which specialists from all over the world make presentations, and breakout workshops where subcommittees grouped by theme have discussions and exchange views.

The venue also features a poster exhibit session, which enjoys the visit of many participants.

2 The SIP-adus Workshop in the First Phase of SIP

2.1. 2014 (First)

November 17 and 18, 2014 (United Nations University)

The First Workshop was taken place in conjunction with the inauguration of the first phase of SIP-Automated Driving for Universal Services.

The plenary sessions and breakout workshops were held on the five themes below.

- Dynamic Map
- Human Factors
- Next Generation Transport
- Connected Vehicles
- Impact Assessment

2.2. 2015 (Second)

October 27 to 29, 2015 (Tokyo International Exchange Center)

The schedule was expanded to three days, with the plenary sessions and breakout workshops on the six following themes. The third day featured a test-ride event conducted in cooperation with various automobile manufacturers.

- Dynamic Map
- Connected Vehicles
- Human Factors
- Impact Assessment
- Next Generation Transport
- Security

2.2. 2016 (Third)

November 15 to 17, 2016 (Tokyo International Exchange Center)

The plenary sessions and breakout workshops covered the same six themes as the previous year.

2.3. 2017 (Fourth)

November 14 to 16, 2017 (Tokyo International Exchange Center)

The plenary sessions and breakout workshops were held on the seven themes below.

- Regional Activities and FOTs
- Dynamic Map
- Connected Vehicles
- Cybersecurity
- Impact Assessment
- Next Generation Transport
- Human Factors

2.4. 2018 (Fifth)

November 13 to 15, 2018 (Tokyo International Exchange Center)

The plenary sessions and breakout workshops covered the same seven themes as the previous year.

3 The SIP-adus Workshop in the Second Phase of SIP

3.1. 2019 (Sixth)

November 12 to 14, 2019 (Tokyo International Exchange Center)

Plenary sessions and breakout workshops were held on the seven themes below.

- Regional Activities
- FOTs and Next Generation Transport
- Human Factors
- Cybersecurity
- Safety Assurance
- Dynamic Map
- Connected Vehicles

Featuring 51 talks, 29 of which were made by presenters from other nations, the event attracted 511 participants from 23 countries.

The opening session was started with a welcome speech by a Minister of State, and keynote speeches by European and American government representatives, as well as by the SIP-adus Program Director (Fig.1).

The plenary sessions and breakout workshops were taken place for each theme, and the event featured numerous presentations and discussions, as well as extensive exchanges of ideas (Fig.2).

Many participants also showed keen interest in the poster exhibits covering the international cooperation activities by ministries and SIP-adus (Fig.3).

Fig. 1: Commemorative Photograph with the Minister of State at the Center

Fig. 2: A Breakout Workshop

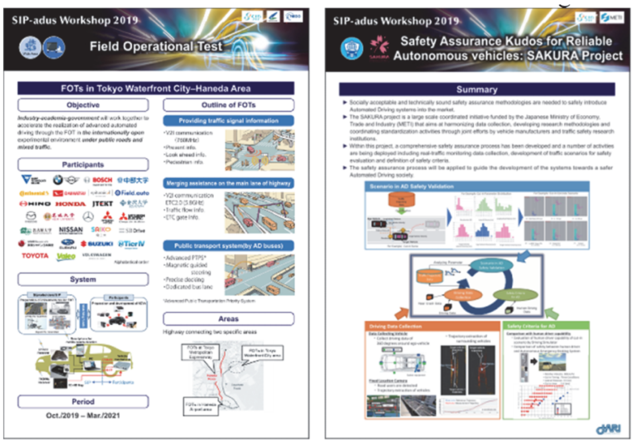

Fig. 3: Poster Exhibits

3.2. 2020 (Seventh)

November 10 to 12, 2020 (Tokyo International Forum on the 10th only)

In 2020, an online virtual Workshop was held for the first time amid the global COVID-19 pandemic stopping specialists from travelling to Japan and preventing the gathering of a large number of participants at the venue.

All events were transmitted in both Japanese and English via simultaneous interpretation, with three separate broadcast feeds throughout the day for Europe and the U.S. to maximize the benefits of holding the event online and allow many people to participate. As a result, there were 76 presentations, 28 of which were made by people outside Japan, and the event attracted a record of 1,152 participants from 29 countries.

On the first day, the SIP-adus Status Report Meeting provided an opportunity to show the results of SIP-adus research and development, with the opening session started with a welcome speech by a Minister of State, and keynote speeches by European and American government representatives, as well as by the SIP-adus Program Director (Fig.4).

The Status Report Meeting consisted of the four sessions below, which involved a total of 20 presentations on SIP-adus activities. The sessions were streamed online in real time.

- Utilization and exchange of data for implementation of Society5.0
- Development and utilization of traffic environmental information
- Toward realization of safe automated driving
- Society with automated driving for universal services

On the second and third day, the plenary sessions as online symposiums were carried out on the eight following themes and by the ministries as in the past years(Fig.5)

- Regional Activities
- Service and Business Implementation
- Dynamic Map
- Connected Vehicles
- Safety Assurance
- Cybersecurity
- Human Factors
- Impact Assessment

Fig. 4: Commemorative Photograph with the Minister of State at the Center

Fig. 5: Online Streaming Screenshot

The event held online attracted many people whose schedule normally did not allow them to do so. In addition, the bilingual Japanese and English streaming, and the time zone feeds for Europe and the Americans also gathered significantly greater number of participants from both Japan and other countries, creating an opportunity for them to acquire various information including the results of research and development through SIP-adus activities and in various countries.

For those who were unable to watch the online sessions during the event and in response to requests of those who wanted to carefully listen to the presentations one more time, on-demand streaming was made available for about a month from December. The event was attended by 1,212 people (including 264 via on-demand streaming) from 12 countries.

3.3. 2021 (Eighth)

Scheduled for November 9 and 10, 2021

With the COVID-19 pandemic persisting in 2021 yet, we decided to hold the Workshop virtually online, for it will be still difficult for specialists to travel to Japan, and to gather a large number of people at the venue (Fig.6).

Over two days, SIP-adus presents the plenary sessions on the eight themes below and by the ministries, via online streaming. We will also hold the theme-specific breakout workshops which had not been conducted in 2020, in providing opportunities not only for the communication to send out information but also for discussion and exchange of views as carried out at the past events, so as to make this SIP-adus Workshop even more fulfilling than in 2020.

Fig. 6: SIP-adus Workshop 2021 Flyer

【References】

(1)SIP-adus website:
https://www.sip-adus.go.jp/

【About the author】

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Japan–Germany and Japan–EU Cooperation

Manabu Umeda (The University of Tokyo)

As inter-governmental international cooperation activities in the second phase of SIP-adus, collaborative activities with the German Federal Ministry of Education and Research (BMBF) and the European Commission Directorate-General for Research and Innovation (DG-RTD) have been progressing by receiving offers of joint research through the frameworks of Japan-Germany cooperation and of EU funded project. With respect to Japan–Germany cooperation, joint research plans in the fields of "Human Factors" and "Impact Assessment" related to automated driving technologies were approved in January 2019, with the subsequent approval of new joint research plans in the fields of "Safety Assurance" and "Cybersecurity" in 2020. Now cooperative research covers four areas of research field. With respect to Japan–EU cooperation, cooperation activities with three projects under the Horizon 2020 Framework Programme for Research and Innovation funded by the European Commission are currently ongoing.

1 Background

In the second phase of SIP-adus, enhancing international cooperation has been defined as one of the four major activity pillars. In response to the automated driving field operational tests (FOTs) carried out globally and various international discussions, SIP-adus is encouraging international joint research and other cooperation activities with overseas research institutes in the field of automated driving.

Many research projects regarding connected and automated driving, including the PEGASUS project under the initiative of German government and project under Horizon 2020 Framework Programme for Research and Innovation, are carried out in Europe, and offerings of joint research through the frameworks of Japan–Germany cooperation and the EU project framework are received to SIP-adus. As a result, inter-governmental international cooperation activities described below have been progressing as Japan–Germany cooperation and Japan–EU cooperation respectively.

2 Overview of Japan–Germany Cooperation Activities

Japan–Germany cooperation activities on automated driving have been carried out between Japanese Cabinet Office and the German Federal Ministry of Education and Research (BMBF), based on the Joint Declaration of Intent on Japanese – German Cooperation of the Minister of State for Science and Technology Policy of Japan and the Federal Minister of Education and Research of the Federal Republic of Germany on the Promotion of Research and Development on Automated Driving Technologies on January 12, 2017.

In order to promote the research and development for automated driving technologies by Japan-Germany cooperation, a steering committee to make decisions on Japan–Germany cooperation activities for automated driving has been established. The committee consists of senior officials, specialists, and other representatives of the Cabinet Office, Ministry of Economy, Trade and Industry in Japan, BMBF, and German Federal Ministry for Economic Affairs and Energy, as well as other Japanese and German agencies involved. An expert workshop for exchanging opinions among experts of related research fields, and a coordinating secretariat that arranges and supports the cooperation activities, have been set under the steering committee to establish the Japan–Germany cooperative structure shown in Fig. 1.

The expert workshop to discuss specific cooperative research topics held its first session in November 2017, by taking the opportunity of SIP-adus Workshop. Since then, the expert workshop has been held as an annually basis, with discussions among experts in various fields of research topics such as human factors, socio-economic impact assessment, and safety assurance.

The first Japan–Germany Cooperation Steering Committee to discuss specific cooperative research themes and to approve joint research activities, was held in January 2019, and since then, total 4 steering committee meetings were held as of June 2021.

Furthermore, in order to enable smooth communication between Japanese and German experts at each joint research theme, the contact person list at each joint research theme in Japan and Germany was jointly created and shared among related members in November 2019.

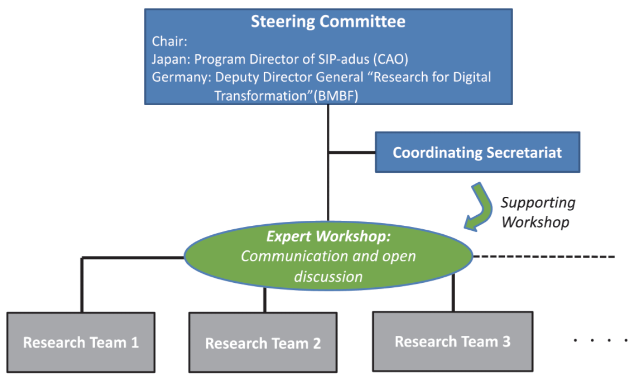

Fig. 1: Diagram of Japan–Germany Cooperative Structure

2.1. Japan–Germany Cooperation Activities regarding Human Factors and Socio-economic Impact Assessment

Through the expert workshops held on November 2017 and September 2018, discussions were held regarding research and development of human factors and socio-economic impact assessment of automated driving, and as a result, the joint research plans for those two fields were approved at the first steering committee meeting in January 2019.

In the field of human factors related to automated driving, Japanese and German academic researchers are jointly investigating any differences in interpreting communication signs between Japan and Germany, and how to address the differences when it exists, with regard to communications with outside environments which are essential to automated vehicles.

In the field of socio-economic impact assessment, researchers are working on developing methodologies to scientifically and quantitatively calculate the impact of the safer and more efficient traffic flow, reduction of traffic congestions, and decreasing fatal traffic accidents that will be brought by the realization of automated driving technologies, as well as researching differences between Japan and Germany in terms of fostering of public acceptance for automated driving technologies.

2.2. Japan–Germany Cooperation Activities regarding Safety Assurance and Cybersecurity

At the second steering committee meeting in November 2019, members agreed to study the opportunities for new joint research themes of safety assurance and cybersecurity, addition to the above-mentioned joint research activities, and joint research plans for both fields were approved at the third steering committee meeting in May 2020.

In the field of safety assurance, researchers are developing evaluation methods for validation, modeling, and simulation to assure the maximum level of safety for automated driving.

In the field of cybersecurity, researchers are developing methods to detect and eliminate potential security threats of modern automated vehicles at an early stage, starting already in the development process.

3 Overview of Japan–EU Cooperation Activities

Based on the recommendations for international cooperation with non-European nations including Japan, the U.S., and Asia and Oceania countries in the Horizon 2020, EU Framework Programme for Research and Innovation of the European Commission, the meeting between SIP-adus and European Commission, Directorate-General for Research and Innovation (DG-RTD) was held to exchange the opinions for future cooperation in April 2018. Since then, the opportunities of specific Japan–EU cooperation activities have been studied.

At the meeting with the European Commission (DG-RTD) in November 2019, considering possibilities to coordinate between already existing European Horizon 2020 projects and SIP-adus research projects was agreed, and now cooperation activities between each program's existing projects are underway.

In order to promote Japan-EU cooperation activities, the cooperative structure shown in Fig. 2 was agreed with the European Commission (DG-RTD) to enable the coordinating secretariats to work together in monitoring and supporting cooperation activities based on coordination between Japan and EU projects.

The first meeting between the coordinating secretariats was held in May 2020, and subsequently held regularly on a quarterly basis . In the meeting, the latest situation of cooperation activities between projects is shared and the opportunities for potential new cooperative research areas are discussed. The first high-level meeting with senior officials was held in March 2021, with the release of the 2020 Annual Status Report, which is summarized the Japan-EU cooperation activities in 2020.

Different from the Japan–Germany cooperation, the Japan–EU cooperation does not have an intention to establish new joint research projects. It features promoting cooperation activities by coordination between existing Horizon 2020 and SIP-adus projects.

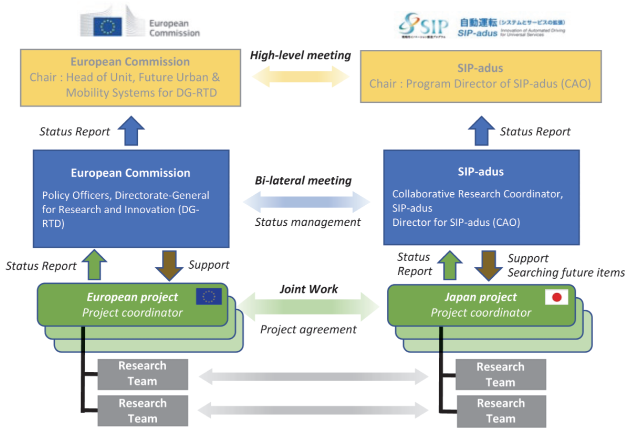

Fig. 2: Diagram of Japan–EU Cooperative strucuture

3.1. Status of Japan–EU cooperative projects

As of June 2021, cooperation activities with following three projects under the Horizon 2020 umbrella are underway as Japan–EU cooperation.

- Cooperation activities with HADRIAN Project
  In the research field of developing human machine interfaces (HMI) to enhance the safety of automated driving, SIP-adus experts regularly exchange the information with HADRIAN project members.
- Cooperation activities with HEADSTART Project
  In the research field of safety assurance, cooperation activities with HEADSTART project through the agency of the European Commission was started. Since September 2020, addition to SIP-adus members, the members from the Ministry of Economy, Trade and Industry-directed SAKURA project participated the meeting with HEADSTART project, and they exchange the information related to safety assurance and discuss specific future cooperation topics.
- Cooperation activities with SHOW Project
  In the research field of realization of automated driving services in the urban area, the Mobility Innovation Collaborative Research Organization, The University of Tokyo (UTmobI) and ITS Japan concluded a non-disclosure agreement (NDA) with SHOW project, which is involved in large-scale demonstrations of mobility services focused on cities in September 2020, and cooperation activities are underway.

In Europe, the Horizon 2020 Framework Programme for Research and Innovation was finished in 2020, and has been succeeded by the new Framework Programme "Horizon Europe" for Research and Innovation since 2021. The Horizon Europe program follows the Horizon 2020 approach of encouraging international cooperation with Japan and other countries outside Europe. In the field of automated driving, various research and innovation programs are planned under the new Horizon Europe framework. Cooperation activities with new Horizon Europe projects will be expected through the relationship built between Japan and Europe.

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6 Promoting International Cooperation

(1) International Cooperation and Activities for Standardization

Dynamic Maps

Satoru Nakajo (The University of Tokyo)

International cooperation activities on dynamic maps are based on the SIP-adus research and development results. The main objectives of these activities are to make them, along with the SIP-adus research results, known outside Japan, and to obtain feedback particularly in the context of dynamic maps. The specific activities can be broadly classified as presentations and participation in international conferences, international standardization activities, industry standardization activities, and Japan–U.S.–EU trilateral cooperation. Achievements from activities of the second phase of SIP to date have included presentations at the ITS World Congress and several other international conferences, and the establishment of three international standards—ISO 17572-4 (Precise relative location references), and ISO 20524 (Geographic Data Files) Parts 1 and 2. In addition, SIP-adus has officially become a member of the steering committee of the Open AutoDrive Forum (OADF), an organization involved in industry standardization of digital maps, and has concluded a memorandum of understanding with the Advanced Driver Assistance Systems Interface Specifications (ADASIS) Forum, another member of the OADF, to cooperate in the next SIP-adus field operational tests (FOTs).

1 Overall View of Initiatives

The main objectives of dynamic map international cooperation activities are to make them, along with the SIP-adus research results, known outside Japan, and to obtain feedback particularly in the context of dynamic maps. In concrete terms, our activities cover (a) presentations and participation in international conferences, (b) international standardization activities, (c) industry standardization activities, and (d) Japan–U.S.–EU trilateral cooperation.

We have made presentations at, and otherwise participated in, the ITS World Congress and several other international conferences. Our international standardization activities have led to the establishment of international standards for several items that SIP-adus has been supporting. The three specific standards consist of ISO 17572-4 (Precise relative location references), and Parts 1 and 2 of ISO 20524 (Geographic Data Files). In the area of industry standardization, we have been attending OADF events held several times per year, presenting the progress of SIP-adus activities to other participants, as well as participating in the monthly OADF steering committee meeting and being actively involved in discussions to determine the direction of OADF operations. At the same time, we have concluded a memorandum of understanding with ADASIS, one of the other members, and obtained cooperation for the next SIP-adus FOTs. As part of the Japan–U.S.–EU trilateral cooperation activities, we regularly exchanged information with the U.S. and European representatives in the Physical and Digital Infrastructure SWG, which forms one element of those activities.

2 Presentations and Other International Conference Activities

During the first half of the second phase of SIP, we gave presentations at the international conferences below. Each presentation covered the positioning of dynamic maps within SIP-adus, as well as descriptions of research and development results and of initiatives carried out as part of second phase activities.

In particular, given the focus on dynamic maps linking dynamic information in the second phase activities, our descriptions have focused on the fact that our FOTs are conducted with the unified handling of both static maps and dynamic information in mind.

2018 ITS World Congress (Copenhagen):
SIS58: A new cooperation approach for an Automated Driving Ecosystem

2019 AVS (San Francisco):
Data/Digital Infrastructure session

2019 ITS World Congress (Singapore):
SIS09: Challenge of Integrating Automated Vehicles into the Digital Infrastructure

2020 International Conference on HD Maps for Autonomous Vehicle (Taipei: attended via video conference)
Keynote address: The development and trends on HD Map Format: SIP-adus

3 International Standardization Activities

3.1. Overview of SIP Second Phase Activities

Since the first phase of SIP, international cooperation activities on dynamic maps have involved ISO/TC 204/WG 3 (ITS geographic data). With TC 204, which studies ITS international standardization, WG 3 mainly assesses international standards related to digital maps and spatial information. The SIP-adus activities carried out to date have led to establishing the ISO 17572-4 (Precise relative location references) and ISO 20524 (Geographic Data Files) Parts 1 and 2 standards. An overview of each of those standards is presented below.

3.2. ISO 17572-4 (Precise relative location references)

Location references standardize the format used to represent location when information is exchanged between different applications or map databases. The purpose is to ensure that the location involved in the exchange of traffic or other information between different systems is understood even if they do not use the same map database.

Past activities led to the establishment of the Pre-coded location references (ISO 17572-2) and Dynamic location references (ISO 17572-3). A pre-coded location profile uses a predefined shared ID (such as a road link) and using it for location referencing.

Such profiles are used by the Vehicle Information and Communication System (VICS) and the Radio-Data System - Traffic Message Channel (RDS-TMC) used in Europe. A dynamic location profile involves transmitting latitude and longitude coordinates with supplementary information to provide location referencing.

Complementing the above, precise relative location references, a fourth profile enabling location referencing with a high degree of accuracy for cooperative and automated driving systems, was approved as NP 17572-4 in April 2016. That proposal was presented by Japan based on studies by SIP-adus. The proposal then went through the assessment and deliberation process, and was published as ISO 17572-4 in April 2020.

Two methods are defined for precise relative location referencing. Method 1, lane number counting, applies to road sections with lanes and is used to identify the specific lane. Method 2 involves measuring the delta from a reference point and is used for road sections where a lane is difficult to define clearly (such as in intersections or near toll booths). An area within roughly 200 m of the reference point is used to enable precise location representation.

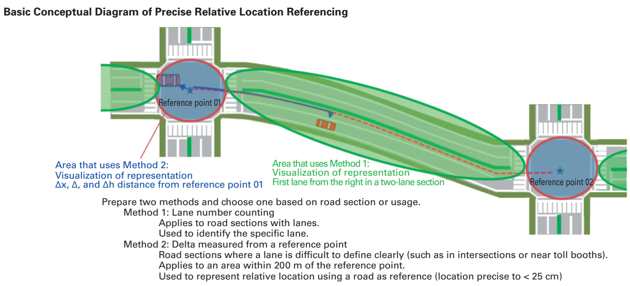

Fig. 1: Basic Conceptual Diagram of Precise Relative Location Referencing

3.3. ISO 20524-1 and 2 (Geographic Data Files)

Until now, geographic data files (GDF) have handled geographic data primarily targeted at car navigation systems. The need for a revision subsequently rose in as new applications such as cooperative ITS, multimodal navigation, and automated driving emerged. This led to the approval of PWI 20524 and the start of work on the GDF 5.0 revision in October 2014. During that process, Japan led discussions on automated driving system based on input from within the country as well as from Europe and the U.S. This resulted in the ISO publishing Part 1 in April 2020, and Part 2 in October 2020.

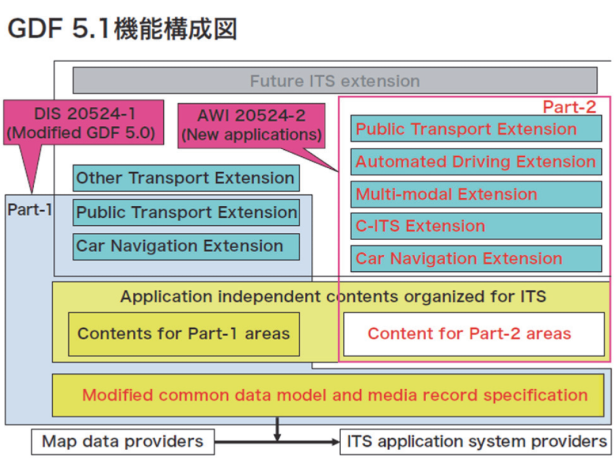

Fig. 2: Functional Diagram of Geographic Data Files

4 Industry Standardization Activities

SIP-adus has been participating in the OADF industry standardization body for digital maps for automobiles. Launched in 2015, the OADF is a forum aimed at exchanging information between industry groups. SIP-adus attended the fifth meeting in 2016 (Beijing), and, along with acting as chair and organizing individual sessions, started making presentations on an ongoing basis with the sixth meeting (Brussels). In 2017, the eighth meeting was held in Tokyo in conjunction with the SIP-adus Workshop. Through these activities, SIP-adus became a member of the steering committee in 2019, and continues to hold that role.

The six groups below are currently official members of the OADF.

ADASIS	:	Advanced Driver Assistance Systems Interface Specifications Forum
NDS	:	Navigation Data Standard
SENSORIS	:	Sensor Interface Specification
SIP-adus		
TISA	:	Traveller Information Services Association
TN-ITS	:	Transport Network Intelligent Transport Systems

In addition, there are ongoing discussions on the OpenDRIVE and OpenSCENARIO simulation standards led by the Association for Standardization of Automation and Measuring Systems (ASAM).

The OADF does define standards itself, and the exchange of information between participating groups remains the main purpose of its activities. SIP-adus is not a standardization body, and its role is to provide test results that can be used as reference for various industrial standards.

Building on ongoing discussions in the OADF, SIP-adus has concluded a memorandum of understanding with ADASIS, with the latter disclosing its specification (version 3) to assess its potential application in SIP-adus FOTs. We are currently exchanging opinions as needed directly with ADASIS as we assess its potential application in FOTs.

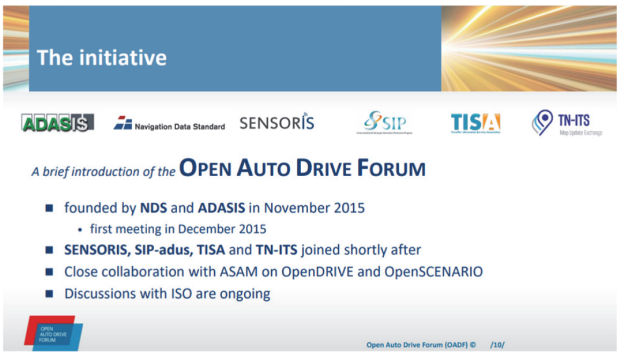

Fig. 3: Overview of OADF Activities (from OADF Meeting Materials)

5 Japan–U.S.–EU Trilateral Cooperation Activities

Japan–U.S.–EU trilateral cooperation consists of government-led international cooperation activities carried out under the memorandum of understanding reached between the European

Commission and the U.S. Department of Transportation in 2009 and the Japan–U.S. and Japan–EU memoranda of understanding on cooperation in the ITS field concluded in 2010 and 2011 by the Japanese Ministry of Land, Infrastructure Transport and Tourism.

SIP-adus has been participating in initiatives concerning automated driving and holding regular exchanges of opinion with its counterparts in the EU and the U.S. One of the automated driving initiatives is the Physical and Digital Infrastructure SWG. This activity involves regularly informing the European and U.S. representatives of trends concerning dynamic maps, and receiving information on the progress of activities in the EU and the U.S.

In past years, trilateral meetings have been held in conjunction with the ITS World Congress and other international conferences. Since 2019, the meetings are held online several times a year.

【 References 】

(1)SIP-adus website
https://en.sip-adus.go.jp/ (retrieved June 30, 2021).
(2)Society of Automotive Engineers of Japan: ITS Standardization 2020 (2020)
https://www.jsae.or.jp/01info/org/its/its_2020_en.pdf (retrieved June 30, 2021).
(3)OADF website
https://www.openautodrive.org/ (retrieved June 30, 2021).

6 Promoting International Cooperation

(1) International Cooperation and Activities for Standardization

Human Factors

Satoshi Kitazaki (National Institute of Advanced Industrial Science and Technology)

Human factors in automated driving constitute a critical aspect of the safety and social acceptance of that technology. In addition, understanding people can be defined as fundamental research, and encompasses a large portion of the cooperative area. Through the first and second phases of SIP, we have relied on proactive cooperation with countries outside Japan both to define issues, as well as validate research methods and appropriateness, for projects concerning human factors and to convey our results internationally. We have also actively worked to incorporate those results in international standards. This article introduces the actual activities.

1 Background

Human factors in automated driving constitute a critical aspect of the safety and social acceptance of that technology. At levels 2 and 3, drivers still has a certain role to play during automated driving, and dangerous situations can rise if they are unable to fulfill that role for any reason. Moreover, when level 3 or higher automated vehicles share the road with other traffic participants (mixed traffic), drivers or pedestrians failing to understand the intent of an automated vehicle can impede the smooth flow of traffic or create dangerous situations. In turn, these concerns present an obstacle to fostering social acceptance of automated vehicles.

A large portion of research and development on human factors in automated driving can be interpreted as fundamental (cooperative) area technology in that field. The scope of that research and development has not been limited to SIP-led "Team Japan" initiatives, but has also involved constant proactive cooperation and exchanges of information with both industry and academia R & D institutes in other countries, as well as the setting of research themes and the validation of the appropriateness of research methods. In addition to making our results known on a global scale, we have been actively contributing to international standardization. This article introduces concrete examples of international cooperation and international standardization activities carried out in the context of human factors in automated driving.

2 International Cooperation

2.1. Japan–U.S.–EU Trilateral Cooperation Activities

Activities have been conducted through the Human Factors Sub-Working Group (HFSWG) of the Automation in Road Transport Working Group (ART-WG) constituted under the trilateral cooperation built on the agreements reached by the Japanese, U.S. and EU governments. The HFSWG is jointly chaired by Stacy Balk (NHTSA) for the U.S., Emma Johansson (Volvo Trucks) for the EU, and Satoshi Kitazaki (AIST) for Japan, and its membership consists of several industry and academia experts in various fields from each region(Table 1).

The coordination aims to (a) share knowledge and information on human factors in automated driving, (b) identify new issues concerning human factors, (c) create opportunities for research cooperation, and (d) author joint papers. Meetings of the sub-working group are held once every three months to exchange information and hold discussions on goals (a) to (c). At the same time, we have planned workshops and organized sessions at the major Japanese, U.S. and EU international conferences, inviting outside experts to share information and hold discussions, as well as to make our results known. With respect to goal (d), the results of cooperative activities led to publishing a paper on the out-of-the-loop concept in automated driving in 2019. We are currently jointly writing a paper on mental models in automated driving.

Table 1: Members of the Trilateral Cooperation Human Factors WG

United States	
Stacy Balk, co-chair	NHTSA
Brian Philips	FHWA
Paul Rau	NHTSA
Dan McGehee	University of Iowa
Johan Engström	Waymo
Chuck Green	MIT
European Union	
Emma Johansson, co-chair	Volvo trucks
Andreas Keinath	BMW
Anna Schieben	DLR
Natasha Merat	University of Leeds
Klaus Bengler	TU Munich
Ludgrer Rogge	EC, DG R&I
Japan	
Satoshi Kitazaki, co-chair	AIST
Makoto Itoh	University of Tsukuba
Tatsuru Daimon	Keio University
Keisuke Ishii	Honda, JAMA

2.2. Japan–Germany Cooperation

In the context of Japan–Germany cooperation on automated driving based on an agreement reached between the governments of the two countries, cooperation on human factors began in 2019 following a one year period of preparation. Each country established a consortium consisting of five research institutions to carry out the cooperation. The Japanese consortium consists of the

National Institute of Advanced Industrial Science and Technology, the University of Tsukuba, Keio University, Tokyo University, and Kumamoto University, all of which are involved in the SIP Surveys and research on HMI and safety education methods in line with the sophistication of automated driving project. The German consortium consists of the Technical University of Munich, Chemnitz University of Technology, Ulm University, TU Dresden, and DLR. The coordinators are Satoshi Kitazaki (National Institute of Advanced Industrial Science and Technology) for Japan, and Klaus Bengler for Germany. The cooperative research has been divided into three SIP themes (on-road communication and external HMI, driver-system interaction, and education and training), with the German consortium tackling the same three themes(Table 2).

The first workshop was held in Tokyo in November 2019, with both sides sharing their research plan. Since then, two workshops per year have been organized alternatively in Japan and Germany. Due to the impact of COVID-19, however, the second and subsequent workshops have been held online. Japan and Germany have also both hosted webinars, inviting students and young researchers to have them learn about general research human factors beyond the three research themes. The cycle of webinars by leaders on both sides completed in 2020, and the next iteration will be led by young researchers. In June 2021, the cooperative activities were promoted with each side presenting research results at an organized session of the International Ergonomics Association (IEA, online). The cooperation will continue to be promoted at other international conferences and events.

Table 2: Japan–Germany Cooperation Research Themes and Implementing Organization

	Research themes	Japanese members	German members
1	On-road communication and external HMI	Keio U	TU Chemnitz TU Dresden Ulm U TU Munich DLR
2	Driver-system interaction	AIST U of Tokyo	TU Munich Ulm U
3	Education and training	U of Tsukuba U of Kumamoto	TU Dresden TU Munich

2.3. International Cooperation with Other Countries

Other international cooperation activities include collaborating in two EU Horizon 2020 projects related to human factors. The MEDIATOR project is carrying out research on new, safer interaction between drivers and automated driving systems, and its advisory board includes Satoshi Kitazaki, the leader of the SIP Surveys and research on HMI and safety education methods in line with the sophistication of automated driving project. Similarly, the HADRIAN project researches a human–machine interface that changes fluidly to increase the safety of automated driving in accordance with the road traffic environment and driver conditions. That project is exchanging information with the similar SIP Task B: Development of evaluation methods of driver's OEDR (Object and Event Detection and Response) and HMI for enhancing driver' take-over in a transition from automated to manual driving project.

3 International Standardization Activities

International standardization activities on human factors in automobiles and HMI are conducted by ISO/TC 22/SC 39/WG 8. The Human Interface (HI) Technical Subcommittee of the Society of Automotive Engineers of Japan is the Japanese representative in WG 8. Therefore, the main members of the Surveys and research on HMI and safety education methods in line with the sophistication of automated driving project consist of HI Technical Subcommittee members active in WG 8.

In the field of automated driving, the TR 21959-1[2)] and TR 21959-2[3)] standards on driver system interaction, and notably the driving transition critical to safety, were issued in 2018 and 2020, respectively. In addition to defining the respective transition processes for the system and driver (Fig. 1), TR 21959-1 presents the common underlying concepts of human factors in automated driving. Similarly, TR 21959-2 includes human factors and system factors that can influence driving transitions, considerations in test scenario design, common measures for human takeover performance, and considerations in choosing a testing environment as conditions in designing experiments to investigate transition processes to eval-

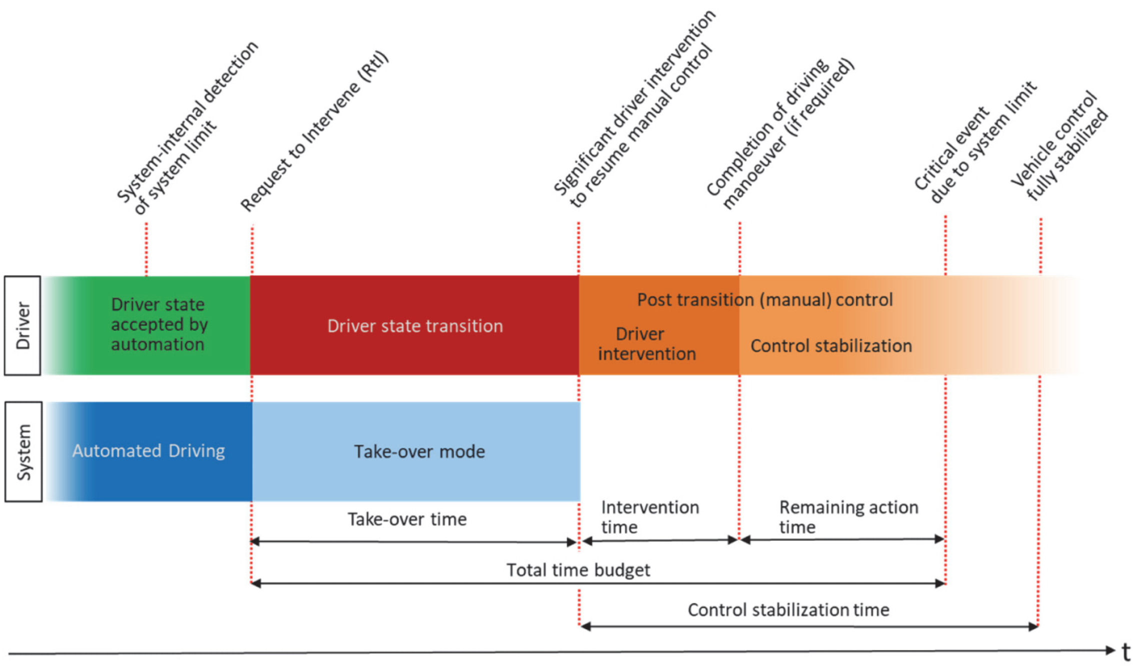

Fig. 1: Transition Process Model Defined in ISO TR 21959-1 (for System-Initiated Transition)

uate human driving takeover performance. For both TR 21959-1 and TR 21959-2, Japan acted as project leader or co-leader, and the standards primarily incorporate the outcomes of the human factors research and development projects of the first phase of SIP. Japan is currently acting as co-project leader for TS 5238[4], which covers driver monitoring systems.

At the same time, TR 23049[5], covering on-road communication by automated vehicle and external HMIs, along with their rationale, was issued in 2018. The U.S. is currently leading two projects, TR 23735[6] on external HMIs and TR 23720[7] on evaluation methods. With respect to those projects, Japan is working to incorporate warnings about the negative effects (dangerous effects) of over reliance on external HMI observed in projects in the first and second phases of SIP into TR 23735, and the various methodologies it has tested into TR 23720.

A potential new human factors-related project currently under discussion involves a proposal for human factors in remote automated driving operations. It will be launched as a new project if it is approved following discussions in WG 8.

4 Conclusion

Through projects pertaining to human factors in the first and second phases of SIP, we have constantly defined research themes and validated the appropriateness of research methods through international cooperation. We have also made our results widely known around the world, and contributed to international standardization. In addition, these activities have enabled us to build a network outside Japan and strengthen Japan's presence in this field.

【 References 】

(1)Natasha Merat, Bobbie Seppelt, Tyron Louw, Johan Engström, John D. Lee, Emma Johansson, Charles A. Green, Satoshi Kitazaki, Chris Monk, Makoto Itoh, Daniel McGehee, Takashi Sunda, Kiyozumi Unoura, Trent Victor, Anna Schieben, and Andreas Keinath: The "Out-of-the-Loop" concept in automated driving: proposed definition, measures and implications. Cognition, Technology & Work 21: p.87–98 (2019).

(2)International Organization for Standardization: ISO TR21959-1, Road vehicles - Human Performance and State in the Context of Automated Driving: Part 1 – Common underlying concepts. (2018).

(3)International Organization for Standardization: ISO TR21959-2, Road vehicles - Human Performance and State in the Context of Automated Driving: Considerations in designing experiments to investigate transition processes. (2020).

(4)International Organization for Standardization: ISO TS5283, Road Vehicles: Ergonomic aspects of driver monitoring and system interventions in the context of automated driving. (under development).

(5)International Organization for Standardization: ISO TR23049, Road Vehicles: Ergonomic aspects of external visual communication from automated vehicles to other road users. (2018).

(6)International Organization for Standardization: ISO TR23735, Road vehicles — Ergonomic design guidance for external visual communication from automated vehicles to other road users. (under development).

(7)International Organization for Standardization: ISO TR23720, Road Vehicles — Methods for evaluating other road user behavior in the presence of automated vehicle external communication. (under development).

6 Promoting International Cooperation

(1) International Cooperation and Activities for Standardization

Safety Assurance

Satoshi Taniguchi (TOYOTA MOTOR CORPORATION)

The development and deployment of practical automated vehicles is regarded as an important way of realizing an even safer, more efficient mobility society that ensures freedom of mobility for all. In this situation, the definition of safety assurance methods is an urgent task, specifically how to judge safety to ensure the public acceptance of this technology, and how to comprehensively assess safety in various traffic conditions. Japan has established the Driving Intelligence Validation Platform (DIVP) with the support of the Cabinet Office to promote the construction of a virtual safety assurance environment and launched the SAKURA project with the support of the Ministry of Economy, Trade and Industry (METI) to promote the construction of a database of safety assurance scenarios. The Japan Automobile Manufacturers Association (JAMA) is responsible for the overall strategy for technical development projects across these two government-led programs and is also liaising with industry, government, and academia to actively support the establishment of international standards. As various safety assurance research projects have been started up around the world, it is important to coordinate closely between projects both inside and outside Japan, and to construct and operate cooperative systems capable of creating leverage toward the establishment of international standards and common basic technology.

1 Issues of Safety Assurance Methods

By replacing human drivers, automated vehicles present various risks. The safety of these vehicles is ensured through tests and assessments over long periods and long distances in actual traffic environments, as well as measures to ensure reliability beyond a certain level through continuous and repeated improvements. However, the hidden black box nature of this process and the fact that assessment results are proprietary and not disclosed by developers or projects creates a lack of transparency for the market. Then, when examined by the authorities, this lack of transparency prevents absolute judgments about safety. Consequently, insufficiencies and a lack of transparency in the assessment range are issues for the whole assessment process. In addition, when certification tests are carried out on proving grounds where the test conditions can be controlled in advance, it is difficult to carry out sufficient safety assurance activities that comprehensively cover the wide range of driving scenarios.

To address the issues of safety assurance technologies for automated vehicles, countries around the world are actively starting up safety assurance projects. These projects can be classified into two main categories.

(1) Projects examining scenario-based tests in which logical safety assurance conditions are constructed and incorporated into an assessment database. Maintenance and improvements are then carried out using this as a scenario database.

(2) Projects examining virtual environment technology that covers the many patterns with conditions that cannot be assessed safely in the real-world or that that cannot be fully carried out in a realistic timeframe.

1.1 Joint Promotion of Safety Assurance Projects in Japan and International Cooperation

Two main projects are in progress in Japan: the Safety Assurance Kudos for Reliable Autonomous Vehicles (SAKURA) project being run by the Ministry of Economy, Trade and Industry (METI) to research and develop basic safety assurance technology for automated driving systems in category (1), and the Driving Intelligence Validation Platform (DIVP) that is being carried out by SIP-adus to examine virtual safety assurance environments in category (2). As SIP-adus entered phase 2 and prototype environments began to emerge from both projects, a working level taskforce and steering committee were set up in the 2021 fiscal year to realize joint project promotion and accelerate their integration and practical application (Fig. 1).

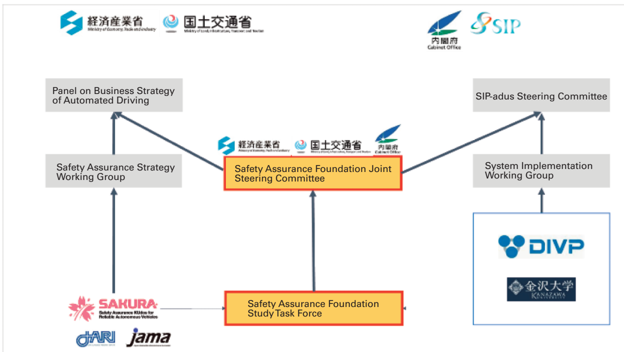

Fig. 1: Joint Promotion Organization for Automated Driving Safety Assurance

Under this joint steering organization, it is hoped that the scenario database and virtual safety assurance environment can be integrated and applied to actual automated vehicle development to accelerate the practical adoption of these basic technologies (Fig. 2).

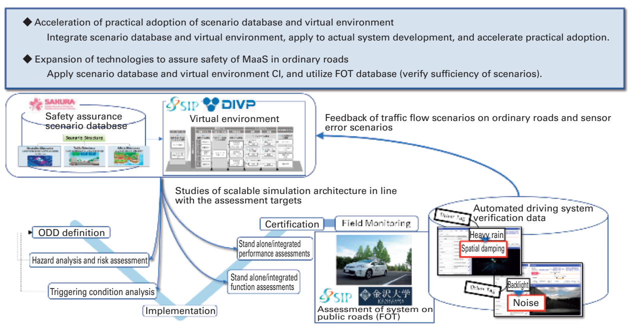

Fig. 2: Aims of Joint Promotion of Automated Driving Safety Assurance Projects

From the standpoint of international cooperation, the same joint steering organization is also strengthening coordination between Japan and Germany by incorporating the bodies promoting cooperation between the two countries under the scenario-based Pegasus project and the virtual environment-based VIVALDI project.

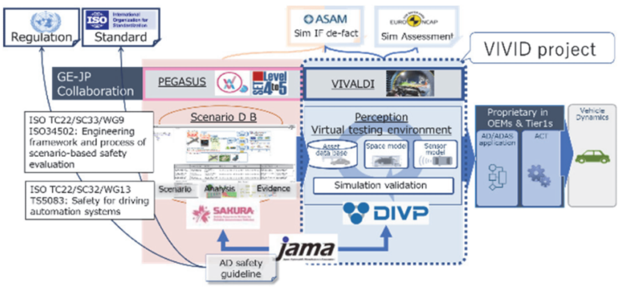

Fig. 3: Strengthening of Japan-Germany Cooperation by Joint Steering Organization

As part of these measures, the Virtual Validation Methodology for Intelligent Driving Systems (VIVID) project was established to liaise with the virtual environment-based VIVALDI project in Germany. As shown in Fig. 4, activities have been divided into specialist task forces to strengthen the standardization of automated driving safety assurance systems and simulation interfaces at the International Organization for Standardization (ISO), ASAM, and elsewhere. The aim of this initiative is to prevent the development of technology that can only be used inside Japan and to facilitate integration with sensor and simulation environments outside Japan.

JTTT	Topic	•SIP safety assurance: Satoshi Taniguchi •DIVP: Hideo Inoue		VIVALDI: Matthias Hein	
1	Simulation and data interfaces Comparison of simulation tool chains	NUL	Nakamura-san	AVL	David Nickel
2	Environmental data Modelling, geometries and materials	MPC	Nerio-san	KIT	Mario Pauli
3	Propagation modelling, sensor modelling, and integration				
3.1	Camera	SSS	Sugiyama-san	UAS Kempten	Stefan-Alexander Schneider
3.2	LiDAR Reference data and model metrics	PSSI	Takemura-san		Thomas Zeh
3.3	Radar Sensor-specific performance simulation and reference data	SOKEN	Ikeda-san	Conti-nental	Frank Gruson
4	V&V testing framework Test facilities and test metrics	KAIT	Nagase-san	TUIL	Matthias Hein
5	Scenario structuring Modularity, criticality, sensor-specific weaknesses	SOLIZE	Minami-san	IPG	Yannik Cichy
6	Simulation validation roadmap, joint test campaigns	KAIT	Itokawa-san	TUDA	Hermann Winner

Fig. 4: Organization of Joint Japan-Germany VIVID Project for Virtual Safety Assurance Environments

2 International Cooperation Related to Safety Assurance Standards

2.1 Background to Harmonization of International Standards

From the standpoint of safety assurance standards, active discussions that include legal and regulatory experts are under way even in national projects about the harmonization of standards, particularly in the UNECE World Forum for Harmonization of Vehicle Regulations (WP.29).

The formulation of international standards related to automated vehicles is being conducted by a specialist committee called Validation Methodology for Automated Driving (VMAD) that was set up in 2018. This is a part of the Working Party on Automated/Autonomous and Connected Vehicles (GRVA) under the auspices of WP.29. Under this structure, industries and government bodies in Japan are cooperating to make active proposals, which resulted in the 2020 agreement to introduce UN-R157 as a regulation for Level 3 automated lane keeping systems (ALKS) on highways.

One existing approach for judging safety is to determine whether the risk level is below a socially permitted level. Although this approach has been used as a judgment standard for the social implementation of technical innovations, discussions are continuing about defining the specific risk level that can be tolerated in the automated driving field.

In Japan, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) introduced safety technology guidelines in 2018 stating that, within the range of the established operational design domain (ODD), it is necessary to ensure that accidents resulting in injury or death that are caused by automated driving systems but that can be rationally predicted and prevented do not occur. This was then incorporated into the GRVA Framework Document after discussion by the GRVA Working Party. In the discussions for UN-R157, which focused on low-speed lane keeping on controlled-access highways and was the first regulation for level 3 automated vehicle type certification, the definition of a rationally predictable and preventable level focused on whether system performance exceeded the capabilities of a human driver. It was agreed to assume a competent and careful human driver as the reference level for human driver capabilities. In addition, as part of these discussions, cooperation between MLIT, the National Traffic Safety and Environment Laboratory, and the Japan Automobile Manufacturers Association (JAMA) under the auspices of the Japan Automobile Standards Internationalization Center (JASIC) resulted in the proposal of a mathematical driver model and its application to safety assurance standards involving quantifiable and comprehensive safety assurance scenarios.

2.2 International Cooperation to Support the Harmonization of International Standards

As the background to the discussions on this topic, a safety assurance scenario project was convened by the China Automotive Technology and Research Center (CATARC) as ISO/TC22/SC33/WG9. The Japanese chair of VMAD has expressed expectations to the convener of SC33/WG9 for technical inputs from the ISO. In response, JAMA has proposed safety assurance guidelines to both the ISO and VMAD and is supporting the promotion of these guidelines while harmonizing international standards. In addition, the organization promoting ISO 34502, which defines the scenario-based safety assurance framework under ISO SC33/WG9, is run by a Japanese leader and German co-leader. Close cooperation between the leader and co-leader has enabled rapid advancement to the Committee Draft (CD) phase, demonstrating the relationship of trust built up through the close technical coordination between Japan and Germany from phase 1 of the Pegasus project.

As described above, the organic result of strategic international cooperation efforts at each layer supported by close communication between industry, government, and academia in Japan, which used UN-R157 as a driving force to realize harmonization of the world's first level 3 automated vehicle international standard after a certain level of technical maturity was achieved through discussions lasting around a year, should serve as the foundation for continued international contribution from Japan even in future discussions and the like to expand ALKS in the future.

2.3 New International Cooperation Initiatives

In contrast to previous efforts to accelerate technical studies by coordinating between individual projects in Germany, France, China, and the U.S., it will be necessary to promote the integration of coordination initiatives to harmonize international standardization activities that are likely to become even more active in the future (Fig. 5).

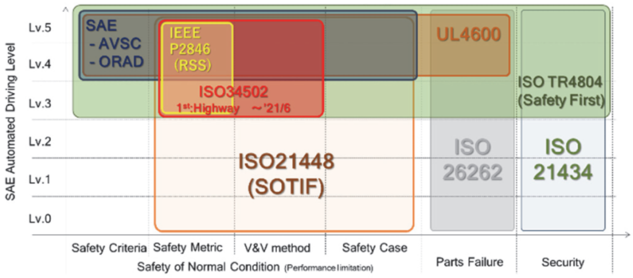

Fig. 5: Organization of Joint Japan-Germany VIVID Project for Virtual Safety Assurance Environments

As part of this approach, a new joint Japanese/European initiative was started up in 2021 to compile a white paper that summarizes the state of the art related to safety assurance frameworks in collaboration with the European Headstart automated driving project (Fig. 6).

SAFETY VALIDATION WHITE PAPER

SAKURA – SIP-adus - HEADSTART

Introduction – Safety validation of highly automated driving

Mission and objectives

Describe the paper mission

To have a storyline complete by December 2021 because of time constraints of the HEADSTART project.

Define the scope and timing of the paper: decide when to freeze

Scope projects: SAKURA + SIP-adus + HEADSTART

Timing: Final draft in early November

Public dissemination: we can take opportunities but it could outlive the project

- e.g. conferences in 2022: TRA, ITS WC 2022, ARTS (former AVS), TRB, Aachen colloquium, ESV, ITSC (include Nicoletta Karitsiotis in the loop), Autonomous Vehicle Symposium, Testing Expo
- Events: SIP-adus workshop (November 2021 – 2022)
- Internal events: Final event HEADSTART (mid-November)
- Potential idea: organize a webinar to show the paper

Fig. 6: Safety Assurance White Paper Created by Japanese/European Collaboration

【 References 】

(1)https://www.mlit.go.jp/common/001253665.pdf
(2)https://sip-cafe.media/column/1210/
(3)https://unece.org/fileadmin/DAM/trans/doc/2019/wp29/WP29-177-19e.pdf
(4)https://unece.org/sites/default/files/2021-03/R157e.pdf
(5)https://www.pegasusprojekt.de/en/home
(6)https://www.headstart-project.eu/
(7)https://blog.irt-systemx.fr/wp-content/uploads/2020/03/VMAD-05-12-AD-safety-validation-french-views-Vdef-1.pdf
(8)http://jama-english.jp/publications/Automated_Driving_Safety_Evaluation_Framework_Ver1.0.pdf

6 Promoting International Cooperation

(1) International Cooperation and Activities for Standardization

Connected Vehicles

Norifumi Ogawa (Mazda Motor Corporation)

International cooperation activities on connected vehicles involve conveying information on cooperative automated driving-related measures that make use of the communication initiatives carried out by SIP via the SIP-adus Workshop, ITS World Congress or other international conferences. They also include gathering information on related activities outside Japan, and building a network with experts in other countries. The SIP-adus Workshop, in particular, provides an opportunity to directly introduce SIP activities to expert from outside Japan during the event, while also providing an opportunity to hold frank exchanges of opinion. Conversely, international conferences held in Europe or the U.S. countries make it possible to listen to the initiatives of other countries and ideas from various corporations, making it possible to obtain a broad range of information. This article presents an overview of those activities.

1 Overview of Activities

As in the first phase of SIP, international cooperation activities on connected vehicles focused on Japan conveying information on the application of wireless ITS in cooperative automated driving, as well as on researching trends in Europe and the U.S. and sharing information with stakeholders in Japan. Specific activities include leading the SIP-adus Breakout Workshop, conveying information on SIP initiatives by participating in international conferences on automated driving in Europe and the U.S. or observing projects from other countries, as well as exchanging information with experts from various countries.

With the launch of the Task Force (TF) on V2X communication for Cooperative Driving Automation in 2019 to start studying cooperative automated driving communication protocols, communicating the results of TF work also became an important activity.

2 SIP-adus Workshop

2.1. 2018 SIP-adus Workshop

1) Plenary Session

Experts from the U.S. and Europe introduced the latest information on connected vehicles. The topics presented by each speaker are introduced below.

Kevin Dopart (U.S. Department of Transport (USDOT)) gave an overview of the Automated Vehicles 3.0 guidelines published by USDOT. The guidelines clearly state principles such as prioritizing safety, remaining technology neutral, and modernizing regulations. The presentation also described a driving safety support pilot project deploying V2X in the 5.9 GHz band (CV Pilot), and field operational tests (FOTs) at 70 locations throughout the U.S. The conclusion of a research project on cooperative automated driving (CARMA2) and the building of the Robot Operating System (ROS) for automated driving was covered as well.

Information on DSRC technology in the 5.9 GHz band was provided by John Kenney (Toyota IT Center) who discussed the formulation of FCC technical requirements, the progress of market deployment (roadside units deployed at 5,315 locations), and the necessity of ensuring compatibility in the market. The presentation also brought up issues concerning the allocation of DSRC, C-V2X, and Wi-Fi frequencies.

The speaker from the EU was Christian Rousseau. The EU SCOOP project is establishing communication requirements and discussing the handling of data. It is also conducting FOTs on Hybrid V2X and ITS-G5.

In the EU, 50 MHz of the 5.9 GHz band has been allocated: 30 MHz for road safety, and 20 MHz for railways. The presentation also discussed the status of the EU C-Roads Platform and the political and regulatory framework in the EU.

Maxime Flament (5GAA) introduced the use of network slicing and edge computing in the context of the latest 5G NR communication technologies. The presentation also indicated that 5G C-V2X technology offers a high degree of compatibility with traffic safety applications and network communication.

Japan presented the first phase of SIP results that involved validating the commercialization potential of V2X applications that make use of existing ITS communication, and described the installation communication infrastructure in the Waterfront City area and the FOTs that are part of the second phase.

2) Breakout Workshop

A total of 15 participants (3 from the EU, 2 from the U.S., 10 from Japan) shared information on global connected vehicle trends.

(a)Information Sharing

The allocation 5.9 GHz frequencies and the necessity of the band were brought up by the U.S. and discussed. Remaining technology neutral and securing communication interoperability between the various states and devices are viewed as technical issues.

Representatives of the EU presented the HEADSTART and ICT4CART automated driving projects, as well as the 5G CROCO, 5G MOBIX and 5G CARMEN projects on 5G technology. The also gave an overview of delegated acts and expected approval schedule (summer 2019).

Japan described the start of studies on technical requirements for traffic signal information and merging on expressways as part of the second phase of SIP plan.

(b)Learn 5G

This event was held to promote understanding of 5G by sharing the status of technical requirements and the progress of activities by corporations and groups promoting 5G. Maxime Flament shared technical information about 5G and introduced FOTs on 5G conducted in Japan.

2.2. 2019 SIP-adus Workshop

1) Plenary Session

Among the originally scheduled speakers (two from the U.S., two from the EU, and one from China), one speaker from the U.S. and both EU speakers cancelled their presentation, leaving a total of three talks including the one by Japan.

Kevin Dopart (USDOT) presented a detailed report of the CARMA cooperative driving automation project.

Kodo Shu (Huawei) introduced the large-scale FOTs using C-V2X carried out in Wu Xi.

Japan presented a summary of measures to use communication in the first phase of SIP, as well as the plan to conduct FOTs in the Tokyo waterfront area during the second phase.

2) Breakout Workshop

The workshop was joined by one participant from the U.S., two from China, and seven from Japan. It involved presentations of activities in the various regions, and the sharing of information on connected vehicles via a question and answer session.

The U.S. gave a detailed description of the CARMA project. The communication protocol consists of a hybrid DSRC and network configuration. The network-based communication system is called CARMA Cloud. In addition, the SAE is working on a taxonomy and definitions for cooperative driving automation, with SAE J2316 scheduled for completion in April 2020.

The detailed presentation of the FOT in Wu Xi by China offered a deep understanding of the project. Commercialization is anticipated to begin with on-board units in buses and commercial vehicles.

Japan presented National Police Agency and Ministry of Internal Affairs and Communications (MIC) measures concerning connected vehicles, SIP FOTs, initiatives by automakers, and the progress of ISO TC 204 WG 14 activities.

Deep discussions were held despite the small number of participants from outside Japan.

2.3. 2020 SIP-adus Workshop

Due to the COVID-19 pandemic, the 2020 SIP-adus Workshop was held by streaming recorded presentations on the web.

Experts from various parts of Japan, the U.S. and Europe gave talks introducing their respective activities. However, there were no Breakout sessions, and it was not possible to hold meaningful exchanges of information.

The first U.S. presenter, Kevin Dopart (USDOT), provided an update on the latest communication trends, including SAE cooperative driving automation class definitions, and introduced the CARMA and Truck Platooning Early Deployment Assessment DOT projects.

Next, John Kenny (Toyota IT Center) described the progress of the ITS spectrum reallocation by the FCC and gave an overview of the next-generation DSRC.

Christian Rousseau (Renault) of the EU presented the PACV2X and InDiD C-ITS FOT projects carried out in France.

In the presentations from Japan, Shinichiro Ebara (MIC) introduced the Frequency Reorganization Action Plan and other policies of the Ministry of Internal Affairs and Communications. In addition, talks by SIP members included a report on the progress of traffic signal information transmission via V2I and V2N by Yoshinori Aoki (UTMS Society of Japan/Nippon Signal), as well as the introduction of cooperative driving automation use cases by this author.

3 Collection of Information and Participation in International Conferences

The SIP international cooperation WG activities involve gathering information and building a network with experts at international conferences, with WG members participating in several such conferences. The topics discussed there are presented below.

3.1. ITS America Detroit/CV Pilot/Smart Columbus (June 2018)

We attended the annual ITS America conference, and observed the CV Pilot FOT in New York, as well as the Smart City project in Columbus to gather information on the progress of various connected vehicle-related activities in the United States.

- At ITS America, GM caused a stir with its bold announcement that it would install wireless ITS in its next Cadillac model. In contrast, USDOT maintained its technology neutral position and refrained from taking a clear stand on supporting either DSRC or C-V2X.
- We visited the DOT traffic management center in New York City and observed the progress of CV Pilot. The installation of roadside units and other infrastructure components is proceeding smoothly.
- We also observed the Smart City FOT in Columbus, which consists of a plant to integrate public and personal transportation.

3.2. Automated Vehicle Symposium San Francisco (July 9 to 12, 2018)

- Groups promoting DSRC or C-V2X both emphasized the relative technical and operational merits of their communication protocol. While USDOT remains firm on its technology neutral stance, it promoted the imminent commercialization of DSRC, citing the progress of FOTs and the installation of on-board units by automakers as examples.
- Cases of communication applications involving the use of DSRC to provide information on traffic signals or construction zones were introduced. The FHWA installed 13 roadside units in Michigan and 15 in Texas for the purpose of optimizing traffic flow through support for passing through green lights and using CACC for priority passing through intersections.

- The EU ICT4CART project aims to achieve real world use of level 4 automated driving through the application of various ICT technologies, including C-ITS and C-V2X. Test sites in Austria, Germany and Italy, and a cross-border test course between Italy and Austria, are used in FOTs to validate interoperability at national borders.

3.2. ITS World Congress Copenhagen (Sep. 17 to 21, 2018)

- With the European Commission preparing to issue a delegated act on V2X, an overview of that act and its approval process, along with privacy and other issues, were presented.
- In the U.S., preparations for the CV Pilot project have been completed, and FOTs are ready to start. Some tests have already begun and highlighted problems concerning accurately detecting vehicle position and collecting data in parts of New York City with many tall buildings in terms of eventual commercialization. Presenters also noted over 5,000 DSRC roadside units have been installed, albeit on an experimental basis.

3.3. Transportation Research Board Washington D.C. (January 13 to 17, 2019)

- The CV Pilot is entering Phase 3, and while testing has begun, not all preparations have been completed.
- The CARMA Program (a project to apply communication technology to automated driving) involved validating CACC in CARMA 1, and building an open source platform and developing applications for highways. In CARMA 3, the commercialization of the platform software will be assessed.
- The EU presenters introduced AUTO C-ITS 2016 to 2019. This project carries out FOTs in a corridor crossing through Portugal, Spain (10 km of highway) and France with the aim of improving safety functions an applying C-ITS to automated driving.
- In the area of 5G technology, the 5G CroCo, 5G CARMEN, and 5G MOBIX projects were launched. They involve FOTs on 1,000 km of highway across eight countries.
- The C-ITS Delegated Act was issued, and will be finalized following a four-week period for public comments.

3.4. European Conference on Connected and Automated Driving (April 2019)

- The C-ITS Delegated Act was presented to the Parliament in March and is scheduled to be issued in mid-May. However, there is opposition from Finland and other members, and forecasting whether the act will pass is difficult.
- We participated in the ARCADE (an EU project) workshop. Information on EU projects consisted of the ongoing progress of the three 5G-related projects, and the validation of interoperability across national borders.
- Information on USDOT projects consisted of the CARMA project for automated driving making use of communication entering its third phase, and the validation of vehicle control and an automated driving platform.

3.5. Automated Vehicle Symposium Orlando (July 15 to 18, 2019)

- In response to the announcement of a revision of the 5.9 GHz band by the head of the FCC, the head of the FHWA declared that the 5.9 GHz safety band would be protected at all costs. However, USDOT is firmly maintaining its technology neutral stance with respect to communication protocols (DSRC or C-V2X).
- In terms of the standardization of cooperative driving automation, the SAE is working on standardizing the taxonomy and definition of terms for cooperative driving automation (J3216).

3.6.2019 ITS World Congress Singapore (Oct. 21 to 25, 2019)

- In the EU, although the C-ITS Delegated Act was rejected by Parliament, some countries and private corporations formed the C-ITS Deployment Group and initiated activities directed at commercialization.
- A presentation from the U.S. explained that 5GAA had requested the allocation of the upper 20 MHz of the 5.9 GHz band (75 MHz) to Cellular V2X.

3.7. Transportation Research Board Washington D.C. (January 13 to 17, 2019)

- The CV Pilot session included a progress report for three regions (NYC, Tampa, and Wyoming) and voice opinions opposing the reallocation of the 5.9 GHz band by the FCC due to ensuring equipment modification costs and project delays.
- The report on the progress of CV pilot introduced the start of tests in NYC, Tampa, and Wyoming.

4 Conveying Information

Since information conveyed through the SIP-adus Workshop was presented in Section 1, other events used to send out information are introduced in this section.

4.1. Automotive Software Frontier 2020 (February 6, 2020)

We spoke at this private sector-sponsored two-day event entitled Looking at the Issues and Potential of Automotive Software Development in the Age of CASE. We introduced wireless ITS communication trends in Europe and the U.S., as well as the progress of SIP studies on SIP cooperative driving automation communication protocols in a presentation called International Trends and SIP Initiatives Concerning Wireless ITS Communication.

4.2. World Forum for Harmonization of Vehicle Regulations (WP.29 ITS IWG) (November 6, 2020), held online

We took advantage of the opportunity to introduce SIP activities at the WP.29 ITS informal group to introduce the activities of the SIP Task Force (TF) on V2X communication for Cooperative Driving Automation. We introduced the objective and activity workflow of the TF, as well as the cooperative driving automation use cases disclosed to third parties.

4.3. Future Networked Car Symposia (March 25, 2021), held online

At the request of participants at the above WP.29, we also participated in these symposia hosted by the ITU. The attendance of approximately 150 participants made it a vibrant event. Our presentation covered the same topics of the progress of our studies on cooperative driving automation communication protocol and the introduction of use cases as at WP.29.

5 Conclusion

As a theme leader for international cooperation on connected vehicles, we have invited experts from outside Japan to the SIP-adus Workshop and participated in international conferences and other events to collect and convey information as described above. This direct communication with experts proved extremely valuable in fostering mutual understanding of the progress of one another's activities. However, after the January 2020 Transportation Research Board (TRB) meeting, the COVID-19 pandemic caused the cancellation of almost all international conferences, regrettably taking away these precious opportunities. We can only hope that they will be revived swiftly.

Cybersecurity

Shigeru Uehara (TOYOTA MOTOR CORPORATION)

Overview

The information on vehicles, people, infrastructure and other elements projected onto maps, along with the advanced map data that constitutes automated driving system platforms, is expected to be primarily retrieved from external networks.

The information retrieved is then sent to units in the control and information systems of the vehicle for the purpose of controlling it. However, this situation is also a factor liable to trigger cybersecurity problems not found in traditional vehicles.

The agreement on UN R155/R156 reached at the UNECE WP.29 also makes addressing cyberattacks necessary from a regulatory perspective.

To solve such issues, our Surveys of New Cyberattack Techniques and Countermeasure Technologies project from the second phase of SIP-Automated Driving for Universal Services focused on intrusion detection systems (IDS) as a technology to combat new cyberattacks after shipment. We formulated IDS evaluation guidelines to serve as a baseline for testing and evaluation when installing an IDS.

At the same time, we assessed the technical requirements for collecting and storing information on connected vehicle threats and carried out collection tests using honeypots and other mechanisms in the context of building a system to provide first response support in the event of an actual incident.

With respect to the theme of formulating IDS evaluation guidelines, we investigated the new cyberattacks disclosed in 2020 and used questionnaires and interviews to examine the specifications of products offered by three vendors to feed that information back into evaluation items for IDS functions. We are also assessing IDS performance evaluation items in actual environments such as test beds and vehicle benches, primarily for the detection functionality of network IDS (NIDS).

With respect to the theme of surveys and research on connected car threat information and first response support, we theorized that sharing information on threats within the industry would contribute to first response support. We therefore analyzed threat intelligence activities and the threat information collection and storage methods from the IT industry, the pioneer in that area, and are planning to conduct threat information collection testing using a honeypot to simulate an after sales product (an external unit connected through OBD, for example), as well as monitoring tests.

1 International Regulatory Trends

The World Forum for Harmonization of Vehicle Regulations (WP.29) is formulating the UN R155 (for cybersecurity) and UN R156 (for software update), and in part due to its role in promoting cybersecurity as the chair of the GRVA in WP.29, Japan has preceded the other countries in establishing legislation.

As a result, automakers will be unable to obtain type certification for new passenger and commercial vehicle models released on the market starting in July 2022 if those models do not comply with the UN R155 process certification (the regulation models already in production starting in July 2024).

Under UN R155, manufacturers must implement a cybersecurity management system as well as processes to respond appropriately to new and evolving cyber threats and vulnerabilities. These processes are audited every three years.

All OEMs and suppliers are using ISO/SAE 21434 as a basis to work on building the aforementioned processes. As of July 2021, ISO/SAE 21434 is a Final Draft International Standard (FDIS) and is expected to be issued as an International Standard (IS) in the near future. The building of processes will have to take differences in ISO/SAE 21434 into account in conjunction with the UN R155 requirements to minimize rework.

Against that backdrop, our project is designed to research technology focused on detecting cyberattacks that emerge after production, as well as to survey systems for collect and share information on vulnerabilities and other threats, and entrust them to an industry organization.

2 Current Issues and Progress of Research

Regarding the theme of formulating IDS evaluation guidelines, WP.29 UN R155 impose a regulatory mandate to detect and respond to cyberattacks, and requires manufacturers to demonstrate that their vehicles are capable of doing so. However, the existing rules and guidelines do not clearly define the types or extent of attacks to detect, making it necessary for the manufacturers to make their own decisions inner diameter that respect. In an effort to contribute to security measures after shipment, our objective for this theme is to formulate IDS evaluation guidelines that OEMs can use as a baseline for selecting, validating, and operating an IDS, and entrust them to an industry organization.

The formulated guidelines also aim to raise security quality after vehicles are shipped, and notably envisions OEMs that have just begun considering introducing an on-board IDS as the primary target audience.

As part of our activities, we used actual attack examples as a basis for surveying conferences held in 2020, Web information, and vulnerability information to identify security events that an IDS should detect.

We further narrowed down the results to twelve cases that directly affect the vehicle by reaching a control system, and analyzed them in detail to identify security events that occur in the network or the host, or represent events that can be monitored (Table 1).

Table 1: Security Events Identified from the Surveyed Cases

Event location	Event	Security event example
Network	Actions that contradict the context in the vehicle network	Sending a control message that does not affect basic actions, or a valid diagnostics message, at a timing that conflicts with the driving situation.
	Attack against the UDS protocol	Attack against the UDS protocol
	Physically connecting an unauthorized device to the vehicle network	Connecting an external device to the OBD I/F
	Fuzzing attack against the vehicle network	Fuzzing attack from the OBD I/F
Host	Unauthorized behavior	System or library calls from an unregistered process
	Unauthorized external communication	Communication with an unauthorized source or destination outside the vehicle
	Unauthorized file system manipulation	Changing critical file attributes (e.g., permissions)
	Unauthorized application installation	Installation of an unregistered application
	Unauthorized logs	Unauthorized system or application logs
	Unexpectedly frequent errors	A number of errors in processing requests to an external public service that exceeds the value set for a time unit.
	High load	High CPU or memory load
	Modification to firmware	Modification to firmware

The plan for this theme continues until March 2022. Our next step will be to work with OEMs and IDS vendors to test the feasibility and validity of the test items based on the ideas provided by already conducted surveys to perform actual tests, which will then be incorporated into the guidelines.

In addition, we will continue to hold regular review meetings with stakeholders to ensure the guidelines prove useful to our target audience.

The theme of surveys and research on connected car threat information and first response support involves establishing methods to collect and store connected car threat information and formulating technical specification documents for first response support that leverages threat intelligence. The goal is to transfer their operation to industry organizations in 2023.

Threat intelligence refers to information on collecting, analyzing and storing information to provide support for responding to cyberattacks and other threats. Some industries are carrying out activities to share that intelligence between corporations1.

Sharing threat intelligence is expected to prove effective at preventing knock on damages from similar cyberattacks, and sharing is centered on threat intelligence in the IT field. In OS systems, the OS and other platform components are largely the same for the organization using them and between users, but in vehicles, the architecture differs in each model.

Consequently, it might not be possible to make use of the format for sharing threat intelligence in the IT field to prepare countermeasures.

This major difference from the IT field stems from the dependence of automotive hardware, software, and communication protocols involved in vehicle control on the OEMs.

Conversely, analyzing the attack sequences leading taking control of the vehicle has shown that the methods used until the final objective is reached are not OEM-dependent. This constitutes promising potentially valuable information to share on common threats.

In the honeypot-based threat collection tests, current monitoring results have demonstrated many instances of activity consistent with the IoT malware (e.g., Mirai) pattern used against IoT products of sending IDs and weak password to the telnet server (Fig. 1). These are viewed as automated attacks from devices infected with the same malware rather than attacks in which the applicable honeypot was targeted specifically as an on-board device.

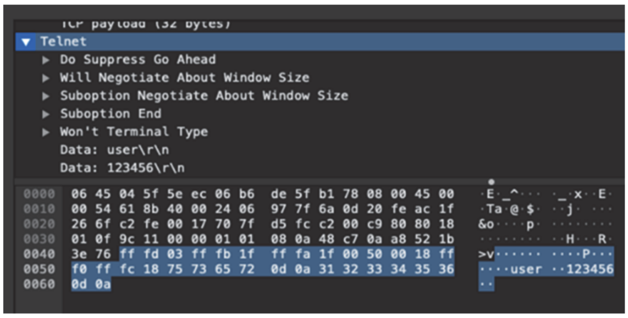

Fig. 1: Examples of Monitored Packets

The plan for this theme extends to March 2023. We will study sharing methods that allow responses to incidents in the industry to make use of the threat information collection tests and the collected information.

To collect information, we are currently considering assessing the parameters to identify an attack targeting the vehicle using approaches such as capture the flag (CTF) and asking white hat hackers or vendors to deliberately attack the honeypots we set, and monitoring the activity during those attacks.

3 Japan–Germany Cooperation

In Germany, the Federal Ministry of Education and Research (BMBF) is leading efforts to support research and development on connected car (automated driving) security, and currently has four projects underway. Of those, SIP is collaborating with the SecForCARs project2, which covers divides research responsibilities between four themes, and also involves experts from universities in Japan and Germany. The themes consist of 1) Security of the hardware, including the ECU and its constituent LSI components and of the vehicle network, 2) Requirements and verification methods required to ensure that vehicle systems built from secure subsystems are also secure as a whole, 3) Methodologies for monitoring, capturing, and analyzing cyber threats, and 4) Methods of using actual vehicles and virtual systems (honeypots) to monitor cyberattacks from various anticipated attack vectors. The progress and outcomes of the research is shared in workshops (five are scheduled until the end of 2022, and the first was held on July 1 and 2, 2021).

4 Conclusion

It is safe to say that ensuring vehicle cybersecurity now has a direct impact on the safety and security of the vehicle. This makes it appropriate to define minimum security standards to meet and shared industry threats as a cooperative area for the entire Japanese automotive industry and to proactively share information. Doing so will facilitate the development of connected services and allow greater operational efficiency that will help Japanese businesses retain their international competitiveness.

At the same time, the framework for sharing stipulated security measures and information should not be restricted to sharing only within the Japanese industry. It is also necessary to present proposals for international standards and rules involving current vehicle security development, and to strategically approach standardization bodies to enable the use of the framework as a strength of Japanese businesses.

Given the above, information security activities involving automated driving systems have a critical role to play and are expected to contribute to the growth of industry security activities.

【 References 】

1. (b2) Information Sharing Platform Technology "Information Sharing Design Guide—Configuration", in Ensuring Cyber Security for Critical Infrastructure in the Strategic Innovation Promotion Program (SIP), Hitachi, Ltd., https://www.nedo.go.jp/content/100904081.pdf (in Japanese)
2. SecForCARs, https://www.secforcars.de/ (in German)

Socioeconomic Impacts

Takashi Oguchi (The University of Tokyo)

International cooperation related to the socioeconomic impacts of automated driving is centered on a collaborative framework established between Japan and Germany. More specifically, this refers to collaboration between the Connected and Automated Driving: Socioeconomic Impact Assessment (CADIA) research project in Germany, which principally features researchers from the Karlsruhe Institute of Technology (KIT) and the German Aerospace Center (DLR), and the SIP-adus phase 2 (fiscal years 2018 to 2021) project in Japan being undertaken by the University of Tokyo and Doshisha University to research the impact of automated driving including traffic accident reduction. This was recognized as a joint Japan-Germany research project by a meeting of the dual Japan-Germany Collaborative Program Steering Committee held in January 2019 and featuring representatives from the German Federal Ministry of Education and Research (BMBF) and SIP-adus in Japan, which operates under the auspices of the Cabinet Office. As part of this project, a gathering of experts was convened in Germany in October 2019, followed by a session at the SIP-adus Workshop 2020 in November 2020 that focused on German-Japanese cooperation. Opinions were exchanged about common international awareness as well as differences due to national and cultural factors with respect to models of automated driving popularization, topics related to the public acceptance of new automated driving transportation services, and so on. At the same time, trilateral meetings featuring representatives from Japan, the U.S., and Europe have also been held regularly to exchange information about impact assessments.

1 Introduction

Japan-Germany cooperation on automated driving began with the conclusion of a joint declaration of intent about the promotion of research and development of automated driving technologies by the Cabinet Office and the German Federal Ministry of Education and Research (BMBF) on January 12, 2017.

With the mutual agreement of both Japan and Germany, during the exchange of opinions on the research and development themes to be pursued in collaboration, it was decided to cooperate in the field of social impact assessments starting from 2019 by coordinating the SIP-adus phase 2 (fiscal years 2018 to 2021) project in Japan to research the impact of automated driving including traffic accident reduction, and a project in Germany being carried out by a consortium led by the German Aerospace Center (DLR) and supported by BMBF.

At the same time, trilateral meetings featuring representatives from Japan, the U.S., and Europe in the ITS field were used to establish impact assessments (IA) as a sub-theme for trilateral cooperation alongside digital maps and human factors. Through harmonized activities between the three parties, the aim is to realize a high-level framework for assessing the impacts of automated driving on the whole traffic environment. With this aim in mind, discussions are ongoing in addition to information provision and sharing.

This article introduces these two initiatives as examples of international cooperation related to the socioeconomic impacts of automated driving.

2 Japan-Germany Cooperation

2.1 Background to Project Creation

Japan-Germany collaboration related to the social impacts of automated driving was initiated by a visit by the researchers involved in the SIP-adus project to research the impact of automated driving including traffic accident reduction to the Institute for Technology Assessment and Systems Analysis (ITAS) of the Karlsruhe Institute of Technology (KIT) in the autumn of 2018, during which opinions were exchanged about the feasibility of Japan-Germany cooperation. Subsequently, in the 2019 fiscal year, as experts from both countries continued discussions, it was agreed that the following two themes had merits and were of interest as collaborative items for both sides.

1) Diffusion of Connected and Automated Driving in a Future Vehicle Stock: The aim of this theme would be to construct a model to quantitatively simulate the spread of automated driving by identifying the factors that affect this spread and analyzing their correlation. Through this initiative, feasible popularization scenarios for the next several decades could be drawn up.
2) Social Acceptance of Automated Driving Explored: In addition to defining what is meant by social or public acceptance of automated driving, the aim of this theme would be to carry out an advanced research and study program to analyze cross-border similarities and differences attributable to separate social and cultural environments with respect to public acceptance of automated driving. In addition, this program would also identify discussion points related to national innovation strategies related to automated driving, as well as issues for international cooperation related to automated driving and its related technologies (including standardization).

In January 2019, BMBF in Germany and SIP-adus in Japan convened a meeting of the dual Japan-Germany Collaborative Program Steering Committee, and decided to launch a joint Japan-Germany research program that combined these two themes into a single project. It was also agreed to set outcomes of the collaboration as holding joint-symposium to deliver the fruits of the collaboration and a publishing book jointly, after having regular research meetings.

2.2 Overview of Progress of Joint Japan-Germany Research Project

In the 2019 fiscal year, after a series of online advance preparation meetings, Japanese experts visited Germany on October 7 and

8, and held the first meeting of the joint project at the Berlin office of the DLR.

The main objective of the first meeting was to outline the projects being carried out by both sides, to describe the points of interest of each country, and to determine the direction of the collaborative project. After discussion through the meeting, the discussion point for the next meeting was determined to be the issues on car ownership and sharing. It was also agreed to hold the second meeting in Japan in March 2020 and to report the progress of the project at the SIP-adus Workshop 2020, which was scheduled to be held in November 2020.

Unfortunately, the spread of the global COVID-19 pandemic in 2020 caused major changes in plans. As of the summer of 2021, it had not been possible to hold any face-to-face meetings since that first occasion. For this reason, the project forum switched to online meetings, through which cooperative activities have been progressing.

In June 2020, two online meetings to be discussed for the issues on car ownership and sharing were held.

As part of the SIP-adus Workshop 2020, which was held between November 10 and 12, 2020, an online symposium was convened primarily by expert members of the collaborative project. This symposium aimed to communicate the details of the joint Japan-Germany initiatives related to IA to a wider audience. In addition, the fourth meeting of experts, which was held on November 25, featured an online gathering of Japanese and German experts in the field of social impact assessment. This meeting featured progress reports directed at the program directors from BMBF in Germany and SIP-adus in Japan.

Two further online meetings were then held in April and June 2021. It was confirmed to realize the joint publication as the results of the joint project, and the details and structure of this publication were discussed.

2.3 Reports Presented at the SIP-adus Workshop 2020

The SIP-adus Workshop 2020 was held and broadcast online between November 10 and 12, 2020. In advance of this period, an IA online session was held and recorded in the evening of November 9, and boradcasted during the workshop.

The program of this session was as follows.

Date and time: 17:30 to 19:00 on Monday, November 9, 2020 (Japan Standard Time)

1. Opening: Takashi Oguchi (The University of Tokyo and SIP-adus IA team leader)
2. Social acceptance of automated driving in Germany and Japan: Conceptual issues and empirical insights: Torsten Fleischer (KIT), Ayako Taniguchi (University of Tsukuba), Satoshi Nakao (Kyoto University, and Kosuke Tanaka (Tokyo University of Science)
3. Analysis of automated driving diffusion: Customers' willingness-to-pay in Japan: Hiroaki Miyoshi (Doshisha University)
4. Analysis of automated driving diffusion: Potential diffusion paths into the German Market: Christine Eisenmann (DLR)
5. Automated driving on the path toward enlightenment: Bart van Arem (Delft University of Technology)

In report 2, conceptual issues, such as the reasons why social acceptance is questioned and analysis of the parties and subjects involved, were presented, based on definitions of the concept of social or public acceptance and the social background related to these definitions in Japan and Germany. Additionally, this report described an initiative to create, implement, and analyze a questionnaire with the same content to gauge the extent of individual acceptance in Japan and Germany. The results of this questionnaire found differences in attitudes to automated driving. In Japan, the attitude tended to be favorable or neutral, whereas, in Germany, some expresses favorable, on the other hand, others did skeptical opinions. Different levels of Nimbyism were also found (NIMBY is an acronym for "not in my backyard" and indicates a recognition of a need (particularly for a certain facility) but an unwillingness to have that facility located nearby. Nimbyism is used as a measure of how far people agree with a general idea but disagree with a core concept of that idea). Differences in awareness about the privacy of location information were also expressed.

Reports 3 and 4 presented interim results for the initiative to develop diffusion models and scenarios for automated driving in Japan and Germany. A diffusion model of automated driving based on consumer willingness to pay in Japan was intended to be developed in Report 3, whereas diffusion of both personal car ownership and MaaS was intended in Germany. Both sides had different approaches for diffusion of automated driving using their own models and now intend to compare the prediction results with mutual reference to future collaborative activities in both countries.

Although report 5 was not directly related to Japan-Germany cooperation, an expert from the Delft University of Technology in the Netherlands introduced the Spatial and Transport Impacts of Automated Driving (STAD) project that was carried out by cooperation among industry, government, and academia in the Netherlands over a five-year period starting in 2016. This report described key points related to automated vehicles sharing pedestrian spaces, as well as studies into different plans for different acceptance levels of automated vehicles in the road infrastructure network planning and the value of time during using automated vehicles.

Although the session was held online, it was an excellent opportunity to hear four reports, and online discussions continued voluntarily after the session ended. Opinions were exchanged actively about the following discussion points.

(1) Diffusion of automated vehicles

Although different routes can be envisioned for diffusion of automated vehicles depending on various underlying considerations, these routes have not been studied properly. It is thought that people will transition to vehicles with a higher level of automation. However, because of the existence of something not to be achieved by vehicle automation technology by the 2050s, it is likely that manually driven vehicles will also remain.

(2) Acceptance of automated driving transportation services

How the transition from existing transportation services can be realized is a major issue. The fact that Waymo, Uber, and Tesla are accepted to some degree by the public in the U.S. is having a major impact on the technical development by car manufacturers in that country, and is contributing to advances in electrification and connected and automated vehicles. Such progress in technical development creates a positive feedback loop for the awareness of the general public. If this situation continues, it may be useful to examine the specific changes in people's actions and habits that this causes over the medium to long term.

(3) Dedicated lanes for automated vehicles

It is difficult to clearly define the importance of securing physically separate lanes just for automated vehicles. It may be possible to realize dedicated lanes for public transportation service vehicles that use automated driving technology. However, in the limited road space available in urban areas, it may be extremely difficult politically to secure dedicated lanes simply because a vehicle uses automated driving technology.

3 Trilateral Cooperation among Japan, the U.S., and Europe

Regular trilateral meetings among Japan, the U.S., and Europe have been held to exchange information and opinions related to general ITS topics, including automated driving. Under the scheme of this trilateral meeting, a sub-group related to Impact Assessment of automated vehicles is organized. This sub-group is run by the following representatives: Dr. Scott Smith from the Volpe National Transportation Systems Center run by the United States Department of Transportation (DOT) for the U.S., Dr. Satu Innamaa from the VTT Technical Research Centre of Finland for Europe, and, currently, Takashi Oguchi from the University of Tokyo (the author of this paper) for Japan. This sub-group meets two or three times a year to exchange information about initiatives being carried out in each region, and the free exchange of opinions has continued throughout. In Europe, research activities funded by the Horizon 2020 and various other government supported projects in each country are underway, which form the background of the research reported in these meetings. In contrast, the Volpe Center in the U.S. is currently building a system dynamics model for establishing the framework of the Impact Assessment. These progresses are reported at the meetings. The research activities of the Impact Assessment of automated vehicles including traffic accident reduction under the support of the SIP-adus project in Japan was reported in the meeting held in September 2021.

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6 Promoting International Cooperation

(1) International Cooperation and Activities for Standardization

Service and Business Implementation

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Studies of use cases, business models, and the like for services using automated driving are an important part of realizing the practical application of automated vehicles. Although field operational tests (FOTs) of automated driving services have been held both inside and outside Japan, various studies and discussions remain ongoing about the issues involved in stepping up from FOTs to actual implementation, as well as the countermeasures for these issues. Consequently, international cooperation initiatives have included information exchanges through SIP-adus workshops and the like from the standpoint of promoting service implementation.This article describes the status of these initiatives.

1 Introduction

Starting in SIP phase 1, the practical adoption of vehicles used in automated driving services (note: vehicles used to transport guests or used for logistics services, rather than private vehicles) has been part of activities of the Next-Generation Urban Transportation Working Group. In the field of international cooperation, it is being promoted as the Next Generation Transport project under the leadership of Professor Masayuki Kawamoto of the University of Tsukuba.

In SIP phase 2, reflecting greater awareness of the need to encourage the further implementation of these services, the Next-Generation Urban Transportation Working Group was renamed the Service Implementation Promotion Working Group. Furthermore, since the SIP-adus Workshop in the 2020 fiscal year, the international cooperation project was also renamed Service and Business Implementation (SBI).

2 Initiatives at SIP-adus Workshops

Although studies of use cases, business models, and the like for services using automated driving are an important part of realizing the practical application of automated vehicles, discussions remain ongoing both inside and outside Japan about the issues involved in stepping up from field operational tests (FOTs) to actual implementation, as well as the countermeasures for these issues. Therefore, as a part of the SBI project, experts from around the world took part in a workshop to discuss items related to service implementation.

2.1. SIP-adus Workshop in Fiscal Year 2018

Guest speakers from Japan, Europe (France and Italy), Asia (Singapore), and North America (the U.S.) were invited to the SIP-adus Workshop in the 2018 fiscal year, and information was exchanged under a theme called “Practical applications of Automated Driving Technology – Get out of Demonstration –.”

For this workshop, experts were also invited to a plenary session to exchange information on two topics: Automated Driving Shuttles and Services, and Truck Automation and Platooning.

2.2. SIP-adus Workshop in Fiscal Year 2019

The SIP-adus Workshop in the 2019 fiscal year featured a joint session with FOT experts called “FOTs and Next Generation Transport.” At the plenary session for the workshop, information was provided about automated driving service FOTs being carried out under the auspices of the Japanese Ministry of Economy, Trade and Industry (METI) and Ministry of Land, Infrastructure, Transport and Tourism (MLIT). In addition, continuing on from the previous fiscal year, experts from Europe, Asia (Singapore), and North America (the U.S.) were also invited to exchange information.

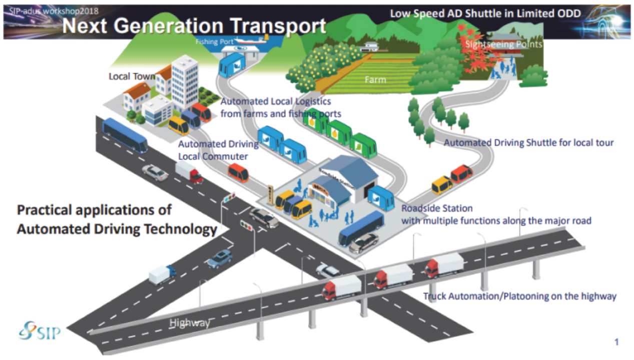

Fig. 1: Scope of Next-Generation Transport (NGT) Session at SIP-adus Workshop in Fiscal Year 2018(1)

2.3. SIP-adus Workshop in Fiscal Year 2020

Staring from the SIP-adus Workshop in the 2020 fiscal year, the name of the Next Generation Transport project was changed to SBI. The targeted scope of public acceptance was defined from the standpoints of various users factoring in the topic of commercialization, to encourage the implementation of automated driving technology in last mile guest transportation and logistics services.

A wide range of research and development related to automated driving is being promoted and tests are under way on public roads around the world. Some regions are also engaged in long-term FOTs and are close to realizing implementation. At the same time, to accelerate the implementation of automated driving services, it is necessary to study the merits of automated driving services to regions and commercial ideas for utilizing automated driving, focusing on that fact that people with a diverse range of circumstances and characteristics are expected to use these services. In addition, to encourage regional utilization, it will be necessary to carry out PR of the merits of using automated driving technologies, and to create the correct public awareness of the safety and reliability of these technologies, without generating excessive expectations or concerns. In addition to studying measures to address these issues, it will also be necessary to promote public awareness and popularization through government-led measures, including the creation of visions for cities with automated driving services. As shown in Fig. 2, these standpoints were incorporated into the workshop in the 2020 fiscal year.

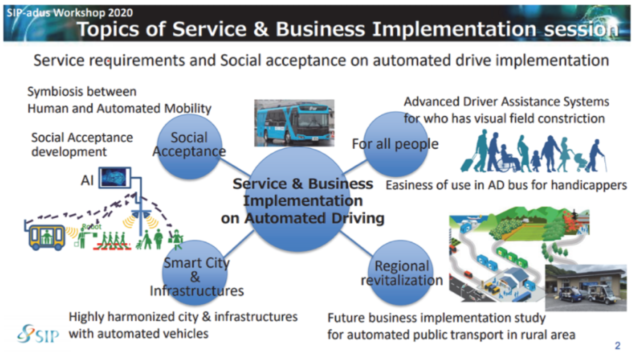

Fig. 2: Scope of SBI Session at SIP-adus Workshop in Fiscal Year 2020[2]

Through these topics, the message of the session (Automated Driving for Everyone) was shared and communicated to the participants. Since anyone might be a driver or a passenger of an automated vehicle, or a resident in a city in which automated vehicles are driving on the streets, it is important to consider a diverse range of standpoints for implementation. Based on this understanding, how to ensure user-friendly overall service design was discussed as the key to implementation.

3 Collection of Information at International Meetings

3.1. Transportation Research Board Annual Meeting 2021

(1) Purpose of participation

At the Annual Meeting of the Transportation Research Board (TRB), information was collected about topics related to the promotion of service implementation. This information was collected focusing on the standpoints of determining which concepts for use cases of automated driving mobility services in the U.S. should be studied for implementation in urban areas, and how to promote discussions related to business model studies and urban implementation.

(2) Summary of meeting

The 2021 Annual Meeting marked the 100th anniversary of the TRB. Although, this meeting is usually held every year in Washington D.C., it had to be convened online this year to help prevent the spread of the novel coronavirus COVID-19. Most of the participants (speakers) were from the U.S. and represented universities, research institutes, federal and local transportation authorities, and public transportation operators. The main premise of discussions was government-led research.

(3) Key words and outline of discussions related to the promotion of service implementation

In addition to sessions related to automated driving, the TRB annual meeting also featured discussions of automated driving in sessions related to public transportation. After the information collection phase, the following five keywords to be tracked in studies of promoting service implementation were identified. The discussions about each keyword are summarized below.

1) Automated driving in the novel coronavirus COVID-19 pandemic

During the coronavirus pandemic, the U.S. made remarkable progress in technologies and systems for the application of automated driving, especially in the logistics field and particularly last mile transportation robots rather than long-distance trucks travelling between cities[4]. New companies such as Nuro and Zoox started FOTs on public roads in quick succession. To realize full-scale implementation, discussion focused on the necessity for better vehicle design, verification of business models and acceptance, and the need for accompanying development of remote monitoring technologies.

2) Popularization and implementation of automated driving

In around 2017, U.S. companies like General Motors (GM) and Waymo stated their aim to commercialize fully automated vehicles in 2019 or 2020. In discussions, based on the circumstances of the past one or two years, 2024 to 2025 was suggested as a more realistic target timeframe. In addition, it was also suggested that commercialization might start with robotaxis, car sharing shuttles for six to seven people, or ultra-compact mobility vehicles (for one or two passengers), before transitioning to private vehicles.

Before implementation, the need for further discussions about safety was raised, and it was proposed that services should be designed in cooperation with the government while analyzing risks through a scenario-based approach with a specified operational design domain (ODD)[5]-[8].

3) Mobility and equity

Several sessions that focused on mobility and equity were held based on the idea that the means and opportunity for mobility should be available to all as well as recent social issues in the U.S. Studies and discussions were carried out about how to ensure equity with respect to automated driving and other technologies.

In addition, questionnaire surveys and the like about the safety of automated driving for elderly people found that elderly people were more cautious about automated driving.

It was suggested that when implementing user-friendly mobility services for the elderly and people with physical impairments, careful consideration should be given to the design of the service (e.g., where and how to enter and exit the service, the reservation and payment systems, and the like) as well as simply the design of the vehicle[9].

4) Autonomous driving in rural regions

Since twenty percent of the population of the U.S. live in rural regions, and at least half of all fatal traffic accidents occur in these areas, there is an urgent need to realize rural automated mobility services from the standpoints of improving safety and ensuring mobility[10][11].

However, since the hurdles for establishing a business model in rural regions are high because of the particular road and environmental conditions (unpaved roads, weather, high speeds, and animals) and sparse populations, tests must be carried out under rural conditions. Research and FOTs are currently under way under the keywords of rural automated driving in Iowa and other states.

Much effort is also being devoted to sharing experimental data and the like in local regions[12]. In Vermont, the state DOT has created a trip planner browser service and app, and is working to facilitate data maintenance by utilizing only open source data as a basic policy. Plans were announced to expand the trip planner functions with the Vanpool reservation system, with the aim of creating a one-stop service for information and data related to mobility services.

Pennsylvania has prepared a database that collects information about traffic signals in the state[13]. This database makes the locations of signalized intersections, as well as the number and specifications of traffic signals open to the public. By doing so, the reported aim is to obtain a wide range of feedback for optimizing the design of traffic signal cycles and so on.

5) Utilization of road and urban spaces in the coronavirus pandemic

San Francisco, New York, Oakland, Toronto, and other cities revised how road spaces are used in the coronavirus pandemic[14]. Various initiatives were introduced to widen the space between pedestrians, including banning vehicles from entering some streets, widening and extending bicycle lanes, establishing so-called slow streets just for bicycles, pedestrians, and kickboards, and creating spaces for PCR testing, eating, and drinking by creating public areas in road spaces.

In this way, if slow streets or similar measures can become firmly established, this might help to create an environment to facilitate the testing and implementation of low-speed automated shuttles, which may lead to a further increase in demand. It was suggested that these changes to road spaces due to the coronavirus pandemic might help to expand the driving environment for low-speed shuttles in U.S. cities.

4 Conclusion

SBI sessions of the SIP-adus Workshop scheduled to be held in the 2021 fiscal year and beyond are likely to feature information and opinion exchanges about initiatives outside Japan, including FOTs of automated driving services that are gaining pace around the world, ideas about critical service design aspects to enable the transition from the FOT phase to implementation, as well as ideas about achieving commercialization. In this way, SIP-adus will continue to find effective ways of acquiring information to promote service implementation in phase 2 of the project.

【 References 】

(1)SIP-adus Workshop Next Generation Transport Plenary Session, https://www.sip-adus.go.jp/evt/workshop2018/file/SIP-adus_Workshop_2018_Plenary_session_NGT.pdf (accessed: June 30, 2021)
(2)SIP-adus Workshop Service and Business Implementation Session, https://en.sip-adus.go.jp/evt/workshop2020/file/sbi/05SBI_01E_Kawamoto.pdf (accessed: June 30, 2021)
(3)SIP-adus Workshop Service and Business Implementation Session, https://en.sip-adus.go.jp/evt/workshop2020/file/sbi/05SBI_06E_Toyama.pdf (accessed: June 30, 2021)
(4)U.S. DOT Volpe Center, "Emerging Automated Urban Freight Delivery Concepts: State of the Practice Scan"
https://rosap.ntl.bts.gov/view/dot/53938 (accessed: June 30, 2021)
(5)World Economic Forum, http://www3.weforum.org/docs/WEF_Safe_DI_AV_policy_framework_2020.pdf (accessed: June 30, 2021)
(6)World Economic Forum, http://www3.weforum.org/docs/WEF_SafeDI_creating_safe_AV_policy_2020.pdf (accessed: June 30, 2021)
(7)World Economic Forum, https://www.pegasusprojekt.de/files/tmpl/PDF-Symposium/04_Scenario-Description.pdf (accessed: June 30, 2021)
(8)World Economic Forum, http://www3.weforum.org/docs/WEF_Reshaping_Urban_Mobility_with_Autonomous_Vehicles_2018.pdf (accessed: June 30, 2021)
(9)RAND, "Approaches to Assessing Acceptable Safety for Automated Vehicles," https://www.rand.org/pubs/research_reports/RRA569-1.html (accessed: June 30, 2021)
(10)University of Iowa, "ADS for Rural America," https://adsforruralamerica.uiowa.edu/ (accessed: June 30, 2021)
(11)U.S. DOT, "Rural Opportunities to Use Transportation for Economic Success (ROUTES)," https://www.transportation.gov/rural (accessed: June 30, 2021)
(12)Vermont DOT, "Commuter CO-OP VT," https://www.connectingcommuters.org/commuterco-opvt/ (accessed: June 30, 2021)
(13)Penn DOT, "Traffic Signal Asset Management System," https://www.tsams.penndot.gov/tsams/login.do (accessed: June 30, 2021)
(14)NACTO, https://nacto.org/program/covid19/ (accessed: June 30, 2021)

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