Sumitomo Electric's Approach for Intelligent Transport Systems

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Traffic conditions in Japan have been improved through the widespread use of traffic control systems, including signal controllers, in the late 1960s and the electronic toll collection systems in the 1990s. Currently, efforts for further reduction of traffic congestion and accidents have been made by using intelligent transport system (ITS) technology that wirelessly connects vehicles to vehicles and vehicles to infrastructure. ITS technology has now further advanced through the emergence of advanced infrared beacons. In emerging economies, on the other hand, there have been serious traffic congestion issues and increased road accidents due to rapid growth. ITS and its wireless communication technology are expected to be used in building effective signal control systems at low cost. To meet these global expectations, Sumitomo Electric Industries, Ltd. will continue to work on the development of ITS technology, drawing on its wide ranging expertise.

Keywords: ITS in Japan, ITS in Europe and the United States, ITS in emerging countries, congestion reduction, safe driving support

1. Introduction

In Japan, explosive motorization has contributed to economic development and the improvement of living standards since the 1960s. On the other hand, it has also caused higher traffic death tolls and social problems such as traffic congestion and pollution. To cope with this situation, Sumitomo Electric Industries, Ltd. (hereinafter referred to as "Sumitomo Electric") has put effort into the introduction of a traffic control system, including the world's largest Traffic Control Center of the Tokyo Metropolitan Police Department, through public and private cooperation since the late 1960s, thereby contributing to the reduction of traffic congestion. Today various efforts are being made in Japan to further ease congestion through the sophistication of signal control using probe information and road-to-road communications, safe driving support using vehicle-to-road and vehicle-to-vehicle communications, and the efficient use of energy associated with the electrification of vehicles. Advanced infrared beacons have been put into practical use since fiscal 2013, and are especially expected to make use of probe information and provide road signal information to drivers.

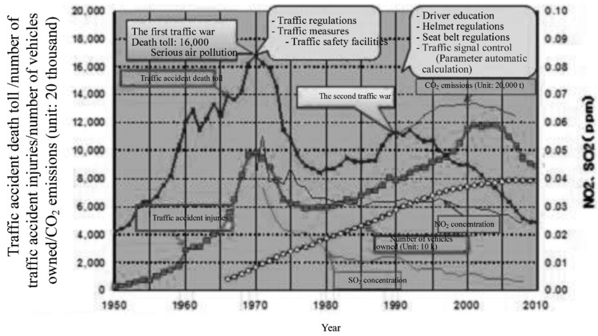
Looking at emerging countries, there have been growing concerns over traffic congestion and accidents due to an explosive increase in vehicles accompanied with rapid economic growth, just as how Japan used to be. Expectations are, therefore, rising for the introduction of Japanese technologies. To achieve better results, it is desirable to modify the traffic control system according to the situation of each country instead of applying it exactly as used in Japan. New technologies using road-to-vehicle communication techniques, such as signal controls using probe information, also have great potential with their compatibility with the situations in emerging countries. European countries have been working on safe driving support by using road-to-vehicle and vehicle-to-vehicle communications and the reduction of CO_2 emissions. In the US, a large scale experiment is being carried out for safe driving support.

In addition to improving the reliability of traffic control systems including conventional traffic signal controllers, Sumitomo Electric works on the development of ITS by expanding and developing its wide range of technologies and products, such as systems, devices, automotive parts and materials, in an integrated way to meet these growing global needs for ITS.

2. ITS in Japan

2-1 Road traffic measures and challenges in Japan

The number of traffic accidents in Japan increased rapidly from the 1950s and the number of death reached over 16,000 in 1970, creating a major social problem (See **Fig. 1**). The number decreased after the Traffic Safety Basic Plan (5-year plan) and other associated measures were developed, but it turned upward again from the 1980s due to the increased volume of traffic, rising to over 11,000 in



Reference: National Police Agency, Ministry of Land, Infrastructure, Transport and Tourism, Ministry of the Environment

Fig. 1. Transition of the number of traffic accidents

1990. Meanwhile, traffic congestion and environmental degradation became a huge problem, which led to the tightening of regulations and the development of a grand design for promoting ITS in 1996. Although traffic casualties are currently decreasing, there are still some problems, including a decreased rate of decline, an increased number of traffic accidents caused by the elderly (people aged 65 or older account for 51%; the highest rate on record) and traffic congestion in urban areas.

2-2 ITS in Japan and efforts of Sumitomo Electric

In the late 1960s, a pilot experiment for computerized traffic signal control was conducted in Tokyo for the first time in Japan, and was proven to be effective. Responding to this, the first traffic control center was established in Tokyo followed by other centers nationwide (see **Fig. 2**) under the 5-year plan since 1971 mentioned above. In addition to this, an experiment for a bus location system using road-to-vehicle communications was started at the same time. An experiment for a comprehensive automobile control system was also performed in an attempt to develop the world's first dynamic route guidance system. Although it was not put into practical use, the technology was drawn on for later systems.

In the 1980s, the function of the system was improved through the development of computer technology. A travel time measurement system using a number plate reader was introduced for information collection, and information processing functions were installed to signals, allowing them to extend the time of the green light display in response to approaching vehicles. Meanwhile, with advanced technologies for information collection and provision used for highways, an automatic traffic monitoring system using image processing technology started to be introduced.

In the 1990s, it was time to drastically update the system of the traffic control center, and a new traffic control center in Tokyo was established. The system was changed from the conventional one that selected control patterns from those previously provided according to traffic conditions, to a new one that automatically calculated the control parameters depending on traffic demand, contributing to a reduction in traffic congestion. With the popularization of car navigation systems together with advanced road-to-vehicle communication technologies (infrared beacon and radio beacon) the Vehicle Information and Communication System (VICS) started to be provided on a full-scale basis. It was put into practical use in Japan before the rest of the world and significantly enhanced the convenience of drivers. A priority control system for buses and emergency vehicles was also introduced and its performance was presented in the 2nd ITS World Congress (in Yokohama), which was held for the first time in Japan, and the system was adopted as the international standard.

In the 2000s, information and communications technologies were further advanced, pushing forward the development of intelligent and networked devices. Internet technology was applied to roadside devices for the first time in the world (adopted as the international standard), interconnecting signals and sensors and highly functionalizing the system. A signal control system based on the prediction of traffic demand was also developed. As for highways, ETC has been available with a utilization rate of more than 90%, largely contributing to the reduction of traffic congestion.

In the late 2000s, the vehicle infrastructure cooperative system, which expands the network described above to vehicles, started to be developed. As the traffic control system will change qualitatively (through the use of probe information, etc.), this system is expected to help support safe driving and eco-driving. Part of the system has already been put into practical use, aiming at further functional sophistication. This state-of-the-art technology was introduced to the world at the ITS World Congress held in Tokyo.

We quickly worked on the development of the above system focusing on traffic algorithms, communications and sensing technology, and contributed to demonstration experiments and international standardization for the system, taking a leading role in the efforts. Meanwhile, since the traffic system, in the case of system failure, can have a significant impact on the society, we have also been engaged in improving the reliability of devices (traffic signal controllers, etc.) and the system.

In the future, it is important to address the challenges related to increasingly sophisticated urban infrastructure, the environment, disasters, and efficient energy use, and to provide a safe and comfortable mobility environment for the elderly. We will therefore actively work on the development of the next generation ITS to create such an ideal traffic environment.

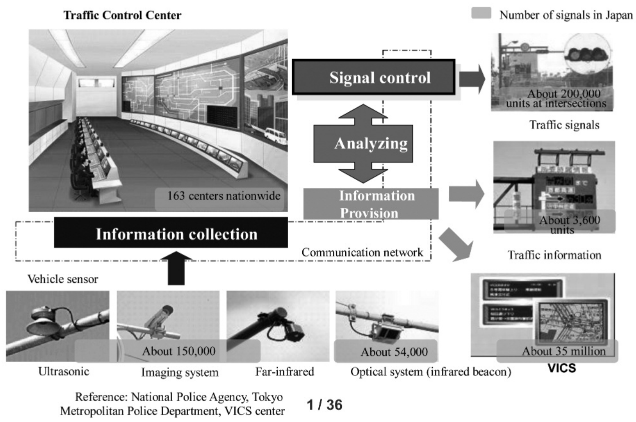


Fig. 2. Traffic control system

3. Traffic Conditions in the World and Needs for ITS

3-1 Efforts in Europe and the United States

In Europe, an action plan regarding the development of ITS was issued as an EU directive in 2010, and standardization has been promoted to ensure the compatibility, interoperability and continuity of ITS throughout Europe. The European Transport White Pater published by the Directorate-general for Mobility and Transport (DG MOVE) in 2011 sets out targets such as cutting in half the number of traffic fatalities by 2020 and reducing CO_2 emissions by 20%, highlighting the need for a vehicle infrastructure cooperation system to achieve these targets. An typical research and development program for a cooperation system in Europe to achieve these goals is DriveC2X (period: 2007-2013, budget: 18.9 million euro), and its demonstration experiments were conducted at six test sites in Germany, France, Italy, Spain, Sweden and Finland. The results of the experiment were announced at the DriveC2X demonstration at the ITS World Congress held in Vienna in 2012. European auto makers have joined these programs and promoted technical development regarding the communalization field for the collaborative system in the Car-to-Car Communication Consortium (C2CC), and have exchanged memorandums to put a cooperation system into practical use in 2015. In tune with this movement, the Amsterdam Group, mainly led by road operators in Germany, the Netherlands and Austria, announced ITS Corridor Plan to begin building roadside infrastructure for a cooperation system along the major transportation artery of Europe connecting Rotterdam, Frankfurt and Vienna by 2015. Thus, in Europe, technological development and standardization activities have been accelerated, aimed at putting a cooperation system into practical use in 2015. Furthermore, under the theme of "Smart, Green and Integrated Transport" in Horizon 2020, a new 5-year EU research program (6.8 billion euro) plans to start to put out the first call for project proposals in January 2014.

In the US, the Connected Vehicle Initiative has been developed based on the 5-year ITS strategic plan since 2010. Its key project is Safety Pilot, aimed at safe driving support using cooperation systems, and a large scale public road demonstration test called Safety Pilot Model Deployment has been conducted in Ann Arbor, Michigan since August 2012. In this test, applications, security and driver/social receptivity are examined with the participation of 2,836 test vehicles. The test results are planned to be used as the basis for the National Highway Traffic Safety Administration (NHTSA) to determine whether the installation of a vehicle-mounted cooperation system to standard-sized cars, and to large-sized cars, should be mandated (2013 and 2014, respectively), and whether roadside infrastructure should be developed (2015). The results of these matters are, therefore, expected to act as an enabler for the cooperation system in the US. In the meantime, the Federal Communications Commission (FCC) proposes that a part of the radio wave frequency band of 5.9 GHz that is allocated to a cooperation system should be shared with WiFi. This will be determined during 2013, and the result is also considered to have a huge impact on the development of the cooperation system in the US.

3-2 Traffic conditions and problems in emerging countries

Traffic conditions in emerging countries, especially ASEAN countries, exude the image of congested roads first. Although they have some common problems (such as the insufficient development of mass public transportation including LRL/subways; the number of cars exceeding the road capacity; signals being controlled manually by police officers at many intersections to respond to changes in traffic volume due to the existing signal indication patterns being mostly fixed, making the already heavy traffic congestion even worse), on closer examination, traffic conditions and causes of traffic congestion vary in each city (or country). Hanoi, Vietnam, for example, is characterized by a massive number of motorbikes and scooters literally flooding the roads, but the stoppage time at each intersection is short with a very short cycle time of about 30 seconds. Cars therefore do not squeeze into intersections and are rarely stuck at the intersections. In Bangkok, Thailand, signals at almost all major intersections are manually controlled by police officers in a heavy traffic jam as shown in **Photo 1**, so the cycle time can be 600 seconds (or 10 minutes) or more when the traffic is seamless. To try to avoid this long waiting time, cars try to squeeze into intersections and get stuck, thereby causing worse congestion in other lanes as well. This is how they slip into a vicious cycle. In Yangon, Myanmar, where cars drive on the right of the road, when controlling signals, police officers customarily extend the yellow signal time to allow left-turning cars to pass. For drivers therefore, it looks like the signal turns to red suddenly after a long yellow signal, which increases the risk of rear-end accidents due to sudden braking. On the other hand, establishing an effective signal system in Yangon is thought to be relatively easy, given that two-wheel vehicles are not allowed to enter the city center and drivers do not rush into intersections because they are highly aware of the need for compliance with traffic regulations. In African countries, as in ASEAN countries, traffic congestion has become severe in tandem with the growing economies. The causes and conditions of the congestion vary from city to city here too, so it is important to provide solutions considering the local situation and economic conditions in each city (or country).

Photo 1. Road situation in Bangkok

4. Efforts for Next Generation ITS and the Global Market

4-1 Smart connected society

For future ITS, the connection between road infrastructure and in-vehicle devices, or more specifically vehicle-to-infrastructure communication, is increasingly important. A safer and more comfortable road environment can be created by road infrastructure that sends to in-vehicle devices information that drivers cannot know otherwise, for example the behavior of moving vehicles at a crossroad, and by in-vehicle devices sending to the road infrastructure information that the road infrastructure cannot fully collect otherwise, for example the moving paths of individual cars (probe information). As electric cars become more common in the future, there will be growing need for information on the locations of accessible charging stations and the selection of routes according to the remaining battery level. We aim to create a society where infrastructure, vehicles and energy are connected, under the theme of a "Smart Connected Society." Our specific efforts are introduced below.

4-2 Safe driving support system

Although traffic accident fatalities have been decreasing in recent years, the number of injuries remains high at more than 800,000, and it is said that the annual loss caused by traffic accident amounts to more than 3 trillion yen. Regarding the situations of accidents, victims aged 65 or over account for 40% of the total fatalities, and the causes of their accidents comprise mostly delays or/and errors in recognition, judgment or operation. As Japanese society has been aging rapidly, the increasing number of traffic accidents caused by elderly drivers is a rising concern and preventative measures are urgently needed. To reduce damage due to accidents, a vehicle autonomous safety support system, including air-bags and automatic braking, has been developed mainly by auto manufacturers, and the results are successful. However, most car accidents are due to events that cannot be detected from the vehicle's point of view, making it difficult to prevent traffic accidents only by the vehicle autonomous safety support system. For this reason, the collaborative safety support system, which uses vehicle-to-vehicle and vehicle-to-road (infrastructure) radio communication to mutually exchange information, is highly anticipated. In the New IT Reform Strategy announced by the government in 2006, Japan set a goal to develop Intelligent Transport Systems (ITS) and proceed with reform to create the world's safest road traffic society, by making efforts to promote practical applications of a "safe driving support system using infrastructure cooperation." In 2009, the government also set a new goal to reduce annual traffic fatalities to 2,500 or fewer in 2018. In response to this growing need of society, the Tokyo Metropolitan Police Department has promoted the practical application of Driving Safety Support Systems (DSSS) which are collaborative safe driving support systems designed to support a driver's recognition and decision making. DSSS are systems designed to alert drivers and prevent traffic accidents by using infrastructure devices installed along roadsides to send vehicles traffic event information that cannot be seen from the vehicle or can be overlooked by drivers, and by determining whether or not the information should be necessary for driver support based on vehicle information such as the vehicle location and speed, to provide safe driving support information (audio or visual) at the right time. Sumitomo Electric has taken part in a demonstration experiment conducted by the Universal Traffic Management Systems (UTMS) Society of Japan, which develops standardization of DSSS, and has carried out research and development on infrared beacons which perform vehicle-to-infrastructure communication and serve as a key infrastructure to support DSSS, ITS wireless devices using 700 MHz band radio waves, and roadside devices such as vehicle sensors which detect the location and speed of a vehicle with a high degree of accuracy, contributing to the practical application of those devices. These efforts have borne fruit with the start of the world's first actual operation of four systems using infrared beacon systems in Tokyo and Kanagawa in July 2011, namely, the "Rear-end Collision Prevention Support System," the "Inadvertent Red Light Crossing Prevention Support System," the "Inadvertent Stop Sign Violation Prevention Support System," and the "Intersection Collision Prevention Support System." Currently, we are working on R&D and a demonstration experiment aiming to put new applications into practical use and improve the accident reduction effectiveness by upgrading DSSS, focusing on the use of ITS wireless devices capable of providing information in real time over a wider range.

4-3 Traffic control system using probe

(1) Expectations for upgrading signal control

Probe information is information regarding vehicle location and speed with time sent from vehicles, which can be positioned by GPS or other devices. In recent years, the communication environment has been improved to obtain real-time probe information with the development of mobile computers including smart phones, infrared beacons, and ITS wireless devices.

It is expected that if traffic conditions including congestion lengths and travel times can be accurately assessed by using probe information, the signal control system will be more sophisticated. In 2009, the UTMS Society of Japan began research on the application of probe information mainly collected by infrared beacons to the traffic control system.

(2) Japan's sophisticated infrared beacons

It has been about 20 years since the operation of infrared beacons began in Japan, and now it is time to update the old infrared beacons. The Tokyo Metropolitan Police Department, therefore, set a standard for high functioning infrared beacons (sophisticated infrared beacons) in 2013. A sophisticated infrared beacon can be used to provide information including safe driving support information, as well as conventional traffic information. Furthermore, it can transmit 16 times as much data from vehicles as the previous beacon, and can collect probe information of a larger data volume, showing promise for effective use with the signal control system.

(3) Probe information collection in emerging countries

In emerging countries, motorization has rapidly accelerated, but with a poor infrastructure, chronic traffic congestion and accidents are causing social problems. Although the sophistication of signal control can be an effective tool in solving these problems, optimal signal control to respond to the volume of traffic has not been introduced in emerging countries because vehicle sensors are not used due to the cost. On the other hand, the penetration rate of mobile terminals is almost 100% in emerging countries, particularly Southeast Asian countries. If, therefore, location information that is obtained through mobile terminals can be used as probe information, signal control can be conducted according to the traffic conditions, leading to an effective reduction of congestion and traffic accidents.

(4) Technology and efforts of Sumitomo Electric

We have been involved in research at the UTMS Society of Japan from the beginning and devoted to the sophistication of signal control using probe information as described below:

- To make it possible to control signals according to traffic conditions with a small number of sensors
- To make it possible to detect the tail end of traffic congestion lines accurately with a small number of probe vehicles.

We have developed a unique algorithm combining probe information, sensor information and signal light information to detect the tail end of a traffic congestion line around an intersection, and have confirmed with a simulation that if probe information can be obtained from 3% of running vehicles, signal controlling as is conventionally conducted is possible by using only sensors installed around intersections. We plan to test its effectiveness in the actual field. In addition to this, we will develop ITS wireless communications and technology using probe information from mobile terminals for emerging countries.

4-4 Image recognition system

License Plate Reader (LPR) is a system used to automatically recognize the license plates of vehicles with an image sensor. LPR is highly important technology for various applications including traffic control because it can identify vehicles using only devices installed in the infrastructure without adding any special devices to vehicles. LPR has been put into practical use for more than 20 years and is widely used throughout Japan.

In ASEAN countries, there has been increasing momentum in the introduction of LPR for the purpose of measuring travel time as part of the sophistication of traffic control. ASEAN is striving to realize an ASEAN Community in 2015, aiming to form a single hub for markets and production as part of which the liberalization of transportation and logistics among ASEAN countries is scheduled. In addition, the ASEAN Highway Network (AHN) connecting ASEAN countries is being built with the goal of completion by 2020. With this background, an increasing number of vehicles are expected to cross the borders, so LPR for ASEAN countries is required to be tailored to each country's license plate.

While the ASEAN region has the same challenges in terms of various number plates as the EU region, where the liberalization of transportation has already advanced, LPR for the ASEAN region has a high hurdle to overcome from a technical perspective due to the following reasons:

- The styles of EU number plates are nearly identical but ASEAN number plates differ for each country.
- EU number plates use only Roman letters and Arabic numbers but number plates in some ASEAN countries, such as Thailand and Myanmar, use non-Roman letters.

With the aim of the commercialization of LPR for the ASEAN region, we conducted a basic study of new LPR different from the already commercialized LPR for Japan, based on the situation described above. The followings are its features:

- Flexible number plate detection technology not limited to specific plate styles.
- Character recognition technology to respond to different scripts.

First we focused on Thai number plates, on which Thai letters are written, as a target of this technology and performed an experiment for the detection and recognition of the number plates using vehicle images collected in Thailand. As a result, this technology was proven to be applicable to Thai number plates.

In the future, we will consider its application to other number plates in different countries as well as verification of its practical application such as in real-time processing tests in the actual field. As for hardware, we will carry out a study on camera and processing devices for the ASEAN region.

4-5 Energy management system

Today, as fuel regulations have been tightened worldwide to avoid global warming due to CO_2 emissions—for example, in Europe it is required to reduce CO_2 emissions from the 2011 figure of 135.7 g/km to 95 g/km by 2020—electrification technology is increasingly necessary. Under these circumstances, auto makers are promoting the electrification of vehicles (EVs/HEVs). Those vehicles, however, have not been widely used yet because many users still think that EVs are not reliable due to their short cruising distance and the lack of charging infrastructure. In response to this, we have developed route functions for EVs to remove these concerns and promote the use of EVs. In doing so, we have improved the prediction accuracy for power consumption by establishing a power consumption calculation model formula for road units and allowing the function to learn how to calculate and estimate power consumption based on probe information collected from EVs. In addition, information can be provided to users with a high level of visibility by calculating the cruising radius in just a few seconds according to the remaining battery level of an EV. In regard to information on road gradients which can greatly influence power consumption of an EV, we are working to improve the prediction accuracy of EV power consumption by independently collecting and compiling information across the country. While these route functions currently under development are designed for EVs, they are also applicable to conventional vehicles using fossil fuels, thereby contributing to our efforts to reduce CO_2 emissions.

5. Conclusion

Sumitomo Electric's ITS began with the development of the traffic control system in Japan, which is now leading to the realization of a Smart Connected Society which closely connects roads, vehicles and energy with each other for the global market. Sumitomo Electric will further reinforce its efforts aimed at establishing a safe and secure society free from traffic accidents, a comfortable society free from traffic congestion, and a livable society free from environmental problems.

· Smart connected society is a trademark or registered trademark of Sumitomo Electric Industries.,Ltd.

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