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Car Navigation System

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From the Editor

In Japan, the development of an Intelligent Transportation System (ITS), a comprehensive traffic safety information system, dates back to a national project called the "Comprehensive Automobile Control System" (CACS) that was implemented by MITI (Ministry of International Trade and Industry) from 1973 to 1978 at a cost of about ¥7.3 billion ($73 M). This project concerned research and development into basic technology for the construction of an Intelligent Transportation System to serve the public interest. After this project was completed, some of the results were used by the Ministry of Construction in its Road Automobile Communication System (RACS) program and also by the National Police Agency in its Advanced Mobile Traffic Information and Communication System (AMTICS). The results of these projects are to be successfully implemented in the Vehicle Information and Communication System (VICS) for the provision of road traffic information, which is to become operational starting in April 1996.

The ITS concept itself originated in Europe, and Japan still lags behind Europe in progress on the whole system level. However, when it comes to the car navigation system, which forms a part of ITS, in Japan commercialization has been achieved prior to other ITS systems components. More than 1 million car navigation units have been sold, and the market has been expanding at a rapid pace, with shipments on the 700,000 level forecast for 1996 alone. Probably no other country has advanced as for in the propagation of car navigation systems. It seems typical of Japan that the initial achievement was the creation of a new, advance market for an individual hardware component, the car navigation system, once again exhibiting Japan's tradition of starting with product development rather than system development.

During the research and development stage of the national CACS project, no one foresaw the use of the small, high-performance computers of today. The configuration concept was that of a host computer placed in the center of a system with low workload terminals. However, car navigation systems in current use incorporate high-performance, small computers, into color liquid crystal display (LCD) units, and can receive TV broadcasts and play music CDs. Furthermore, two-way communication using cellular telephone networks is already a reality. The VICS system now broadcasts traffic information unilaterally, but has the technological leeway to be expanded to two-way communications. In the not-so-distant future cars will be able to run while communicating with beacons installed along the road. All the car navigation system vendors in Japan have come out with policies supporting the VICS system. In that sense, car navigation systems are the key to promoting use of multimedia for automobiles and may be the driving force that will make the whole ITS a reality.

At present, Japan has about 67 million cars on the road. For this issue, we have selected the theme of car navigation systems in Japan, where competition between vendors to get the largest possible share of this enormous market leads the rest of the world. We hope the feature articles will be of value to the readership.

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I. Car Navigation System

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1. Explanation of the present condition:

(1) Outline

The purpose of a car navigation system is to guide a driver to his or her destination safely and comfortably. In recent years, traffic jams, accidents and air pollution caused by exhaust gas have become more and more serious due to an increased number of automobiles. These problems cannot be solved by simply improving and expanding roads because of soaring land prices and the amount of time it would take. Therefore, a highly advanced road information system for more efficient road use is in great demand. If the number of automobiles can be reduced and traffic smoothed, driver frustration and fatigue would be reduced, leading to a reduction in accidents in the end. Furthermore, reducing in frequency of stops, promoting efficient energy use and decreasing exhaust gas would contribute to improving the environment. Car navigation systems would play an important role in all of these areas.

The main functions of a car navigation system are shown below.

(a) Positioning of a vehicle

(b) Route guidance
- Map displaying
- Indication of distance and direction to destination
- Calculation and display of optimum routes
- Drive guidance (voice and magnified intersection display)
- Use of traffic information

Table-1 shows the development of car navigation systems from the first ones suggested in the 1980s, which used rough printed maps and manual road form tracing, to the present ones which use electronic maps and GPS.

There are two typical types of car navigation system. One is for route guidance without map displaying, the other, for route guidance with map displaying. Research on the former type thrives in Europe and America, where watching a map while driving is considered dangerous. However, it will take more time to realize this type of car navigation system because it requires completeness of the database. If high-quality routing selection becomes possible, navigation will be achieved with simple displays, and this device may become available at a reasonable cost. The latter type shows the present location and direction of the car, the destination, the route, the direction of the destination, etc. on the map, and supports driver selecting an intersection of turning. Though the display is relatively expensive, the presently available level of database is sufficient and the development is easy. Thus the latter type has spread in Japan.

Table 1 Development of the Car Navigation System (classified by generations)

Generation	Zero generation	First generation (1987) Dead-reckoning navigation	Second generation (1988-) Feedback dead-reckoning navigation	Third generation (1990-) Hybrid navigation
Media	Plastic cards Magnetic tapes	CD-ROM		IC cards
Methods of locating position		Geomagnetic sensor, speed sensor, rate gyro	Map matching	GPS, beacon
Characteristics of information displayed	• Only rough maps	• Rough maps • Indication of interchanges	• Scroll • Destination route search • Voice guidance of the traveling route • Town information such as hotels and gas stations	• Road traffic information • Search for the optimal route based on traffic information • Weather forecast and news • Voice guidance of routes

* The above table was created by partially modifying the data prepared by the Nomura Research Institute based on "Nikkei Electronics".

Present car navigation systems are roughly classified as follows by positioning method:

(I) Satellite (GPS) navigation type:
mainly in the after market/low accuracy and low price

(II) Feedback dead-reckoning (self-contained) navigation type:
(genuine products in early time)

(III) Hybrid (self-contained + GPS) navigation type:
mainly in OEM market/high accuracy and high price

The satellite navigation type, using electronic maps (CD-ROM or IC cards) and later-mentioned GPS, locates and displays position based on signals sent from artificial satellites. GPS is accurate to within 30 m to 100 m. The downside is that position cannot be located where GPS signals cannot be received, such as behind a building or in a tunnel. This type of navigation systems, however, has such merits as easy installation with no distance sensor needed, no cumulative position error, and relatively reasonable price.

The dead-reckoning navigation type shows car position relative to the origin using a dead-reckoning azimuth sensor and a dead-reckoning distance sensor, so error accumulates. Therefore, it adjusts position automatically by map-matching with an electronic map. However, due to errors on the map this automatic adjustment may become impossible during the long period of driving, therefore this type is gradually being replaced by the hybrid type (III). The hybrid type has higher position accuracy by taking advantage of the characteristics of both of satellite navigation and dead-reckoning navigation, though it costs a little more than (I) and (II).

(2) Market scale and technological trend

The cumulative number of car navigation systems increased to 1.25 million units by 1995 with 750,000 expected to be sold in 1996. The market is expected to grow to an annual sales amount of 1.5 - 2 million units, that is, annual sales of approximately ¥350 billion. Figure-1 shows the market progress.

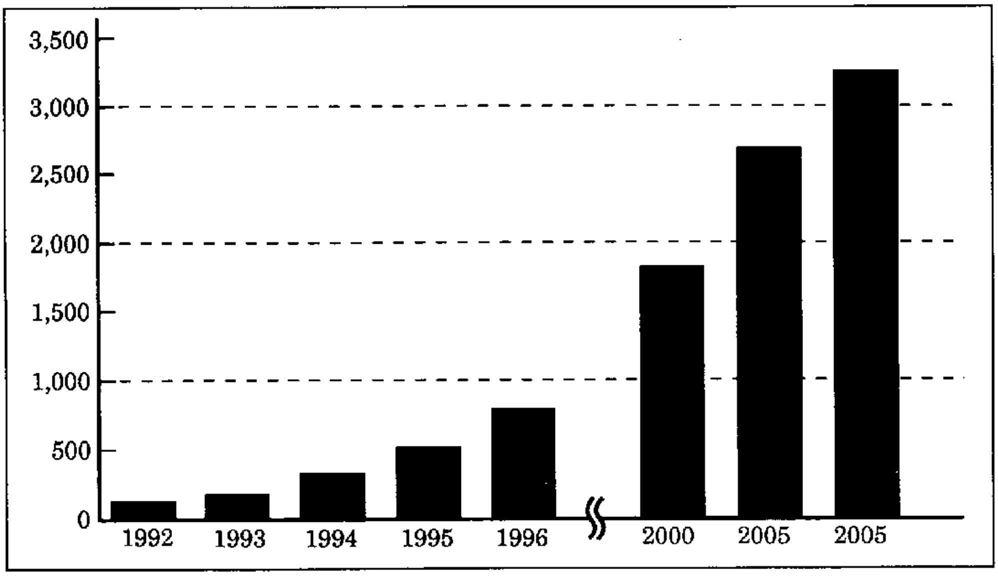

Figure 1 Growth of the Car Navigation System Market

There are some points to be noted about technology trends in car navigation systems.

First is the downsizing and the decreased price of car navigation systems, which have contributed to the sharp rise of sales in the market.

This may be the result of highly advanced map-matching as well as downsizing, the decreased price and higher performance of a GPS receiver, which relaxed the required gyro specification and enabled adoption of an vibration gyroscope.

Second is advances in the optimal route search function and route guidance function.

Shortening of the processing time required to search for recommended route to less than half, improvement of route quality, improvement of voice guidance accuracy and magnified intersection display functions have resulted in safer and more comfortable navigation. Therefore, higher position accuracy is expected from car navigation system, so the hybrid type is gaining market share in the aftermarket, too. Most storage media of maps are CD-ROM, and double-speed drives are being adopted gradually.

Third is the improvement of the human-machine interface.

Products with a voice interface have already appeared, aiming at improvement of driving safety. Whether strict requirements on size, price and noise can be conquered remains to be seen.

Map display has been improved for easy comprehension. House forms, town maps indicating road edges, and bird's eye views considered to be the beginning of three-dimensional maps are noticeable. Map indication already plays the important role of indicating present position, destination position and transit position. From now on, improvement in scrolling and zooming speed will become points of competition.

The final point is about providing traffic information. This will have much influence on the popularization of car navigation systems in the near future.

ATIS (Advanced Traffic Information Service) started providing traffic information in the Tokyo metropolitan area and optimum route searches using telephone lines in April 1995. VICS (Vehicle Information and Communication System) will start providing traffic information in the Tokyo metropolitan area and on main expressways using FM multiplex broadcast, infrared beacons and radio beacons in April 1996. VICS aims at nationwide service and lower usage fee and is expected to contribute greatly to easing traffic jams, shortening travel time, conserving resources and reducing air pollution.

References:

1) Irie, Namio: "Automobile Electronics Seen in the Articles of the Nikkei Electronics for the Past 19 Years" Nikkei Electronics, No. 573, February 1, 1993

2) "Toward the Establishment of VICS Center" VICS Promotion Council

II. Present Situation of Car Navigation Market

The present car navigation system consists of the Global Positioning System (GPS) and a CD-ROM-used map information system. Some are hybrid systems using gyros for positioning correction.

In Japan, car navigation has been put to practical use, forming a substantial market. This is because the U.S. has completed a military satellites system, which allows around-the clock GPS usage. In addition, the following technological factors have contributed:

- A nationwide digital road map DB completed
- Mature car-mounted audio CD technology available
- Advanced LCD technology available

The nationwide digital road map DB was prepared by Japan Digital Road Map Association. This DB is used by all vendors as described later.

CD players are required to be free from head jumps or immune to vibrations when they are mounted on vehicles. Mature anti-vibration technology for car audio equipment facilitated the development of the CD-ROM-used navigation system.

Technological progress in LCD and semiconductor devices was also significant because this brought about size/cost reduction.

Further, one more important factor was the Japanese car culture distinguished in interior decoration. As found in various cases, the Japanese sense of beauty tend to place a variety of fine goods in a limited space to complete it as a living space. The color LCD-used car navigation system was a long-awaited product as a piece of car furniture. With the rapid increase of participating vendors, the car navigation system has become available to ordinary users through price reduction and functional progress.

1. Preparation of Digital Road Maps

Japan Digital Map Association (DRM) is a joint Government-private organization founded in August, 1988 as an auxiliary organization of the Ministry of Construction to prepare digital road maps.

DRM has produced a digital road map DB based on 1/25,000-scaled maps issued by the Ministry's Geographical Survey Institute. However, its update is not reliant upon updated maps issued several years later by the Institute. Rather, DRM is making independent efforts to keep the DB up-to-date by collecting data form national and prefectural road administrators.

Preparation of the digital road map DB started from "Major" roads (ordinary national and prefectural roads and those wider than 5.5 m). This version completed at the end of March, 1989 on a scale of 1 to 50,000 to 1/25,000, DRM has continued preparing a DB of "Medium" roads (ordinary national and prefectural roads and those wider than 3.0 m). At the end of fiscal 1995, this version will be complete with "Medium" roads drawn on a scale of 1 to 25,000.

This rapid preparation of digital road maps reflects the Japanese road situation, where narrow, tangled and puzzling roads are not rare, that is, the high demand for navigation.

To use the digital road map DB, you must pay a charge consisting of a lump sum payment (a kind of annual membership fee) and royalties for the DB-based secondary productions. A later subscriber is demanded an initial lump sum payment, an amount equivalent to the original subscribers' initial payment with interest. This intends to secure equal burden sharing among the subscribers or beneficiaries of the DRM activities.

Each vendor produces its own map software based on these digital road maps. To the map software, the vendor adds a several times larger amount of data, such as traffic regulations (one-way traffic, etc.), hotel information, restaurant information, sightseeing information and golf course information.

2. Situations of Competition

Although vehicles equipped with other car navigation systems had been sold earlier, Mazda Motor

Corp. became the first in April, 1990 to have introduced a vehicle equipped with a navigation system based on DRM's map DB. The first separate type car navigation system, which can be mounted in all vehicles, was that introduced by Pioneer Electronic Corp. in June, 1990.

As described earlier, GPS and digital road maps, which are the two key elements of car navigation systems, are completely common to any vendors. Because functional discrimination is therefore difficult, pricing and the quality of software utilizing the GPS and road maps are significant in product competition. In addition to the conventional two-dimensional presentation, three-dimensional bird's eye view display has begun to appear. Voice guidance has become popular, too. Offering a rich list of entertainment CD-ROM software titles is also very advantageous to each vendor.

Therefore a different CD-ROM format is employed for software optimization by each vendor aimed at discrimination by unique software. No CD-ROM compatibility is secured among the vendors. The present market is now in the stage of harsh selection. There are several proprietary standards in the market. Vendors, which are not producing their own CD-ROM software, form the Navigation System Researchers' Association (Naviken) and are developing a common standard (Naviken Format), but this is not yet a de-facto standard.

Pioneer and Sony are the leading two vendors in the market. Price competition is occurring below 200,000 yen.

In Japan, a total of about 67 million vehicles are being used. So far, about one million car navigations sets have been sold, accounting only for about 1.5% of the total number of vehicles. Competition has just begun aimed at the goldconda.

3. Market Prospects

It is estimated in the industry that 540 thousand sets were shipped in 1995 and this figure will increase to about 700 thousand sets in 1996. As described in Section III, the VICS service will start in April, 1996, providing not only road guidance but also traffic information including traffic snarls, accidents, tentative regulations, arrival times and parking spaces. Because each vendor announced the support of the VICS, it will give a big impact to the car navigation market.

The car navigation system can be considered as a multimedia system because it can provide sound and still pictures although they are primitive. Its integration with communication systems, however, has not really begun yet. The VICS will urge the car navigation system to introduce one-way communication. In a long range, bi-directional communication is expected to become popular because this function provides various capabilities. At present, cellular phone systems are a single communication infrastructure available for this bidirectional communication. As described in III, although ATIS has already started bidirectional traffic information service through cellular phones, this service is not attractive yet because of the high telephone charges and low transmission capacity. Most car navigation vendors are not supporting this service.

■ Progress of Preparation of National Digital Road Map DB

Fiscal Year	Activities	No. of Digitized Maps					Coverage by 1/25,000 Digital Maps (Area Ratio)
		1/25,000 Scale				1/50,000 Scale	
		Cities with 200,000 or More Population	Cities with 100,000 to 200,000 Population	Other Regions	Total	Other Regions	
'88 | '89	① Data Preparation for "Major" Roads (Complete Nationwide) ② Data Preparation for "Medium" Roads (Cities with 200 Thousand or More Population) ③ Enhancing Data Attributes for "Major" Roads ④ Annual Update of Existing Data	475 Maps	—	—	475 Maps	1,122 Maps	About 10%
'90 | '91	① Data Preparation for Other "Medium" Roads ② Annual Update of Existing Data	—	323 Maps	490 Maps	1,288 Maps	849 Maps	About 30%
'92	① Data Preparation for Other "Medium" Roads ② Annual Update of Existing Data	—	—	941 Maps	2,229 Maps	639 Maps	About 50%
'93	① Data Preparation for Other "Medium" Roads ② Annual Update of Existing Data	—	—	76 Maps	2,305 Maps	620 Maps	About 52%
'94	① Data Preparation for Other "Medium" Roads ② Annual Update of Existing Data	—	—	643 Maps	2,948 Maps	434 Maps	About 67%
'95 plan	① Data Preparation for Other "Medium" Roads ② Annual Update of Existing Data	—	—	1,460 Maps	4,408 Maps	—	100%

Note) The total number of maps is not equal to the present total number of maps issued because some maps are integrated.

III. Traffic Information System - VICS and ATIS -

1. Governmental Guidelines

In August 1995, the Advanced Information and Telecommunications Society Promotion Headquarters headed by the Prime Minister decided "Guidelines on Increasing Use of Information and Communications in the Fields of Roads, Traffic and Vehicles" based on the "Basic policy for promoting advanced information and communication society" formulated in February 1995. The guidelines were prepared under the leadership of the National Police Agency (NPA), the Ministry of International Trade and Industry (MITI), the Ministry of Transport, the Ministry of Posts and Telecommunications (MPT), and the Ministry of Construction (MOC). The guidelines are to be revised as necessary based on yearly reviewing.

The guidelines were prepared not just for car navigation systems, but for promoting R&D and practical application of Intelligent Transport Systems (ITS) which aim at greatly improving safety, transportation efficiency, and comfort by establishing an automatic toll road toll payment system, supporting safe driving, optimizing traffic control, and raising the efficiency of road management. The VICS, which is a road traffic information and communication system for car navigation systems, is taken up as one of them. Governmental offices concerned and other organizations concerned are requested to take positive actions in linkage for developing the VICS.

2. VICS

The Vehicle Information and Communication System (VICS) is a system for providing road traffic information such as congestions, accidents, temporary traffic control, time required to a destination, and vacancy at parking places. The VICS Center established in July 1995 plans to start the service in April 1996.

(1) System Configuration of VICS

Basically, the VICS is a digital data

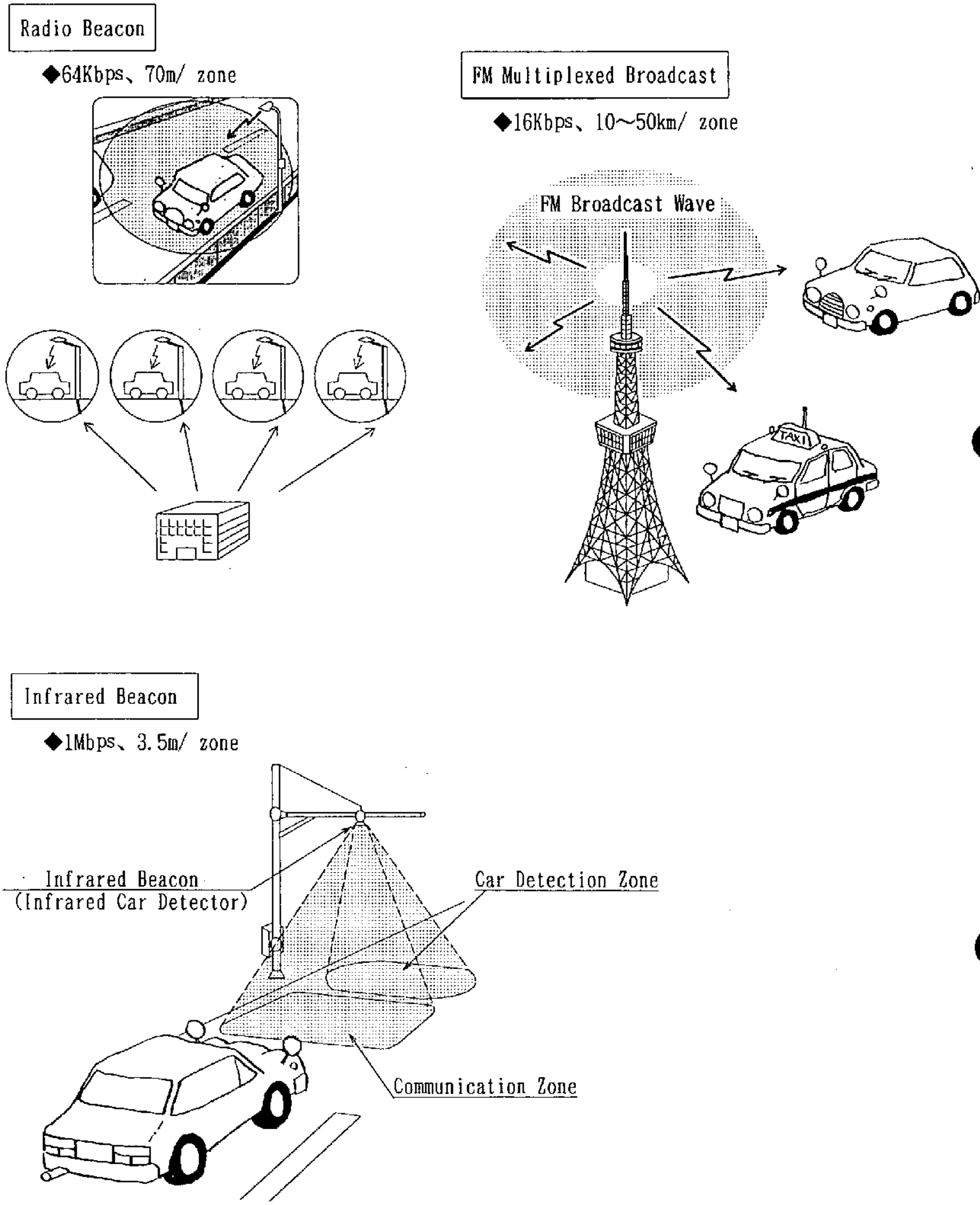

Figure III-1 VICS Media

broadcasting system. It uses beacons and FM radio broadcasting wave as the transmission media (Figure III-1). Beacons will be installed at fixed intervals along roads. Each beacon has small and discontinuous communication areas. Infrared beacons and radio beacons will be installed along ordinary roads and expressways, respectively.

The difference between beacons and FM radio broadcasting wave lies in the quality and quantity of information transmitted by them. They can be regarded as different programs or different menus. A beacon can supply detailed traffic information related closely to its location on an obvious assumption that "a vehicle exists at the location where it received information." In other words, individual beacons can exactly meet user needs by offering local information.

In contrast, FM radio broadcasting wave sends information that is useful for drivers in a wide area because of its nature. It has a wide and continuous communication area.

The VICS is to use NHK (Japan Broadcasting Corp.)'s FM radio multiplex broadcasting because it is only NHK, a public broadcasting organization, that has FM broadcasting stations nationwide. NHK had been prohibited to allow another organization to use their radio waves, but MPT revised the regulation to allow NHK to lease the wave to VICS.

Information supplied by the VICS is not what is collected by the VICS Center, but information received from the Japan Road Traffic Information Center and other sources.

(2) VICS Center

Since the VICS consists of facilities controlled independently by NPA, MOC, and MPT, it needs an organization that interlocks and connects them into one system. The VICS Center is a foundation established in July 1995 for operating the VICS and is placed under joint jurisdiction of NPA, MPT, and MOC. The funds were provided by the private sector only. Administrative organizations provided no fund such as a subsidy for it.

At the ITS Second World Congress held in Yokohama in November 1995, the VICS Center provided 33 vehicles with VICS supporting navigation systems for test driving. About 1,200 Japanese and foreign participants tested driving them.

(3) VICS Development Plan

Since the VICS Center can lease FM broadcasting wave from NHK, this media presents no problem for nationwide development. It can be said that the VICS development plan is nothing but a beacon installation plan. Beacons will be installed by administrative organizations.

To control investments appropriately, they plan to start the service from large cities and their nearby areas and gradually expand the service area step by step. Specifically, they will install beacons in eight prefectures such as Tokyo, Osaka, and Aichi in the first phase, and then expand them nationwide in several phases. They are planning about 7 years for the first phase, but will make flexible decisions for the subsequent phases. The service area consists of Tokyo and three prefectures (Chiba, Saitama, and Kanagawa) during the initial period of the service started in April 1996.

(4) VICS Fees

Since VICS fees are included in the prices of navigation equipment, no fee will be collected directly from users.

(5) Support by Navigation Equipment Manufacturers

Most of the manufacturers are taking actions to support the VICS. However, there are not many manufacturers at present that produce ATIS supporting equipment. ATIS is explained below.

3. ATIS

The Advanced Traffic Information Service (ATIS) is not directly connected with the above guidelines, but it is similar to VICS in that it provides traffic information. Its major difference from VICS is that it is an interactive system using telephone lines (fixed telephone, cellular phone, and leased line). A user can access to the ATIS not only from car navigation equipment, but also from a personal computer. For this reason, the ATIS can offer value added services such as display of the time required from the current location to a destination using its interactive function while VICS simply provides collected information.

The ATIS was started in April 1995 by ATIS Corporation. The service is made available to ATIS members only. A member must pay a subscription fee and monthly service fee (which does not include communication cost).

The ATIS has 2,550 members as of the end of 1995. Companies account for a large percentage of ATIS members and take advantage of its service for assigning business use vehicles. The cost of cellular phones is a large burden for general car navigation users. Another reason for its slow dissemination is that the service area is limited to Tokyo and the three nearby prefectures because the Tokyo Metropolitan Government is the major investor for ATIS Corporation.

It is a promising system because of its interactive nature, but has no advantage over VICS from the viewpoint of providing traffic information in the current stage. It is expected that VICS users will increase rapidly because they can use the service without being aware of its fee, namely, they feel that the service is free.

For this reason, ATIS Corporation set the policy of differentiating their service from the VICS by changing to a realtime information system offering not only traffic information, but also news, weather forecast, railway reservation status, aircraft departure and arrival information, stock prices and exchange information anytime and anywhere. (The company positions this service as an urban information infrastructure.) In December 1995, they started experimenting "ATIS dew" service which provides traffic information and other city information — various information for supporting safe and affluence city life — in cooperation with NTT.

IV. Guidelines on Increasing Use of Information and Communications in the Fields of Roads, Traffic and Vehicles

Introduction

These guidelines were formulated August 1995, based on "Basic policy for promoting advanced information and communication society" that was set by the Advanced Information and Telecommunications Society Promotion Headquarters (on February 21, 1995). The guidelines were prepared by the National Police Agency, the Ministry of International Trade and Industry, the Ministry of Transport, the Ministry of Posts and Telecommunications, and the Ministry of Construction with cooperation from related governmental offices.

Remarkable technological innovations are taking place in the field of informatization and the telecommunication infrastructure is being developed rapidly. The guidelines are to be reviewed yearly based on such progress and the state of implementation and revised as necessary.

1. Basic Concept

Positive actions are to be taken for R&D and practical application of Intelligent Transport Systems (ITS) to promote informatization in the road, traffic, and vehicle.

Intelligent Transport Systems which are constructed by integrating men, roads, and vehicles and applying the latest information and telecommunication technology will greatly improve safety, transportation efficiency, and comfort and contribute to realizing affluent and energetic lifestyles because they will be effective for developing advanced navigation systems, establishing an automatic toll collection system for toll roads, etc., supporting safe driving, optimizing traffic control, and raising the efficiency of road management. At the same time, they greatly contribute to environmental preservation by decreasing congestions and promoting smooth traffic flows.

In Japan, R&D and application efforts for individual systems constituting ITS are already underway. R&D on ITS is actively promoted in Europe and the U.S. as well because it is expected to be effective not only for improving road traffics, but also for generating new industries.

For this reason, the Government will further promote activities in linkage with the academic and private sectors for developing an overall concept of Intelligent Transport Systems, promoting its R&D, field tests, infrastructure development, dissemination, and standardization. At the same time, the Government will positively promote international cooperation.

2. Policy Development

(1) Objective

The objective is to construct an Intelligent Transport System by the beginning of the 21st century by promoting its R&D by linking governmental, academic, and private resources and sequentially starting to operate systems that become ready for practical use.

(2) Description

1) Development of a system architecture

Develop an overall concept comprising target functions and basic ideas related to major R&D themes so that an Intelligent Transport System may be constructed systematically and efficiently with mutual coordination among the parties concerned. Review the basic concept as necessary as R&D and technology progress.

2) Organizing concerned agencies for ITS promotion

A wide range of technology in diverse fields and cooperative activities by a wide range of people are essential for constructing an Intelligent Transport System. The public, academic, and private sectors are to take positive actions while linking and cooperating with one anther to realize the system.

3) R&D

The public, academic, and private sectors are to positively promote diverse R&D required for constructing an Intelligent Transport System, taking advantage of their characteristics and dividing roles. For example, the Government conducts R&D in fundamental fields or long-term themes by assigning them to national research organizations, conducting joint projects of the public and private sectors, or commissioning research to academic or private organizations. At the same time, the Government will improve test and research facilities. On the other hand, the private sector is assigned to R&D in fields of relatively high commercial nature.

4) Field tests

Since an Intelligent Transport System is a new system constructed by applying the latest information and telecommunication technology, field tests are effective for evaluating its practical aspect. For this reason, make considerations for facilitating field tests by the private sector as R&D progresses. For example, appropriate fields should be secured.

5) Provision of infrastructure

Develop infrastructures for systems constituting an Intelligent Transport System in a planned manner based on the results of field tests and so on.

6) Deployment of ITS for practical use

Gain an accurate understanding of market trends in related hardware and software and take measures for practical use and dissemination in an efficient and planned manner so that an Intelligent Transport System may be put to use smoothly.

7) Consideration of legislative institutions

Make considerations for product liability (PL), privacy protection, and the intellectual property right and improve the related legal system as necessary so that R&D and application of an Intelligent Transport System can be promoted smoothly.

8) Standardization

Take positive actions for international standardization activities related to Intelligent Transport Systems by international organizations such as International Telecommunication Union (ITU) and International Standardization Organization (ISO) by sequentially proposing specifications of systems developed and applied in Japan. At the same time, consider international conformance in constructing systems.

9) System compatibility

An Intelligent Transport System will consist of a number of systems. It is anticipated that a number of systems will use similar data. The functions of individual systems will be extended sequentially as R&D and application progress. Therefore, construct systems in consideration of their compatibility with other systems, system extendability, and consistency of basic data specifications.

10) International cooperation

Positively promote international cooperation in the field of Intelligent Transport Systems with European, American, Asian, and Oceanian countries by holding and participating in international meetings and seminars for exchanging international information, by participating in studies on international standardization, by promoting technology cooperation related to R&D and field tests, and by transferring technology of developed systems by such means as ODA.

11) The ITS World Congress

Continue to participate in the ITS World Congress where various countries in the world exchange opinions and information for smoothly promoting Intelligent Transport Systems. The Government will take positive actions for the Second World Conference on Intelligent Transport Systems to be held in Yokohama this year. For example, R&D and dissemination of Intelligent Transport System in Japan will be introduced.

3. Development Areas and Projects Underway

The following development areas are expected for an Intelligent Transport System. They will be reviewed as necessary as R&D and technology progress.

(1) Development areas

① Advances in navigation systems

Navigation systems are being disseminated rapidly in Japan. R&D in this area aims at realizing more comfortable traveling to destinations and improving user conveniences by constructing systems with functions for collecting and providing congestion information, required traveling time, traffic control and service information in realtime and realizing navigation systems with even more advanced functions.

② Automatic toll collection

An automatic toll collection system enables automatic payment without stopping at toll gates on expressways and other toll roads. It decreases congestion by eliminating the need to stop at toll gates, provides greater conveniences to users in the age of cashless trading, and decreases management cost by means of automatic toll collection.

③ Safety drive assistance

R&D in this area aims at increasing safety by preventing or minimizing traffic accidents by constructing a system that uses various sensors providing information about roads, traffic conditions, and nearby vehicles, that provides realtime information about nearby vehicles and sudden unexpected phenomena by means of telecommunications between the infrastructure such as roads and vehicles and between vehicles, that gives warnings to drivers, assists driving by means of driving control, and enables automatic driving.

④ Optimization of traffic management

The objective is to realize traffic control that enables controlling of traffic flows themselves and improves traffic safety and comfort as well as the environment by conducting the following R&D: 1) R&D on optimum control algorithm applicable to efficient signal control at intersections, 2) R&D on a system for providing traffic information to car-mounted equipment for the purpose of distributing traffic flows, 3) R&D for improving signal control techniques for placing high priority on public vehicles, 4) R&D on dynamic route guidance techniques that enable optimum vehicle distribution using destination information, 5) R&D on techniques for efficiently operating business use vehicles by dynamic information of vehicles, 6) R&D on detour information and signal control techniques aimed at decreasing traffic pollution.

⑤ Increasing efficiency in road traffic management

R&D in this area aims at quickly providing road users with information of road work, etc. and taking quick and appropriate road management actions by constructing a system that can collect and provide information such as road surface conditions and work underway. At the same time, it aims at improving user services and decreasing physical distribution cost by increasing the speed of passage permission procedures for special vehicles and further optimizing control by electronic processing of passage permission applications for special vehicles and other procedures, storing passage permission routes in a database, constructing a system for automatically collecting data of actual passage routes of permitted vehicles and their load.

⑥ Support for public transport

R&D in this area aims at raising the efficiency of business operations and providing greater conveniences to users and implementing optimum division of roles among the means of transportation by constructing a system for collecting operation status information of public transport facilities and providing such information to transport companies and users and by constructing a system that supports smooth operation of public transport facilities.

⑦ Increasing efficiency in CVO

R&D in this area aims at raising the efficiency of physical distribution business, decreasing the volume ofbusiness traffic, greatly raising the transport efficiency, and thus improving the environment by constructing a system that collects commercial vehicle (such as trucks and sightseeing buses) operation (CVO) information and provides the information to transport companies, by constructing advanced, automatic, and computerized physical distribution centers, by developing a system that provides joint delivery and return cargo information, and by developing an automatic driving system that enabling continued driving of commercial vehicles.

⑧ Support for pedestrians, etc.

R&D in this area aims at realizing safe and comfortable road traffic environment especially for the elderly and the physically handicapped by constructing a system that provides route and facility guidance information to pedestrians and bicycle riders carrying portable information equipment, by constructing a system that provides magnetic or voice route guidance information for the visually handicapped, and constructing a system that enables extension of green light duration using portable transmitters carried by pedestrians.

⑨ Support for emergency vehicle operation

R&D in this area aims at realizing quick and reliable recovery and rescue activities during disasters by constructing a system that collects information about traffic conditions and road damage due to a disaster in realtime, transmits such information to the related organizations, quickly guides rescue vehicles to the disaster locations, and executes traffic control.

(2) Promotion of current development projects

① Vehicle Information and Communication System (VICS)

The VICS provides realtime traffic information such as congestion information, required traveling time, and traffic control to vehicle-mounted equipment in the form of digital data. This system is constructed to meet the needs arising from the rapid dissemination of advanced navigation systems. The service will be started in the spring of 1996. The service will cover the Metropolitan area only during the initial period, but will be positively expanded nationwide through cooperation of the related governmental office and other related organizations.

② Universal Traffic Management Systems (UTMS)

UTMS aims at comprehensive traffic control covering elements up to road traffic occurrences. Its objective is to support safe and comfortable driving by developing advanced traffic control centers that provide advanced traffic information, provide dynamic route guidance, control vehicle operations, place high priority on public vehicles, and decrease traffic pollution. This concept is to be further promoted.

③ Super Smart Vehicle System (SSVS)

This is a future motor vehicle traffic system that will be developed by fully applying informatization and intelligent functions. It aims at raising the safety, comfort, and efficiency of motor vehicle traffic by adding sophisticated functions such as environment recognition and danger avoiding functions, traveling information exchange functions, and traffic flow control functions. At present, R&D on communications between vehicles is being conducted by mounting environment recognition, information exchange, and information processing functions on vehicles.

④ Advanced Safety Vehicle (ASV)

An Advanced Safety Vehicle (ASV) realizes high safety using highly intelligent functions developed by applying electronics technology. This project is being conducted through cooperation between the public and private sectors. At present, basic specifications for various safety technologies are being set, assessment methods are being studied, and a study on accident decreasing effects is being conducted. The environment for applying these technologies is to be improved so that ASV may be implemented by the beginning of the 21st century.

⑤ Advanced Road Transportation Systems (ARTS)

The objective of ARTS is to integrate pedestrians, vehicles, and roads so that all the people including the elderly and the physically handicapped may be able to use roads more easily and pleasantly and in an more advanced manner. R&D is promoted systemically under the following six themes: 1) Optimization of travels (including plans), 2) Safe driving support, 3) Optimization of travels by pedestrians and bicycle riders, 4) Optimization of public transport facilities, 5) Optimization of distribution, and 6) Efficient road management. R&D on automatic driving road system (AHS) is to be promoted positively.

⑥ Wireless card system

It is expected that a wireless card system can be applied to a non-stop automatic toll collection system and automatic ticket gates at stations. The Telecommunication Technology Council of the Ministry of Posts and Telecommunications is studying technological standards for the system. Technological standards are to be developed based on the results of experimenting a non-stop automatic toll collection system.

⑦ Non-stop automatic toll collection system

R&D on a non-stop automatic toll collection system is to be promoted positively by means of research, field tests, and experimental operation so that it can be put to use in the near future.

⑧ Small power millimeter wave radar

It is expected that small power millimeter wave radars can be applied to prevention of vehicle collision and automatic travelling control. A study on establishing a system of technological standards is being conducted.

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