# TRENDS IN AUTOMOTIVE INFORMATION SYSTEMS

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## 1. Overview of Automotive Information Systems

### 1.1 Present state of mobile communications

An infrastructure linking the automobile with the external world is absolutely essential to the successful implementation of in-vehicle information systems. Representative of such an infrastructure is the cellular car telephone which has seen explosive subscriber growth in recent years. A breakdown of the rougbly three million car telephone in use throughout the world today is given in Fig.1. By the year 2000, it is estimated that Japan will have 5.7 million cellular car telephone in use, North America 120 million units and Europe a total of 9 million units (including portable telephones ). If we combine the terminals and land-based facilities, then the market scale in Europe alone amounts to from US$7.7 billion to US$11.5 billion.

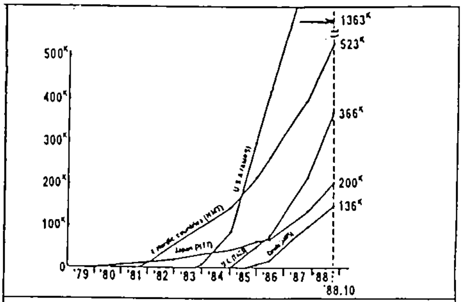


Fig. 1 State of mobile-telephone penetration in major countries

In addition to car telephone used mainly for voice communications, there is an increasing demand for automobile data telecommunications systems, which allow many users to share the use of multiple frequencies. At present, the U.S. Trunked System, Sweden's MOBITEX system, and Japan's MCA system, provide data telecommunications services that are primarily industry oritened.

Japan's MCA system is a communications system in which several mobile and command stations make joint use of various frequencies. The MCA system has been providing services since 1982. As shown in Fig.2, the basic configuration consists of MCA control stations installed by a nonprofit organization and command stations and mobile stations installed by users. The MCA control station consists of shared-use equipment covering an area with a radius of from 15 to 25

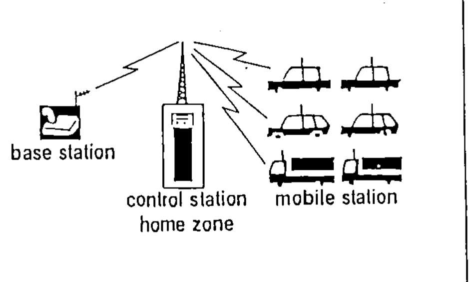


Fig. 2 System configuration of MCA

kilometers. Open channels are allotted in succession to users of the system. The control station and command and mobile stations are linked by radio.

Between these stations, voice communications is limited to one minute and data communication to 20 seconds. At present, 120,000 stations are in operation, and by the year 2000 this number is expected to reach to one million.(1), (2)

Today, as we move closer towards the 21st century, the development of integrated services digital networks (ISDN) is progressing well in all advanced nations. Work is under way to link mobile communications systems to ISDNs so as to create more advanced mobile systems that will take advantage of their capability to enable anyone to communicate anything, anytime, and anywhere. Indeed, there is an increasing demand for the kind of services that can be provided by mobile communications systems. Mobile communications can meet the needs of diversification, quality improvement, and the shortage of frequency resource caused by increasing demand. Currently, development efforts in all industrialized countries are being focused on digital mobile communications systems, which are recognized as the next generation in communications systems.

## 1.2 Merits of digitization

Following is a discussion of the merits of digital telecommunication systems.(3)

(1) Improvement of spectrum efficiency

Digital communications systems can narrow the spacing between radio channels more than analog systems. Additionally, since they increase the transmission capacity of the circuit control signal, spectrum efficiency can be further enhanced through the use of smaller spacing zones than what is possible at present.

(2) Improvement in data communications quality

Digital systems can apply a better error correction technique than their analog counterparts. Additionally, the introduction of diversity reception technology and adaptive equalization technology has resulted in digital systems capable of providing a bit-error rate that is 1/1000 that of analog systems. Such advances have contributed to the realization of high quality, high speed data transmission.

(3) Compact terminal design

The use of LSIs to fabricate high frequency circuits has made it possible to design more compact terminals. In addition, with the lower power consumption of these LSIs, it is expected that batteries for portable terminals will become smaller and lighter.

(4) Assurance of confidentiality(4)

The problem of security for highly confidential or important data is an issue of growing significance. Digital systems are able to assure confidentiality because of the encryption coding techniques employed.

(5) Cost reductions

Due to the introduction of multiple access technology, digital systems can increase the number of users per system by several times, resulting in a reduction in communications costs.

### 1.3 Development trends in mobile communications

Europe leads the world today in research and development of next-generation mobile communications systems which offer the advantages described in the foregoing discussion. Yet, because car telephone systems differ from one European country to the next, the mere crossing of a border can make car telephones useless. Obviously, users of car telephones in Europe are put to a great deal of inconvenience, and this partially explains the low and uneven rates of penetration.

In view of the problems discussed thus far, the European Conference of Posts and Telecommunications (CEPT) established the Special Group on Mobile Communications (GMS) to implement the Pan-European Digital Cellular System. Development work is progressing toward a service start up target date of 1991.

The specifications that have been agreed upon are shown in Table 1. Not only is this project intended to be a major showcase for European technology when the EC market is integrated in 1992, it will also feature many new technologies. When completed, it will be the world's first digital car telephone system and, for this reason, it is drawing the attention of various parties around the world concerned with land-based mobile communications.(3)

| Item | Specification |
|---|---|
| Frequency | 890～960MHz |
| Carrier separation | 200KHz |
| Users per carrier | 8 |
| Transmission data rate | 270kbit/s |
| Modulation | GMSK |
| TDMA burst length | 0.58msec |
| Speech coder rate | 13kbit/s |
| Speech codec | RPE-LTP |
| Diversity methods | |
| Adaptive equalisation | YES |
| Channel coding | YES<br>(Convolutional code) |
| Frequency hopping | YES<br>(217hop/s) |

Table 1
The principal specification draft of GMS

By comparison, in the United States, Bellcore (Bell Communications Research) has proposed the concept of Universal Digital Portable Communications(5) involving the use of an upgraded cordless telephone. AT&T has proposed the idea of Cellular Access Digital Networks (CADN)(6) that will allow car phones and future ISDN-compatible cordless telephones to access a public digital network. In Japan, research has begun on a digital car telephone system that uses a quasi-microwave band (1.5 GHzband). Additionally, service start up for a teleterminal system, a two-way data-only transmission system consisting of a multichannel access system and a packet transmission

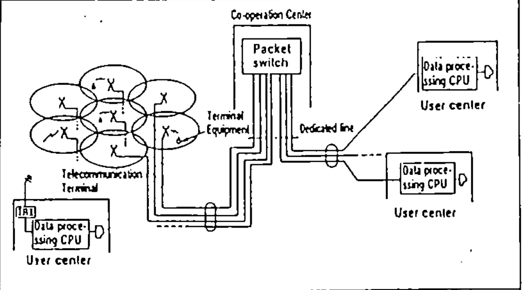


Fig. 3 Basic configuration of Teleterminal System

system, has been set for December 1989 (Fig. 3, Table 2).

The International Radio Consultative Committee (CCIR) of the International Telecommunication Union (ITU) is deliberating on the Future Public Land Mobile Telecommunication Systems (FPLMTS) as third-generation systems to follow the second-generation systems noted above. The system will offer worldwide communications by means of portable telephones. The basic system configuration has been agreed upon (Fig. 4),

In any case, it is an undeniable fact that further development of automotive information systems is dependent upon the construction of the essential infrastructure.

| Item | Specification |
|---|---|
| Frequency | 900MHzband |
| Modulation | 4800bps : directFSK |
| Transmission power | Terminal equipment 5W<br>Teleterminal 10W |
| Channel separation | 25KHz |
| Channel | 200ch |
| Zone structure | 3km radius : 19zone |
| Channel per zone | control channel 1ch<br>signal channel 9ch |
| Access type | slotted ALOHA |
| Throughput | max 0.4 |
| Packet length | 400bit |
| Admission user | 200,000sets/system |

Table 2
The principal specification of teleterminal

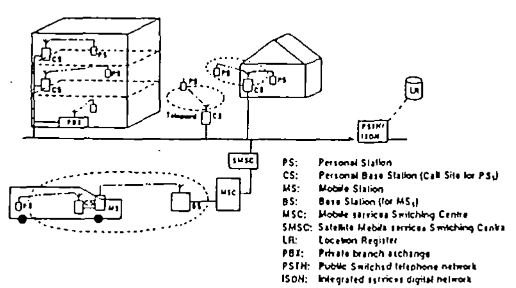


Fig. 4 Basic configuration of FLMPS

## 1.4 Data communications in current systems

In Japan, data communications functions are being developed for car telephones and multichannel access (MCA) radio units. The specifications of these devices are shown in Table 3.

According to the experiments that we have conducted, a practical data transmission speed for car telephones was 750 bps, whereas with MCA radio data transmission was effected 90% of the time at speeds of up to 350 bps. The difference in transmission speeds between the MCA radio and the car telephone experiments is due largely to variation in the strength of radio waves within the service area and to protocol differences. A car telephone modem has improved transmission efficiency by varying the error control system according to the electric field strength of the radio waves.

| Item | Specification | |
|---|---|---|
| System | Mobile Telephone | MCA |
| Carrier Frequency | 1500Hz | 1800Hz |
| time limit | No | 20sec |
| Error Control | FEC+ARQ | BCH code<br>Hagelbarger code |
| Modulation | MSK | FSK |
| Transmission data rate | 1200bps | 1200bps |

Table 3
The specification of the mobile-telephone modem & MCA

Through innovation in system configuration and in communications methods, we have been able to attain functions that heretofore were not possible for even the data transmission rates discussed in this section.

## 1.5 The two categories of information systems(7)

The information handled by automotive information systems can largely be divided into that relating to vehicle operation and that which is not. The former is referred to here as "front-seat use information" and the latter as ""back-seat use information".

The new mobile communication systems with broad service areas that were mentioned earlier were not designed solely with automobile use in mind. Looking at such systems from the standpoint of the automobile, they provide an infrastructure that promotes the development of back-seat use information capabilities.

Such back-seat use information systems will probably become popular mainly in commercial vehicles due to the tradeoff between cost and benefits. Corporations that have implemented in-company information network systems (INS) will be able to improve the mobility of their business operations by linking their company vehicles into the INS network through back-seat use information systems. It is also envisioned that the improvements in customer service realized through implementing such systems will enable companies to gain an edge over their competitors. Examples of such a trend are already emerging and many companies have achieved greatly improved performance by using these systems. Figure 5 shows a future commercial vehicle that has been designed and developed around a totally new concept. This type of system will be extended to privately owned automobiles once the requisite database and peripheral infrastructure are available.

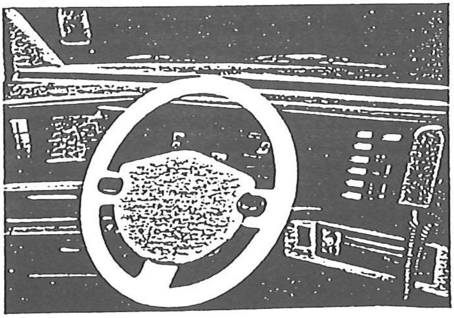


Fig.5

The front-seat use information systems will be equipped with functions for providing vehicle operation support information, failure diagnosis,warnings, and driving support. Some luxury cars are already being equipped with rudimentary systems.

A prime example of a vehicle operation support information system is a navigation system. In the future, this system will provide accurate two-way information on traffic conditions to road management authorities by means of beacons situated along the roadside. Such systems will be designed to aid road management authorities in city-wide traffic control. One function of such comprehensive traffic-control systems will be to provide drivers with information on the best route for reaching their destinations.

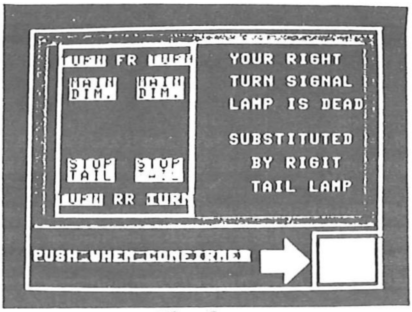
As the various features of automobiles have become increasingly more complex, there has been a growing need to develop failure diagnosis technology for automobiles. This is of course an urgent issue for automobile manufacturers. Examples of the failure warning indicator systems for a concept car that we have developed are shown in Figs.6 and 7.


ANTI SKID MALFUNCTION

(NOMAL BRAKING OK)

DRIVE TO YOUR NEAREST DEALER

Fig.6



YOUR RIGHT TURN SIGNAL LAMP IS DEAD

SUBSTITUTED BY RIGIT TAIL LAMP

Fig.7

Driving support functions are fairly futuristic issues compared with the other two systems mentioned above. One example of a driving support function that we are developing is a preventive safety system which employs radar to detect the car ahead as well as obstacles. Another such system features a human-machine interface which gives consideration to human faculties for perception and recognition.

Figure 8 depicts an example of a concept car prototype that represents a passenger car of the future. As can be seen from the figure, it is necessary to develop on-board units that are indirectly supportive of the implementation of automobile information systems.

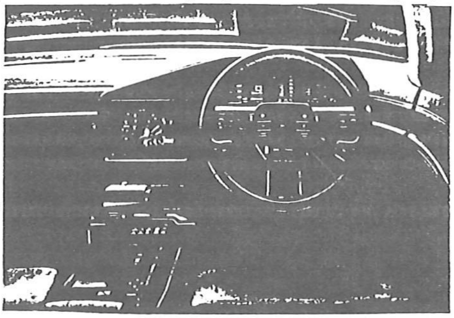


Fig.8

## 2. Navigation System Development(8), (9), (10)

### 2.1 Development programs

At the beginning of the 1980s, navigation systems were commercialized which determined a vehicle's location by means of dead reckoning using compasses and range finders. Based on that information, the system indicated the distance and direction to driver's destination.

At present, map databases are being achieved in large-capacity storage systems built around CD-ROMs and other storage media. These systems now being commercialized support the driver's route decisions by indicating the vehicle's present position and course on a map display. However, the stand-alone type of navigation system based on dead-reckoning is limited in its ability to accurately detect the vehicle's position, which is its most important function. To overcome this limitation, the following new position-finding system is being studied.

## 2.2 Position-finding technology

In dead reckoning, the position of a vehicle is determined by integration of the direction of travel and the distance travelled per unit of time, and therefore accumulation of error cannot be avoided.

Basically, the distance sensor employs a method that detects tire revolutions. Although affected somewhat by tire pressure and wear, this type of sensor still provides an accuracy ratio of from 0.25% to 1%, and so it presents no real problem for practical use.

At present, many different types of direction sensors are employed, including geomagnetic sensors, gyrocompasses, gas-rate sensors, two-tire rotational speed variance sensors, and steering wheel angle sensors. These sensors are used either independently or together in a variety of combinations. However, the geomagnetic sensor is by far the most popular device due to its various merits, which include small size, inexpensive price, and the fact that it can constantly detect the true direction in which a vehicle is moving. The drawback of using geomagnetic sensors is that they are easily affected by local geomagnetic deviation caused by magnetic structures such as buildings and bridges. As a result, their accuracy may vary within a range of ± 2° to ± 5°.

One of the greatest problems with geomagnetic sensors involves magnetization of the automobile body which occurs when the automobile passes over railroad crossings or through other strong magnetic fields. In a worst case scenario this could cause the geomagnetic sensor to indicate a driving direction that is 180°, or the exact opposite of the direction in which the automobile is actually travelling.

It is generally thought that in the future, most systems will use direction-finding methods that employ geomagnetic sensors in conjunction high-accuracy yaw rate sensors such as vibration gyrocompasses or optical gyrocompasses. At present, however, gyrocompasses are greatly affected by drift and its reliability is still very questionable under harsh vehicle environments involving high levels of vibration and heat. Obviously, such problems must be solved before commercialization can be achieved.

No matter what type of sensor is used, a dead-reckoning navigation system has the inherent drawback that a small amount of error will accumulate. For this reason, a maximum error rate of 4% is considered to be the limit of its accuracy. Map-matching technology is currently coming into use for the purpose of attaining more accurate position-finding systems. In map matching, the actual route being driven and road configurations stored in a map database are compared. The configuration closest to the actual route is determined through a pattern matching process, after which correction is made for the actual position. For this process, accurate road maps are obviously essential. As a stand-alone type system, map matching provides the best position-finding accuracy. However, errors in position detection will occur if the automobile is driven in a straight direction for a lengthy period of time, or if the same road configuration, such as a grid pattern, borders the route driven on, or if gentle curves are encountered along the route.

Studies are now being carried out on systems that employ an external information source which are capable of surpassing the position detection accuracy limits of stand-alone systems. One such system employs roadside beacons that transmit position information used in determining a vehicle's location.

Another promising system employs the global positioning system (GPS) satellites launched by the U.S. However, in order to conduct such measurements, it will be necessary to receive radio waves from four of the satellites at one time. In some remote mountain areas and even in some urban areas with high-rise buildings, it may not be possible to receive the radio waves. This means that the GPS-based system cannot be used independently.

## 2.3 Map databases

Issues relating to the map database are as important as the position-finding technology. A map database is necessary for the map display, map matching, and route search functions. In fact, the map database is the main part of the navigation system. However, the cost of making and maintaining a database is enormous because it must include all the roads in the country and be periodically updated by adding newly constructed roads. For this reason, the preparation of a map database is a project that must be carried out at the national government level. Details of this file structure are given in Table 4.

| Filename | Contents |
|---|---|
| Road Link File | Road link number, attribute, etc. |
| Road Node File | Road node number, attribute, etc. |
| Route List File | Route number, name, etc. |
| Background File | Narrow path, lane |
| Railroad File | Railroad |
| Border Line File | Administrative border line |
| River File | River |
| Coastline File | Coastline |
| Lakes File | shape of lakes, marshes |
| Station File | Railroad station's position, name |
| Institution File | Institution's position, name, etc. |
| Place Name File | Name of prefecture, city, town |

Table 4
The file structure of the digital road map data-base

In order to popularize navigation systems in the future, map and navigation system manufacturers should add their own independently prepared information to the systems so as to improve their salability. Since it is expected that navigation systems will come to be extremely important information mediums, compatibility is essential.

## 2.4 Traffic control link

The introduction of automotive information systems will perform an extremely important function in that it can provide better mobility, the original function of the automobile. In other words, by linking the navigation system functions with traffic control, the system can contribute to the easing of the current situation of increasing traffic congestion in urban areas. This trend is especially evident in Europe where many projects, such as PROMETHEUS, are currently under way.

In Japan, development of the Road and Automobile Communication System has been proceeding under the auspices of the Ministry of Construction and the Highway Industry Development Organization since 1986. Additionally, the Advanced Mobile Traffic Information and Communication System (AMTICS) was started in 1987 under the auspices of the National Police Agency and the Japan Traffic Management and Technology Association. Many private corporations are participating in these projects.

Since 1983, a roadside communications system has been used in Japan to transmit traffic information via roadside cables. However, information updating is slow and inaccurate and information is often unavailable on certain areas that users wish to know about. Such inconveniences have caused a great deal of user discontent with the system. As a result of these problems, the newer projects have been launched.

Development work on these new projects is proceeding under the assumption that navigation systems will be popularized in the future. The AMTICS system is expected to contribute to reducing traffic congestion and to decreasing traffic accidents by providing detailed traffic information to each vehicle by way of the teleterminals mentioned earlier. It is envisioned that this will result in a safe and smooth flow of traffic.

The Road and Automobile Communication System involves the installation of roadside beacons having localized communications zones. Goals of the system include transmission of position detection and traffic information for navigation systems and the two-way transmission of messages between vehicles and external stations. According to a corporate user survey, the average facility cost that users were willing to bear to implement a system was $760, while a tolerable monthly rate was in the neighborhood of $60.

Automotive information systems were originally developed only from the standpoint of improving user convenience, as it was thought that this would lead to the creation of a larger user market. The work of gauging traffic conditions and of collecting related information was mainly left to the efforts of the authorities responsible for road and traffic management.

At present, though, we are on the verge of developing automobiles that conduct various measurements relating to their own driving performance and environment, and soon the automobile will be equipped with functions that allow communication with external entities. As such, we feel that more serious consideration should be given to using the latent traffic information collection functions of automobiles. By constructing a comprehensive traffic administration system, it will become possible for automotive information systems to display their full capabilities in contributing to enhanced mobility.

## 2.5 Navigation system functions(11)

Nissan is also participating in the above-mentioned projects as one aspect of the company's development programs for navigation systems. The basic configuration of the Nissan system is shown in Fig.9. A magnetic- flux gate type of geomagnetic sensor is employed as a direction sensor. The system is also equipped with a GPS signal receiver and a beacon signal receiver

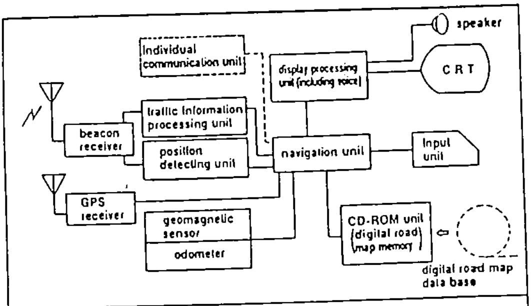


Fig. 9 Configuration of NISSAN navigation system

(Fig.10). For software, the system is provided with map-matching functions. Because all of the functions are integrated, it is possible to attain position accuracy within 30 m at all times.

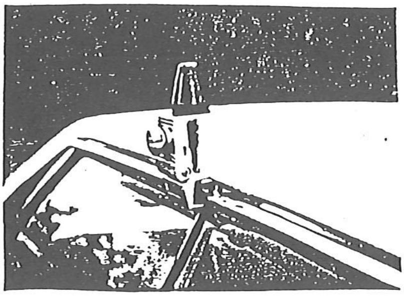
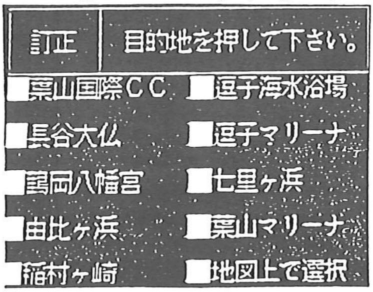


Fig.10.

We feel that the ultimate form of a navigation system will be a route guidance system that is linked to a comprehensive traffic management system. The function of the traffic management system will be to relieve traffic congestion by controlling the flow of traffic based on the latest traffic condition information. To achieve this kind of functional capability, we have developed a route guidance system that can receive traffic information from roadside beacons, determine the optimum route and indicate the direction in which the driver should proceed at crossroads. The route guidance procedures are explained below.

(1) The driver sets the intended destination by indicating a place name on a map displayed on a CRT screen (Fig.11). Maps are zoomed to an increasingly smaller area until the driver can select the name of a place or a building on the map (Fig.12).



訂正　目的地を押して下さい。

□葉山国際ＣＣ　□逗子海水浴場

□長谷大仏　□逗子マリーナ

□鶴岡八幡宮　□七里ヶ浜

□由比ヶ浜　□葉山マリーナ

□稲村ヶ崎　□地図上で選択

Fig.11

設定された目的地です。

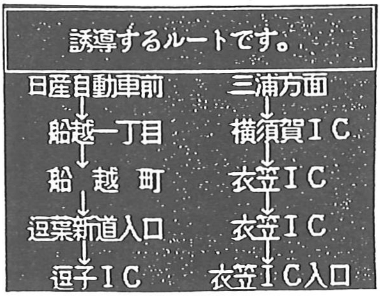
Fig.12

(2) The starting point is calculated according to signals received from GPS satellites. 'If the GPS signals cannot be received, the driver must input the starting point in the same way as the destination.

(3) Traffic condition information is input into the system from the experimental communications control center via the car telephone or information beacon or teleterminal signals.

(4) The optimum route is calculated taking into account any traffic congestion. The names of intersections along the route are shown on the CRT screen (Fig.13). Additionally, yellow circles are displayed at the corresponding intersections on the map (Fig.14).

In calculating and determining the optimum route, distances are weighted in terms of such factors as the degree of traffic congestion and the type of road involved (freeways, bypasses, ordinary roads, etc.).



誘導するルートです。

日産自動車前 → 船越一丁目 → 船 越 町 → 逗葉新道入口 → 逗子IC

三浦方面 → 横須賀IC → 衣笠IC → 衣笠IC → 衣笠IC入口

Fig.13

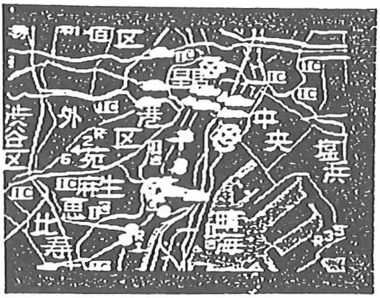


Fig.14

(5) The name of the first intersection (starting point intersection) and the direction to take are displayed at the top of the screen. The driver is guided to the first intersection by following the route indicated on the map.

(6) When the automobile approaches to within 500 meters of the starting point intersection, the CRT display will change to show the name and configuration of the intersection and the direction in which the driver should proceed.

(7) Upon passing through the starting point intersection, the display will change once again to show the map indicating the route to be taken. The map displayed on the CRT screen may be either reduced or enlarged.

(8) When the automobile approaches to within 500 meters of the next intersection on the route, the CRT display will change to show the name and configuration of the intersection. The direction in which the driver should proceed and the distance remaining until the intersection is reached are also shown on the CRT screen (Fig.15).

(9) Upon passing through the intersection, the display will change once again to show the map indicating the route taken.

(10) Steps (8) and (9) are repeated until the driver arrives at the final intersection (end point intersection).

矢印方向へ進んで下さい

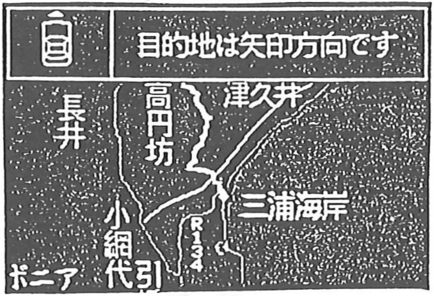
船越一丁目

300 m

Fig.15

(11) When the vehicle approaches to within 500 meters of the final intersection, the direction of the destination is displayed at the top of the CRT screen to aid in guiding the driver to the desired place (Fig.16).

According to the results of our experiments, GPS reception ratios vary from region to region. Results of the driving tests that we conducted are given in Table 5 and as might be expected, mountains, buildings, and other such obstructions reduce GPS



目的地は矢印方向です

Fig.16

reception ratios. Nonetheless, mountainous areas generally have good geomagnetic environment conditions and this allows for sufficient dead-reckoning accuracy. In areas where buildings are numerous, the distance between beacon installation positions is relatively close. Additionally, because the roads in such areas have distinct configurations and are quite numerous they provide good conditions for map matching, which achieves highly accurate position detection.

| Geographical conditions | Reception rate |
|---|---|
| Roads along the ocean | 75% |
| Open urban areas | 73% |
| Ordinary urban areas | 33% |
| Freeways(in mountains) | 22% |
| Urban area with many mountains and buildings | 13% |

table 5
Relationship between geographical conditions and reception rate

## 3. Development of an On-board Mapping System

### 3.1 TUMSY development

Lastly, as an example of a back-seat information system we will introduce the mapping system employed in vehicles dispatched to perform emergency gas line maintenance work. This system was jointly developed by Nissan and Tokyo Gas Company, Ltd.

Tokyo Gas' metropolitan service area covers 3,000 km$^2$. In the past the company used 27,000 paper maps on a scale of 1/500 to manage maintenance operations in the Tokyo metropolitan area. However, in 1977, the company initiated development of a computer-based management system to attain more accurate information on gas supply facilities, improve maintenance management, attain optimal operating conditions and achieve an optimum configuration for its gas line networks. The system, known as the Total Utility Mapping System (TUMSY), was finally completed in 1982, and became partially operational in 1983. Full-scale operation of the system began in 1987, and the system has since demonstrated an excellent performance record.

The system has a unique hierarchical data structure that allows systematic administration of the large volume of map data and diverse range of accompanying data. Such data include a variety of hardware details, such as pipe and valve information, as well as environmental data such as the depth of supply lines. The hierarchical structure enables the system to retrieve only the data actually needed and to output various combinations of data. Furthermore, data on other underground installations such as water, power, telephone, and sewage lines can also be input into the system.

### 3.2 Development of the on-board mapping system

In the case of gas leaks and other incidents, data reflecting the latest road conditions and pipeline configurations are absolutely essential. This system has made it possible to update maps much more quickly and has thus solved a pressing problem facing the company.

The installation of workstations at maintenance centers made it possible to retrieve the latest updated maps. However, that improvement was still not very helpful for the emergency maintenance crews dispatched to sites where problems had occurred. To cope with that situation, all emergency maintenance vehicles were equipped with between 30 to 50 gas line network maps covering their respective areas of jurisdiction. This resulted in a substantial burden in terms of weight and space for the emergency maintenance vehicles which were already heavily loaded down with repair equipment and tools.

The maps provided in the vehicles were updated only once a year or every year and a half. Because of this, when maintenance vehicles were moved from one emergency site to another, updated maps would be referenced at the maintenance center and sent to the next emergency site in another maintenance vehicle. This system was extremely inefficient, but it was the best available at the time. Because of space considerations, the maps used at that time often lacked necessary information on the gas supply lines running to individual households. These circumstances created the need for a system that could provide fast, accurate, and up-to-date information on emergency sites.

The basic configuration of the system is shown in Fig.18. We will now explain the system beginning with the functions of its constituent units. First, the car telephone and radio equipment are connected to a switchbox. For data communications, the switchbox sends the signal received by the car telephone to a modem coupled to the telephone. For facsimile communications, the switchbox sends the signal to a facsimile machine. The CRT and on-board facsimile were developed as part of this work. The facsimile has also been provided with a copier function for making hard copies of CRT screen displays. The modem is used for data communications via the car telephone. A data adapter, linked to the maintenance center, functions as an error control device and is the core piece of equipment for data transmission in mobile communications. The communications control computer at the maintenance center converts data received from the data adapter into a format that can be referenced by the host computer. It also converts data from the host computer into a format that can be communicated to the data adapter.

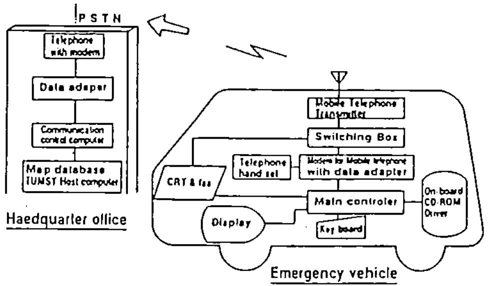


Fig. 18 System configuration of Mobile Mapping System

Next, we will discuss the data structure and system functions. Because information pertaining to roads, housing configurations, residents, and buildings is not directly related to emergency work at the site, such information is stored in a CD-ROM system as fixed information. Data that are constantly being updated, such as information on gas lines, can be obtained from the headquarters database via the car telephone by inputting the address of the emergency location. This system insures that the latest updated data are available at the emergency site. Data transmitted from the headquarters database and the CD-ROM database are combined and shown on the CRT screen. This enables the maintenance crew at the emergency site to utilize accurate information in performing the required maintenance work.

Additionally, emergency maintenance vehicles can communicate with the head office database and obtain requisite information while enroute to the site. This shortens the time needed to mobilize an emergency team at the maintenance center.

At present, a prototype of the system has been completed and is now undergoing field testing.

### 3.3 Expansion and application possibilities of the on-board mapping system

Lastly, we will discuss the expansion and application possibilities of the on-board mapping system, beginning first with future expandability. In addition to the functions described above, other functions now being consider for future inclusion in the system are a vehicle status information function.

The various situations to which emergency maintenance vehicles must respond range from relatively insignificant gas line problems to extremely critical situations involving the need to prevent explosions at fire sites. As such, maximizing the efficiency with which emergency vehicles are dispatched is an important factor in assuring safety. This requirement has prompted studies of a vehicle status information system that would enable emergency vehicles to transmit status information to their command center in the form of messages such as: proceeding to site; arrived at site; investigation of cause concluded; repair work in progress; and repair work concluded. Such vehicle status transmissions would improve emergency vehicle mobility by enabling command center to issue further instructions, rerouting emergency vehicles to other emergency sites.

One application of the previously discussed navigation system is to link it to an automatic vehicle monitoring (AVM) function that would enable a command center to directly monitor the positions of dispatched vehicles and issue further instructions.

Other areas of application for the mapping system include use in processing and storing information on underground facilities such as power, water, telephone, and sewage lines, in addition to gas line information. The mapping system could thus be used to categorize and manage the complex mass of urban underground utility information, which is becoming increasingly more complicated as urban facilities are enhanced. The on-board mapping system could be installed in the maintenance, construction, and emergency-use vehicles of the utility companies without modifying the system substantially. Additionally, by linking the system to the special emergency communications infrastructure, it could also be used in emergency vehicles, such as ambulances and fire trucks.

By adding new attribute data to the mapping database, the mapping system could be used in general business-use vehicles. This would open up possibilities for the realization of mobile offices, the ultimate form of back-seat use information systems.

## 4. Conclusion

Previously, the history of automotive technological development was not much related to social systems and there were very few opportunities to conduct comprehensive studies on automotive traffic systems.

However, as we have noted, automotive information systems are now being developed for both front and back seat use. Construction of the new infrastructure that holds the key to realizing the full capabilities of these systems is also progressing. Such developments are inseparable from progress in automotive information systems. These developments are symbiotic and when merged will transform the automobile into a mobile information medium.

If the functions of these systems are to contribute to the further enrichment of society, there is a keenly felt need for greater cooperation among many fields, including the automotive industry, data processing and communications and road and traffic management.

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