Hitachi Group Initiatives as ITS Businesses Begin to Take off

Yasushi Fukunaga
Akio Muko, Dr. Eng.
Tatsuo Yoshioka
Yutaka Saito

OVERVIEW: Hitachi, Ltd. took the initiative in launching research and development on ITS (intelligent transport systems) businesses in the early 1990s, and the results are now clearly evident in the growth of VICS (vehicle information and communication system) and car navigation businesses. The latter 1990s then saw the sudden emergence of mobile communications, thus setting the stage for new ITS capabilities exploiting dedicated cell phones, general purpose communication networks, such as mobile and broadcasting systems. As a comprehensive electrical equipment manufacturer, Hitachi has divisions dedicated to information and telecommunications systems, power and electrical equipment, semiconductors and integrated circuits, automotive products, and consumer data appliances. By combining core technologies from these different areas and adding Hitachi's extensive experience gained in working on ITS over the past ten years, Hitachi is ideally positioned to vertically integrate new services and promote the emergence of new markets. Enhancing its position even more, Hitachi's Automotive Products group has close ties with the auto industry, the company has built up relationships as "Best Solutions Partner" with many of leading auto manufacturers and transport companies, and has pioneered many new business areas such as telematics.

INTRODUCTION

NOW at the outset of the 21st century, society on the whole is being totally transformed by IT[1]. Especially compelling is the use of IT not in the virtual realm of data per se but in the real world, and efforts to improve productivity through organic linkages as evident in the "third-stage digital revolution"[2)–4)] and the "ubiquitous information society" are attracting enormous interest. One market that is part of this new development is the emerging market for ITS (intelligent transport systems).

Hitachi provides many operational bases that are relevant to ITS. For example, the Information & Telecommunication Systems group provides IT as business base, the Power & Industrial Systems group provides public system infrastructures as a business base, the Automotive Products group provides in-vehicle equipment and systems as a business base, and the Semiconductor & Integrated Circuits group provides system LSIs (large-scale integrations). These are not conceived by the company as isolated businesses, but rather as elements that can be organically interconnected and combined to achieve significantly higher value-added systems.

In the complex science, this is known as "emergent evolution," and creating a multiplier effect by this kind of lateral organizational synergy is becoming increasingly important. Even as operational areas of the parent company are becoming more clearly defined by spinning off subsidiaries, new organizational structures are being put in place to maintain lateral ties between related divisions.

In April 1999, Hitachi Group simultaneously launched the ITS Business Promotion Committee to ensure lateral ties across ITS-related businesses, and a "special research project" to ensure lateral coordination of ITS-related research and development efforts. From a global standpoint as well, quite a number of new ITS-related projects involving Japan, the U.S., and Europe have been launched, and we have clearly reached the point of transition from a period of infancy to one of growth.

To grasp the significance of this transition, here we will briefly retrace the history of ITS development[5], discuss the latest developments and outlook for current ITS businesses, and highlight Hitachi Group's initiatives in this area.

RESEARCH AND DEVELOPMENT HISTORY

The history of research and development regarding

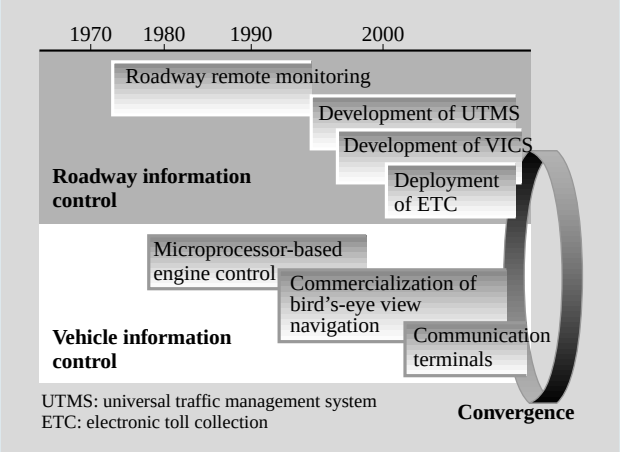

Fig. 1—History of Vehicle-roadway Information Control Systems.
Recent general-purpose networking technologies are now bringing about the convergence of two separate systems that emerged in the 1970s.

ITS can be divided into two broad approaches, one focusing on electronics-based roadside infrastructure systems, and the other focusing on in-vehicle information and control systems based on electronic technologies. Fig. 1 shows the evolution of these two approaches.

The roadway information control system launched in 1973 in Japan provides centralized control over high-speed expressways and monitors road conditions from a central control office through a remote monitoring control system. The deployment of this system brought tunnel ventilation control and image monitoring capabilities into practical use. As more sophisticated image-processing capabilities became available in the 1990s, the AVI (automatic vehicle identification) system was implemented that features the ability to calculate approximate trip times, a system for detecting traffic congestion, and a signal control system that is part of the UTMS (universal traffic management system) which is being promoted by the National Police Agency[7].

In April 1996, VICS (vehicle information and communication system) was put into service that delivers road congestion, driving time, and other information to suitably equipped vehicles using three different transmission media: radio, optical, or FM multiplex broadcast. Hitachi has been actively involved in the development of VICS from the start, and has been a strong advocate of commercialization. This technology was also featured at the 1998 Olympic Games in Nagano, where it was used as part of the UTMS in regular vehicles and in official vehicles associated with the Games[8].

Meanwhile, in-vehicle information and control systems based on electronic technology trace back to the innovative adoption of microprocessors for engine control in the 1970s.

This technology was later applied to information systems in addition to control systems, and this facilitated the development of vehicle navigation systems. In order to display information in vehicles, the human-machine interface is extremely important. Hitachi adopted the "bird's-eye view map display" proposed by Nissan Research Center[9], and developed a microprocessor-based implementation of the system[10]. The development of this system was achieved by exploiting the expertise of Hitachi teams that were investigating graphic systems for graphic workstations and game systems[11].

Turning to vehicle sensors, good progress was made in developing radar and image-monitoring capabilities based in part on engineering expertise from the industrial sector.

Essentially, we tried to emphasize research activities producing results that could be readily transferred to other application markets to provide new value-added technologies and services at relatively low cost. As an organization, in other words, Hitachi was attempting to achieve the synergic technology transfer through its research and development activities.

This approach is especially apt in the fast-paced areas of IT and electronics that show double-digit growth every decade. This kind of technology transfer is relatively easy and constitutes an enormous advantage for comprehensive electronics manufacturers like Hitachi that have a broad range of operations across many different areas.

RECENT BUSINESS TRENDS

Convergence of Roadway and Vehicle Information Control Systems

As noted earlier, we have entering upon a new era when systems developed for installation in vehicles or for roadside infrastructures are now being organically linked and much more broadly disseminated through the rapid emergence of general-purpose communications and networking technologies including wireless capabilities (see Fig. 2).

Vehicle-roadside communication is supported by cellular networks, digital broadcasting networks, DSRC (dedicated short-range communication) networks, wireless LANs (local area networks), and other networks. The technology has also now matured

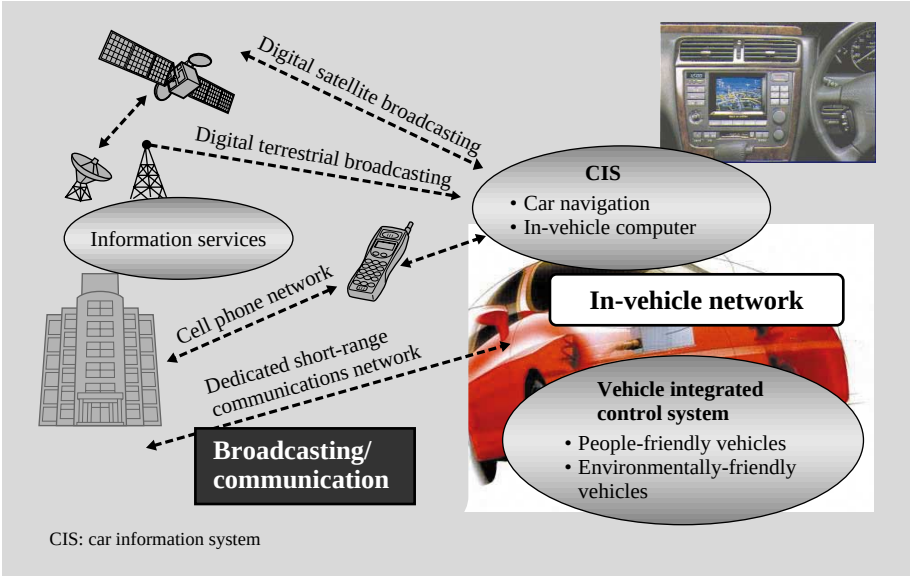

Fig. 2—Concept of Vehicle Information Control Systems. Vehicles and information service centers are linked by various broadcasting and communications media, while information and control systems in the vehicle are also interconnected by a network.

to the point that vehicles can be fully equipped with networking capabilities, and information systems can be fully integrated with control systems.

With such a system in place, we already have the technological ability to check the tires and engine in near real-time basis and at relatively low cost of a car driving on the far side of the globe.

On the other hand, the roadside systems can now use their remote monitoring capabilities to do much more than just collect road-related information (traffic congestion and road surface conditions), and these systems are now capable of communicating with other traffic systems, such as railroad systems. Being well aware of the business potential of these systems before they became widespread, Hitachi pursues its research and development objectives while paying careful attention to the business needs of the marketplace.

Private Services Based on Cell Phone Networks

Many new businesses have sprung up over the past two years, some tailored to individual consumers and others targeting business users, that leverage cell phone networks.

Services for individual consumers

Hitachi was a partner and closely involved in the development of Nissan Motor Co., Ltd.'s integrated telematics service that will be offered as an option on new model Nissan cars. A new team from the Information & Telecommunication Systems group joined forces with the earlier established navigation system development team, and working together brought a number of key technologies to completion:

(1) An IT terminal based on Hitachi's SH microprocessor that connects to a cell phone and provides an excellent man-machine interface for use in vehicles

(2) A verbal interface (not prerecorded) providing voice-activated operation and text-to-voice capabilities

(3) A robust data center system that can handle communication requests from a large number of terminals

(4) A driving route assistance system server that assists drivers in finding optimum routes to their destinations[12].

One significant point to note about these technological advances is that the software on the server is not dependent on terminals and can be periodically updated. This makes it easy to provide users with fresh information even long after they have purchased their vehicles.

Services for businesses

In April 2001, Hitachi unveiled its sophisticated vehicle tracking service that will be offered to the logistics industry by application service providers and system integrators[13]. When it first came out, the service only allowed dispatch centers, stores, and retail branches to track their own trucks in real time, but the service has subsequently been upgraded to provide a range of useful functions: automatic output of daily reports, verification of driver operating conditions, provisioning of traffic information, and more.

From a systems perspective, there are many shared elements with systems designed to provide information

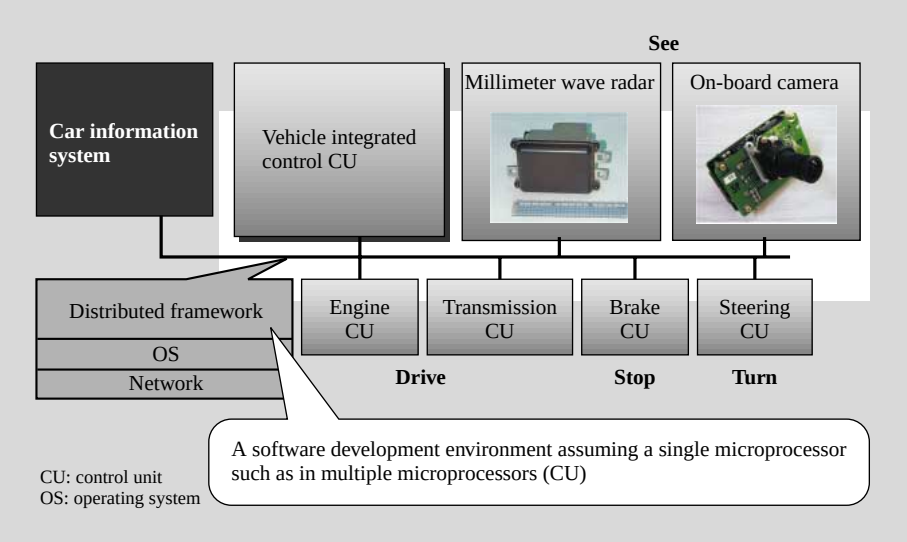

Fig. 3—Driving Control System Configuration. Numerous control units are interconnected by the on-board network, and an organically interconnected system is realized by a distributed control system.

to ordinary individual users, so technical advances on one system can be immediately applied to further our efforts on other systems.

DSRC-based ETC Business

Even with the rollout in Japan of an ETC (electronic toll collection) system that was put into operation on Japan's major highways in 2001, a wide range of business developments are being pursued from systems to semiconductors. The ETC system exchanges information between vehicles and roadside equipment over a 5.8-GHz-band DSRC connection, and toll fees are automatically charged using an IC card and in-vehicle unit. This is a state-of-the-art system that incorporates the latest mobile communications, electronic commerce, and security technologies. ETC equipment has now been installed in most toll stations on Japan's main highways, and the system has enormous potential for growth as demand for terminals increases and services are diversified.

The DSRC-based communication scheme between roadside and vehicles for ETC has now been recognized as an international standard, so it is likely to be adopted in Asia and other overseas markets.

Adaptive Cruise Control System

Working in cooperation with the auto manufacturers, Hitachi developed an ACC (adaptive cruise control) system that assists drivers by using sensors to measure the distance to the vehicle ahead. Here we will mention two of the technologies that are part of the ACC system.

(1) Integrated driving control over the engine, transmission, brakes, and steering (see Fig. 3)

With the need now to organically connect by a network units that up to now have worked in isolation, we have adopted distributed control system framework, an approach used in the industrial sector to achieve linked control of multiple microprocessors[14].

(2) Driving environment sensing technology

Good progress has been made in the development of a millimeter wave radar system that completely eliminates the need for mechanical mechanisms, and in the development of an image-processing system that provides excellent cost-performance. These technologies have been put to good use in the development of a system that senses the white lines on the highway and helps drivers stay in their own lanes while driving.

FUTURE ANTICIPATED BUSINESS EXPANSION

Expansion of Communication Bandwidth

Hitachi is also opening up new business areas that exploit cell phone networks. While continuing to improve the level of services, we envision that greater communication bandwidth will be demanded in the future. Hitachi has thus committed research and development resources to the following systems.

(1) Integrated mobile broadcasting/communications system for digital broadcast networks[15]

Scheduled for practical deployment in 2003, the digital terrestrial broadcast system supports the transmission of data in a mobile environment with little noticeable loss of quality. Above and beyond services for delivering images and voice over the broadcast network, we are also making good progress in developing a system that will support services for

delivering map data and related information using the broadcast network. In addition, Hitachi is also closely involved in the development of a satellite system (a quasi-zenith satellite) that supports robust mobile communications and will enable these services to be made available nationwide.

(2) Systems for next-generation cell phone networks

A major upsurge is in progress around the world to develop next-generation high-speed cell phone networks, wireless LANs, and wireless Internet capabilities that will enable cell phones to send and receive multimedia data. Considering the enormous improvement in responsiveness of services provided over this network, Hitachi is committed to the development of technologies for this system.

Linking Information and Control

A vast array of potential new businesses could be made available by linking vehicle control systems with information systems. By gathering control data at a higher level, for example, many new remote monitoring businesses could be offered, such as illustrated in Fig. 4. Here we consider a few specific services that could be made available.

(1) By monitoring someone's driving over time or their driving behavior, this could be used to generate individually tailored suggestions on how they might improve their driving safety, or it could provide useful feedback to auto insurance companies.

(2) The adverse environmental effects of vehicles could be greatly reduced by monitoring the running condition of engines and thereby catching problems before they occur and keeping engines in peak operating condition.

(3) Using floating car runs and other techniques to gather data on average congestion and other conditions, more detailed traffic and weather information could be made available.

By going one step further and incorporating this kind of information into control systems, this would enable more exacting driving control systems. Finally, Hitachi is also pursuing research and development on automatic driving systems that, although apparently from the realm of science fiction, essentially do the driving for you.

Making Roads More Intelligent

Promoted as a national project, research and development began on the AHS (advanced cruise-assist highway systems) in 1996. The system seeks to assist driving with sensors and communications equipment installed along the roadway, and Hitachi has played an active role in the project. The primary objective of the system is to reduce traffic accidents, and considering the importance of this goal for society, plans have been made to extend AHS nationwide in the future. Hitachi has made a significant contribution to the deployment of this project through such key technologies as image monitoring and ETC.

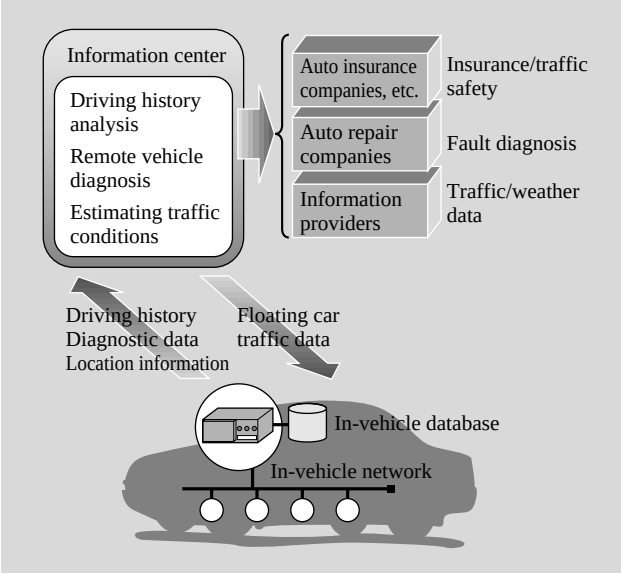

Fig. 4—Businesses Linking Information and Control.
A wide range of data processing capabilities could be realized by connecting a control system with an on-board network, storing data on engine and brake conditions in an on-board database, and delivering the data to an information center.

Realizing Interoperability

In the current ITS, developments relating to motor vehicles have tended to figure more prominently. Taking a broader view of Japan's transportation system, however, there are infrastructures in place for railroads, motor vehicles, and aircraft. And indeed there are many opportunities for people to move about by walking. Thus, an ITS in which these different infrastructures are interconnected is most desirable, and it is important that the system take these linkages into account.

Ever since the Shinkansen (bullet train) commenced operations, Hitachi has had a group dedicated to the railroad data control business. Hitachi also has a group involved in the development of motor control systems for hybrid vehicles, and numerous other technologies with shared aspects. By exploiting this advantage and making a conscious effort to establish links these two cultures, Hitachi will be in a good position to pursue developments that are linked and have shared elements

in the years ahead.

By participating in the pedestrian ITS and other national projects, and by sharing information with the cyber railroad development project, Hitachi is seeking to build a basic integrated platform that will support various systems—systems that will certainly be interconnected in the future.

CONCLUSIONS

In this article we focused on a critical turning point as ITS businesses make the transition from the formative stage to the growth state, and touched on the past, present and future outlook for ITS businesses.

The very meaning of ITS has tended to change over time and become so ramified that even people involved in the technology are not quite sure where to draw the line.

Hitachi is seeking to exploit its advantage of covering a broad range of relevant technologies, and while putting forth proposals exploring what solutions are available and gathering essential technologies from around the globe, will continue to involve itself in business planning with some sense of readiness.

REFERENCES

(1) T. Nakatani, "Impact of the e-economy," TOYO KEIZAI INC., ISBN: 4492393242 (2000) in Japanese.

(2) S. Timacheff et al., "From Bricks to Clicks: 5 Steps to Creating a Durable Online Brand," McGraw-Hill Companies (2001).

(3) N. Idei, "Toward the Third Stage of the Digital Revolution," Nihon Keizai Shimbun, Inc., (9 Mar. 2000) in Japanese.

(4) "TECHNOTALK," *Hitachi Hyoron* **83**, pp. 392-393 (June 2001) in Japanese.

(5) P. J. Denning et al., "Beyond Calculation; The Next Fifty Years of Computing," Spring-Verlag (1997).

(6) Special Theme Issue on "ITS: Paving the Way for Mobility Services in the 21st Century," *Hitachi Hyoron* **82** (Sept. 2000) in Japanese.

(7) K. Inoue et al., "Offset Design for Congested Periods Using Simulations of Event-scan Methods," *Transactions of the Inst. of Electronics, Information, & Communication Engineers*, Vol. J81-A, No. 4 (April 1998).

(8) K. Yamane et al., "Development of VICS with Adaptive Parameter Tuning for Providing Traffic Information," ITS World Congress, Turin (2000).

(9) M. Watanabe et al., "Development and Evaluation of a Car Navigation System Providing a Bird's-Eye View Map Display," *SAE Paper* 961007 (1996).

(10) Y. Endo et al., "Development of a Three-dimensional Bird's-eye View Map Drawing Technique for Car Navigation Systems," *SAE Paper* 980605 (1998).

(11) Y. Fukunaga et al., "Trends in Three-dimensional Graphics and Technical Issues," *Journal of the Information Processing Society of Japan*, No. 34, Vol. 7, pp. 902-908 (July 1993).

(12) K. Machii et al., "Development of an Off-board Navigation System," *The Institute of Electrical Engineers of Japan* (Dec. 2001) in Japanese.

(13) T. Fushiki et al., "Arrival Time Prediction System Based on Floating Car Data in the Fleet Management ASP," 9th ITS World Congress, Chicago (2002).

(14) S. Suzuki et al., "A Distributed Control System Framework for Automotive Powertrain Control with OSEK Standard and CAN Network," 1999 SAE International Congress, 1999-01-1276 (Mar. 1999).

(15) M. Okude et al., "Investigation of an On-board Vehicle Information System for ITS," *Transactions of the Information Processing Society of Japan*, Vol. 42, No. 7 (July 2001) in Japanese.

ABOUT THE AUTHORS

Yasushi Fukunaga

Joined Hitachi, Ltd. in 1975, and now works at Hitachi Research Laboratory in the Research and Development Group. He is currently engaged in the research and development of ITS and other social infrastructure information control systems. Mr. Fukunaga is a member of The Institute of Electronics, Information & Communication Engineers (IEICE), The Institute of Electrical Engineers of Japan (IEEJ), and Information Processing Society of Japan (IPSJ), and can be reached by e-mail at fukunaga@hrl.hitachi.co.jp.

Akio Muko

Joined Hitachi, Ltd. in 1967, and now works at the Development Headquarters of the Automotive Systems. He is currently engaged in the development of ITS, vehicle-equipped and driving control systems. Dr. Muko is a member of SAE, The Society of Automotive Engineers of Japan, Inc. (JSAE), The Chemical Society of Japan, The Society of Polymer Science, Japan (SPSJ), and Japanese Liquid Crystal Society. He can be reached by e-mail at mukoh@cm.jiji.hitachi.co.jp.

Tatsuo Yoshioka

Joined Hitachi, Ltd. in 1972, and now works at the Public & Social Systems Division of the Total Solutions Division. He is currently engaged in the integration of roadside ITS and public infrastructure systems. Mr. Yoshioka is a member of IEEJ, and can be reached by e-mail at yoshioka@siji.hitachi.co.jp.

Yutaka Saito

Joined Hitachi, Ltd. in 1979, and now works at the Public & Municipal Systems Division, Power & Industrial Systems. He is currently engaged in the integration of roadside ITS and public infrastructure related systems. Mr. Saito is a member of IEEJ, and can be reached by e-mail at yutaka_saitou@pis.hitachi.co.jp.