Feature

Aiming for Passenger Interoperability

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Intermodal Transport and Interoperability

Offering comfortable mobility

It is now widely realized that information promotes movement and mobility. The recent development of broadband Internet services makes us to access a very large amount of information quickly and easily. Despite this easy access to information, the number of international meetings and conferences is still increasing, suggesting that when people get some information, they want to visit places and meet people. Even if some new information technology (IT) can handle smell and taste, it is doubtful that this basic human tendency to congregate would change. It seems that as people acquire knowledge, they want to travel to acquire more information.

Eliminating the inconveniences in changing the modes of transport is an essential part of providing our mobile society with pleasant and efficient travel. One of the advantages of using automobiles is a door-to-door convenience, but long-distance and overseas travel will always require changes of transport mode.

Several attempts were made in the past to facilitate changes between transport modes. Typical examples are flying boats and seaplanes that combine the functions of airplanes and ships, or road trains that create linked truck convoys running on roads, or train ferries that link trains and ships. However, such technologies have yet to become mainstream transport modes probably because our present-day transport modes have developed over many years into higher efficienfcy on the basis of core hardware technologies that have very little fundamental compatibility.

As a result, the concept of hardware-based intermodality between present-day transport modes may be flawed. But if we can offer people easy access to software-based effective information for smooth intermodal transfer, it will be possible to make travel on different modes of transport easier.
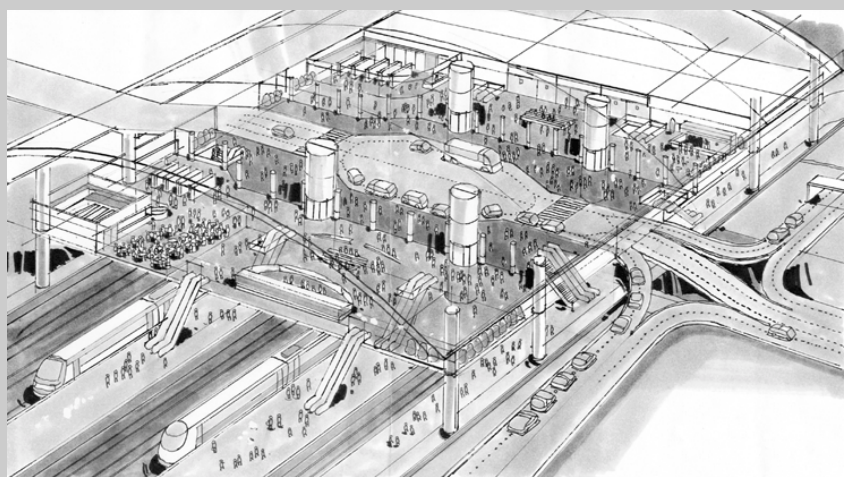
Interoperability

The aim of intermodal technology is to facilitate efficient and comfortable use of compatible transport modes. The CyberRail research project of the JR group is a software-based intermodal concept

for improving efficiency and comfort. Software offers a variety of options for supporting intermodal transport. Different countries, operators and manufacturers, therefore, will construct their own unique systems in accordance with the their own needs, business activities, profit levels, etc.

Looking at the various independently developed systems mentioned above, from the viewpoint of user interoperability (meaning that all passengers can travel through transport modes by one device and method), other barriers have arisen, forcing passengers to face other inconveniences until a globally unified system can be offered.

In these circumstances, it is most important to establish a general system with sufficient flexibility and openness for the anticipated various systems to assure user interoperability while meeting the individual requirements of localities and operators without undermining the principles of competition. It is becoming more-and-more important to develop software-based interoperability technologies that can meet new social needs by fusing the various hardware solutions into a comprehensive and effective whole.

What is CyberRail?

This section describes the CyberRail project as one attempt to support efficient and comfortable intermodal transport by offering passengers tailor-made and timely travel information.

CyberRail is a railway-related information business model that has been developed to facilitate passenger travel while improving the efficiency and business opportunities for railway operators. On the railway's side, the name CyberRail aims to give the impression of achieving intermodal transport through use of IT, but it also has a deeper potential

Artist's Image of Future Intermodal Transport Station

(RTRI)

relationship parallels with the road-based Intelligent Transportation Systems (ITS). In the current investigatory stage, we are examining an interface with road-based ITS. However considering the essential scope and ultimate functions of ITS, CyberRail seems most likely to ultimately become one important sub-system of ITS (see p. 34).

CyberRail concept

The basic concept of CyberRail is not to offer mass public transport centred on railways, but is instead to offer tailor-made transport choices.

Let us explain a scenario of this new concept, where IT is a key technology to offer potential railway customers a virtual assistant. A traveller would explain the purpose of the journey to this virtual assistant with various information including the destination, preference, budget, priorities, etc. In this example, perhaps the person would like to visit tourist resorts. The virtual assistant would then access the travel history and personal preferences of the person making and complementing the enquiry, and offer various suggestions based on preferred cost, duration and other conditions.

Travel planning is often a time-consuming process. If there are several potential destinations, the assistant could evaluate the timetables, booking conditions, overcrowding, etc., to propose suitable travel itineraries. Then the traveller could make a final decision based on budget and then ask the assistant to make the necessary reservations and virtually purchase the tickets. On the day that the journey starts, the assistant uses IT to become a virtual travelling companion who continually accesses the travelling conditions on all the transport modes so that the passenger can enjoy even the most difficult trip. Furthermore, if the passenger becomes bored during the trip,
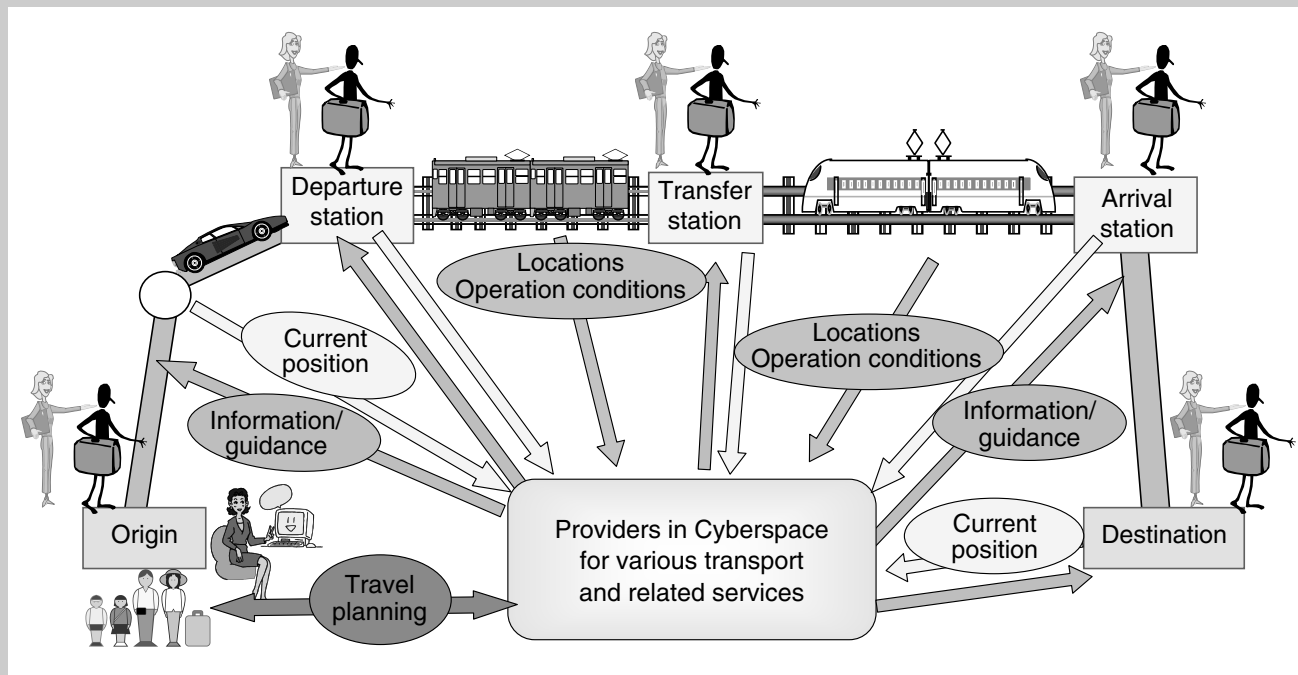
Changing from Mass Transport to Tailor-made Transport
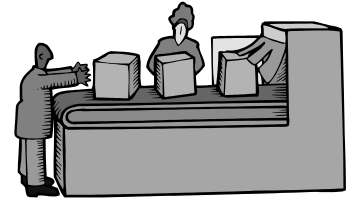
From mass to tailor-made transport

Travel by CyberRail

the assistant would give advice about entertainment, resorts, etc., or if the passenger wants to rest, the assistant would not disturb them unless absolutely necessary.

Other assistant services might include handling rebookings if a connection is missed, providing advice on shopping, restaurants, etc., or perhaps even on which shops have bargain sales.

If CyberRail is constructed as part of the social infrastructure, any service charge can be kept very low or even eliminated. The service might not only be for passengers—relatives might be able to use it to locate a passenger *en route* or to contact the virtual companion, etc. The higher level of travel safety and security might permit elderly passengers, young school students and foreigners who do not speak the local language to travel alone with more confidence.

Using IT

If this type of social infrastructure can be provided at very low cost or for free, there is little doubt that many more passengers will find public transport systems more convenient to use.

This type of information business model focused on railways and based on the future growth of IT offers benefits to both railway passengers and operators and it is an essential component in achieving an efficient and mobile society

If CyberRail-type systems become reality, all the business functions of today's railway stations will be handled by the virtual travel companion and the functions of today's railway stations will be refocused on providing a physical space for operating trains and making transfers between transport modes as well as a point of contact between travellers and cyberspace. These types of systems will act as a turning point in the actual and symbolic business model of railways.

Required systems

The virtual travelling companion function of the CyberRail system will require both a central and distributed IT system with duplex communications functions for providing and displaying information on various devices used by passengers, called tags.

In addition to data on the passenger's destination, travel objectives, travel conditions, personal attributes, etc., to guarantee up-to-date information on all aspects of the journey, the system will use data, to the system via tags, on the passenger's location, status, together with data from fixed ground points. As a result, virtual objects in an IT-based transport cyberspace represent actual objects within the real transport domain. The CyberRail system will use two-way communications technology between actual objects and cyber objects so that the movement of an actual object in real space will be mirrored in cyberspace to be traced constantly. As a result, in addition to the virtual travelling companion function, the CyberRail System will offer various information processing and control functions to information service providers in cyberspace, which gives railway operators the potential for growth and development of new business fields.

Necessity for Position Data

'What's the time?' seems completely different from the question, 'Where are we now?' However, time and position are fundamental elements when moving people and goods and they are also important parameters when considering the use of IT in transport systems.

In the early days, ships measured the movements of constellations by sextants chronometers to calculate their positions. In the modern era, we use artificial constellations consisting of 24 satellites to provide measurements of position on the earth's surface with an accuracy of centimeters. However, recently, an improved method to eliminate blind spots of Global Positioning Systems (GPS) has been proposed using additional so-called ground-based pseudolites that broadcast the same radio wave information as the GPS. As this method spreads, it seems likely to be able to track position with high accuracy even in underground spaces and in the radio-shadow of buildings that cannot be measured by conventional GPS. However, the computing power required to calculate position accurately using present-day technologies is quite large, a large battery capacity and preventing use of small hand-held units. Solution of this difficulty might bring the CyberRail system to the stage where it will be able to provide universal global positioning functions for anywhere outside and even in underground shopping malls.

Tracking moving objects

The mobile telephone is without doubt one of the most essential devices of modern times and functions for tracking position or predicting the next position to move are essential to manage mobile telephone systems. Mobile phones require a function for deciding the next service cell as quickly as possible during the movement through the overlap area from the current cell to another. Second-generation mobiles still get cut off if this function is unable to track the movement. For example, when using a mobile while travelling at high-speed on a shinkansen, if the train passes through the overlap area between cells too quickly, the handover time required for switching the service between the adjoining cells is insufficient and the call is cut off. Overcoming this problem requires widening the overlap between cells to provide a sufficient handover time.

The current car navigation system used in Japan makes some assumptions about the destination of the moving car. When the car navigation maps (including public transport routes) and the track of the moving body overlap, it becomes possible to make a rough assumption about the direction of the moving body. Although a system for finding the position of a moving body and detecting movement direction, used in the CyberRail system, is not yet completely implemented, the basic function is already being used by the society. To facilitate completion and usage of this technology at reasonable cost, the number of systems that use it should be increased, the functionality should be standardized and the installation and maintenance costs should be divided proportionally between the users.

Security and position information

Although position information is required to control and identify a moving body, to identify the moving body, it is also necessary to track it continuously. The system proposed by railway operators, is basically targeted at sales of travel services and products such as magazines, food and refreshments where tracking is even more important from the viewpoint of security of the payment system.

One of the most important problems for payment systems is credit card validation. In current systems, validation is performed by furnishing the system with validity data, which only true owner knows. The simplest way of validating the card is to use a personal identification number (PIN) but recently, systems using biometric parameters such as fingerprints, iris recognition, are appearing. This type of unique personal identification has a much higher reliability than password-based systems.

Tracking an object inspires another idea for security. Since a basic principle of physics dictates that a body cannot exist simultaneously at two points, if the position of a moving body can be tracked continuously, we can guarantee that the body is genuine at any time. We have proposed the following type of validation system based on this type of concept.

For example, when a new credit card is issued and mailed to the owner's address and then used by the owner, if it is tracked continuously, it is easy to confirm as genuine. And if the card is stolen, it can also be tracked. Of course, there are quite a few technical hurdles to overcome in implementing this type of system on a commercial basis, but theoretically such a system is highly likely to offer very good security. There might be fears of creating the same type of privacy problems as those described in George Orwell's novel *1984—Big Brother is Watching You*, but if the system is designed prudently, it offers a good opportunity of providing the added value of a credit validation system in a position-location system.
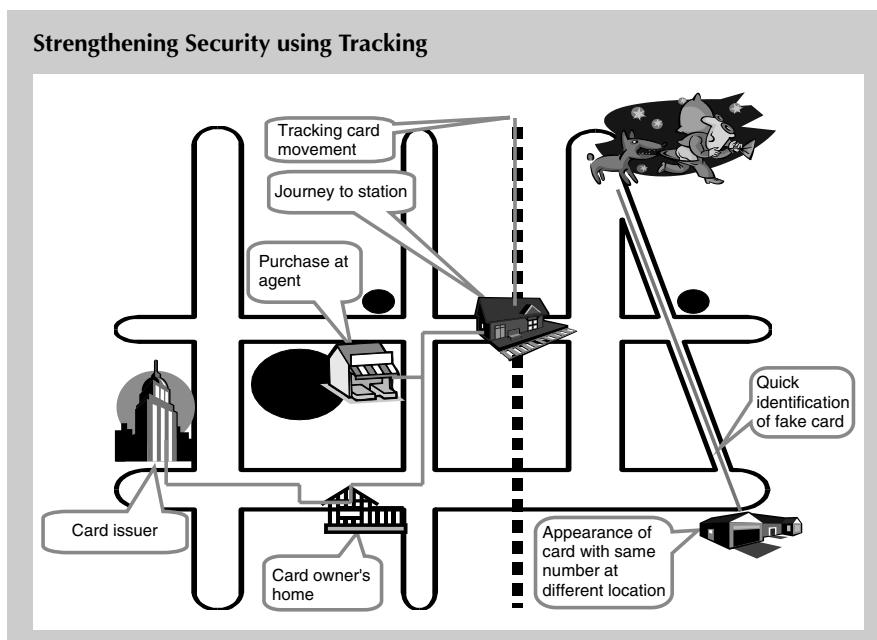
If position information can be obtained simply and cheaply, it will not only have genuine usefulness for portable telephones, but also have other useful applications such as credit validation systems and will expand the possibilities for CyberRail.

System Architecture

Architectures and standards

In adopting IT, railway operators have developed their own unique systems based on regional characteristics, cost performance and business concepts.

However, from the user's viewpoint, barrier-free and seamless functionality are the most important requirements when travelling on all the various types of public transport. In other words, the preconditions for establishing an ideal software-based intermodal transport system centred on railways include creation of a new business model based on improving transport efficiency, solving environmental problems, planning increased barrier-free mobility for elderly and disabled passengers, etc. To achieve these preconditions, railway operators and other transport providers will need to work together to guarantee smooth

Strengthening Security using Tracking

Tracking card movement

Journey to station

Purchase at agent

Quick identification of fake card

Card issuer

Card owner's home

Appearance of card with same number at different location

transfer of data between their various systems, including road-based ITS; this in turn demands global compatibility of data and communications systems.

However, standardization to ensure system compatibility is not an easy matter. The recent introduction of JR East's Super Urban Intelligent Card (Suica) is a good case study. The Suica can be used as either a commuter pass (season ticket) or as a stored fare (SF) card and it has an embedded microprocessor chip; it provides automatic passage through ticket wickets without removing the card from the wallet, card case, etc., simply by touching the card on the wicket mechanism. When using the Suica as a commuter pass, the card has a function for saving the owner's ID so that if the card is lost, it can be cancelled and a new card re-issued. When the Suica is used as an SF card, the passenger can add more money to the card when the stored fare runs out. More details of the JR East Suica system are described on pp. 20–27.

Suica is a very convenient and expandable business system and users welcome the system and wish the extension of the available area. However, planned participation in the expanded service area by non-JR companies' has been poor due to lack of interest in making the necessary capital investment, as well as due to the companies' different business strategies. It is quite natural for the different business strategies of companies to lead to the creation of different systems, but the end result for users is more inconvenience and dislike for the systems. We urgently need joint specifications and standardization that allow each company to adopt their business stralegies while securing user convenience through guaranteed interoperability.

The CyberRail concept uses IT to standardize the technologies planned for improving the usefulness of various transport modes. One of its most urgent research objectives is facilitating joint research into common specifications. Looking at the success of Hong Kong's Octopus card (see pp. 4–19), it seems likely that business strategies will be centred on non-contact IC cards. However, adopting open hardware and communications protocols, which suggests a need to examine the total system architecture for using IC cards, will most likely faciliate the spread of IC cards.

Open System Security

CyberRail is high-level wide-ranging system that raises important issues concerning security and cyber terrorism (hacking/cracking). Anticipated forms of cyber terrorism directed at a large-scale system can either aim to destroy the system, throw it into confusion, or obstruct the system functions. To secure the spread and stable functioning of the CyberRail system, we need R&D about hacking/cracking prevention and protection schemes, and fast recovery mechanisms.

CyberRail security R&D

CyberRail security requires the following policies on structure:

Key system safety
The key systems running on the CyberRail servers must be designed to be invulnerable to unauthorized entry by hackers. Since CyberRail is a true public access information system, there would be little necessity to protect the contents except the system administrative information, against unauthorized access by people. However, as there will be some costs associated with monitoring to prevent hacking and recovering the key systems, some protective measures should be taken. Achieving this will require examination and testing of the effectiveness of firewall programs.

In addition, another form of cyber terrorism could involve using high-power portable radio frequency generators to jam radio transmissions, meaning that the ability of CyberRail hardware to withstand this type of sabotage will have to be investigated.

Since businesses, such as ISPs, that form part of the CyberRail systems can also be adversely impacted by hacking and unauthorized entry, it will be necessary to investigate measures to ensure the security of their CyberRail data and business information.

Independent and stand-alone systems like the present-day Suica system do not present security problems to the CyberRail systems for the first iteration. However interfaces mechanism should be examined for the future data security. Finally, prior investigation is required to ensure the future compatibility of CyberRail systems, IC card systems and mobile telephones.

Preventing Web page hacking
Since the essence of CyberRail is a Web-based public information resource, similar to the key systems, there would be limited necessity to prevent unauthorized access to the CyberRail data. However, if information on the Web is maliciously altered or damaged, the CyberRail functions would be stopped or paralyzed, so preventive controls are needed. If incorrect information were to be supplied due to malicious alteration of CyberRail data, it would cause public damage. Consequently, there must be some method to constantly monitor the data validity and to recover quickly in the event of a system failure or malicious alteration by hackers. This will necessitate examination of countermeasures that do not hinder functionality but that do guard against any type of cyber attack.

Resisting business damage caused by bulk junk email

A recent social plague that damages Internet businesses is the sending of large volumes of unsolicited junk email (spam), requiring businesses to filter out spam. Since central servers of CyberRail use a different core communications architecture from that of general email accounts, spam is not an immediate threat. However, since the user interface will probably depends on mobile telephones or offer general access devices, we must investigate any possible impact. CyberRail might be attacked by spam and we need to test the extent of the impact on the system.

Security problems of Internet services by mobile phone

The CyberRail data communications will most likely be achieved using this type of mechanism. So far, Internet services by mobile phone have experienced no remarkable security problems but it is very important to counter any problems.
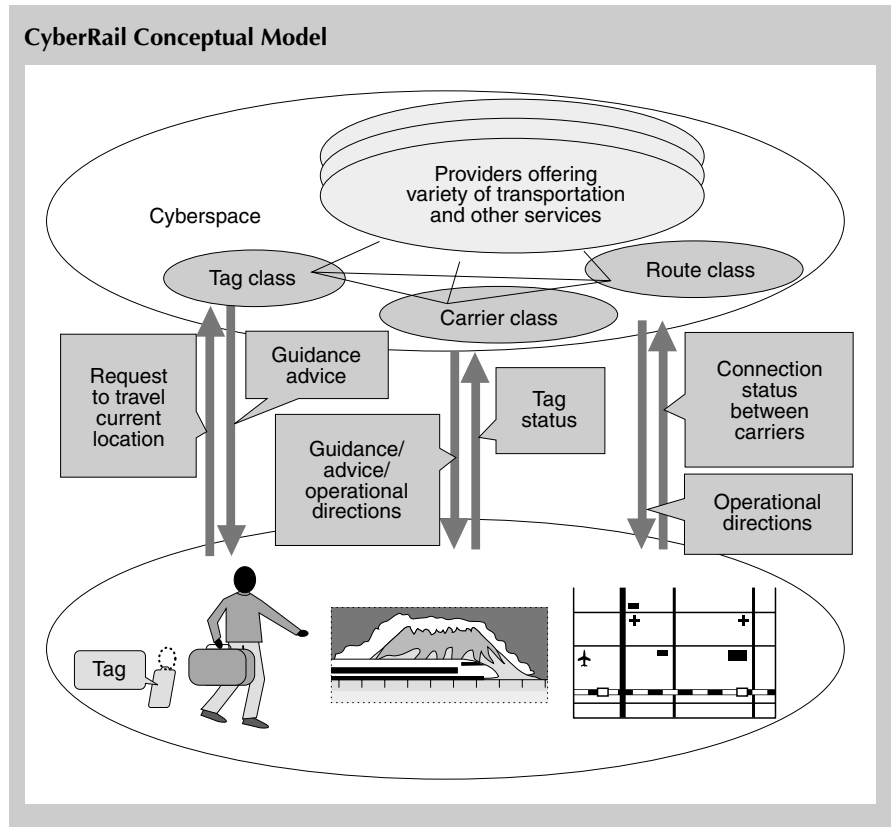
Structure of CyberRail System

Conceptual model

To facilitate smooth use of different public transport modes, it is necessary to know the transport demand and current position. There must be a constant communications link between the tag carried by the moving passenger and the virtual object representing the transport demand in cyberspace. The tag provides continuous updates on the passenger's status.

Basic classes of cyberspace

The cyberspace that comprises CyberRail is composed of the following three basic classes:

CyberRail Conceptual Model

Demand class (tag class)

This class is a mapping in cyberspace from the abstract object 'tag' in real space that represents its holders. Its attributes are movement demand, current position, profile, etc. The profile includes the preferences of the travel demand, the up-to-date history and other customer management information.

Carrier class

This class is a concept that is established as a precondition of intermodal transport in order to perform abstraction of automobiles, trains and planes on the same level. Its attributes include current position, status of passengers (tags) on carriers, status and condition of vehicles, maintenance data, etc. Looking at this model, it is possible to view the current road-based ITS as a system in which only a part of the carrier classes that the

individual driver/passenger has exclusive control is considered, that is, carrier classes that carry plural travel demands are excluded.

Route class

This class is an item composed principally of transport plans and control functions plus the management and maintenance status of roads, railway tracks and airplane routes. Consequently, its attributes are the route status of the carriers, meteorological data such as amounts of precipitation, maintenance data, etc.

Need for Future Cooperative Research

To summarize what we have learned so far:

• Application of IT to transport

engineering is welcomed by current providers of each transport modes. However, travellers' wallets are becoming stuffed with a variety of cards and almost everybody worldwide would like to see all these cards integrated into a single system.
- An essential part of the CyberRail research is the approach by railways to apply IT to all future transport modes as an integrated global system.
- Transport technology has two major fields—ensuring safe and smooth services plus user convenience. From the safety aspect, ensuring safe and smooth services requires a locally closed system and many operators have made substantial progress in applying this technology. Conversely, globally open technology is important from the viewpoint of travelling convenience.
- An important theme of present CyberRail research is what form of globally open integrated IT can be applied to future transport modes. As a consequence, Japanese transport operators and hardware manufacturers have formed the CyberRail Research Group, which now has a membership of 230 research workers from about 140 companies.

ITS intended to use IT to solve a variety of transport problems centred on roads. Although the current focus of ITS is transport as a whole, it has become targeted principally at solving the negative aspects of road transport. On the other hand, railways have played a leading role in IT research in the fields of railway operations, management and maintenance to make safe and smooth railway operations a reality. It is very much meaningful for railways to propose a leading system, which gives passengers a seamless and unified convenience through various transport modes, from a viewpoint of future global application of IT.

The CyberRail system models the general transport system particularly including 'human' users, based on the achievements of leading IT researchers, to provide an open system that covers multimodal and intermodal transport systems. However, railway-related organizations alone will clearly not be able to complete this work. The CyberRail Research Group has been established based on this concept to manage and systematize cooperation between the various research fields. Furthermore, to ultimately perfect a global system, R&D should not be limited just to Japan and volunteers are needed to manage the groups' English website (http://cyberrail.rtri.or.jp/English/) and open up the CyberRail concept for worldwide discussion. ∎

What is ITS?

Intelligent transportation systems (ITS) are comprised of a number of technologies, including information processing, communications, control, and electronics. Joining these technologies to transportation systems saves lives, time, and money by reducing the heavy traffic accidents and congestion. Although large-scale development and deployment of ITS is a true revolution in the way we think about transportation, ITS is anything but futuristic and actual systems, products and services are already at work worldwide in Japan, Europe and Australia. While advanced technologies have made many aspects of our lives more pleasant and productive, we still endure transportation systems whose primary controlling technology is the four-way traffic signal—a technology that has changed little since it was first invented. ITS enables people and goods to move more safely and efficiently through a state-of-the-art, intermodal transportation system.

Among other services, ITS technologies:
- Collect and transmit information on traffic conditions and transport schedules for travellers before and during their trips. When alerted to hazards and delays, travellers can change their plans to minimize inconvenience and additional strain on the system.
- Decrease congestion by reducing the number of traffic incidents, clearing them more quickly when they occur, rerouting traffic flow around them, and automatically collecting tolls.
- Improve the productivity of commercial, transit, and emergency vehicle fleets by using automated tracking, dispatch and weigh-in-motion systems that speed vehicles through much of the red tape associated with commerce.
- Assist drivers in reaching a desired destination with navigation systems enhanced by route guidance.

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