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Passenger Service Technologies

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Introduction

This article describes passenger service technologies on Japanese railways. The main topics are trends in seat reservation systems (especially for express trains), automatic ticket machines in stations, and automatic fare collection systems, such as automatic ticket checking machines. Ticket systems using contactless IC cards, which have the potential to revolutionize passenger services, are also described. Another recent topic is making railway facilities barrier-free in order to facilitate their use by elderly and disabled people. Some of these activities are also described.

Characteristics of Japanese Railway Environment

The decision about what passenger services to provide, and what technologies and systems to develop in order to achieve these services is closely linked to a country's railway environment. A distinguishing characteristic of Japan's railway environment is the existence of many railway companies (for example, the JRs and other publicly and privately owned railways), forming a complex network providing high-density, high-volume passenger transport typified by the metropolitan areas, especially Tokyo. Passengers commonly change between lines run by different companies to ride from a suburb well outside Tokyo, into the heart of the city, and then out to another suburb, all without ever stepping outside a station.

This kind of commuter network has developed in the major cities, but the JRs' high-speed shinkansen services on standard gauge also link major cities. The shinkansen lines are linked to narrow-gauge express lines at main stations, forming a railway network linking every major city in Japan. In addition to the JRs, most larger private railways also operate express train services with reserved seating. The JRs alone offer over 1 million reserved seats each day, and these seat reservations must be managed efficiently.

All entrances to Japanese train stations have ticket barriers, unlike many stations in Europe, the USA and elsewhere, where tickets are not checked between entering the station and boarding the train, with tickets being collected on board. However, with the exception of some low-traffic lines in rural areas, this method is not used in Japan, partly due to historical precedent and partly because on-board ticket checking is almost impossible during rush hours due to the extremely high density of passengers.

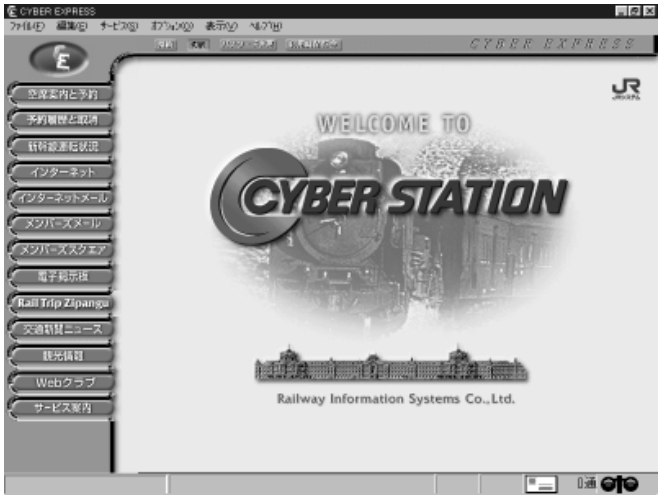
This environment makes speed and accuracy the first requirements for ticket reservation and automatic fare collection systems. If automatic ticket machines and ticket-checking gates are unable to perform as needed, stations would soon be in chaos. Companies in the JR group begin accepting seat reservations at 10:00 one month before the reservation day, and each day's reservation requests are transmitted from over 8000 terminals nationwide. The number of reservation requests is really high around the New Year and other holidays so the computer systems must be high performance and highly reliable or else glitches are reported on TV and in newspapers.

Platforms at Japanese stations are usually built level with the train floor, making it possible to board without having to step up or down. However, these platforms are rarely built at ground level, passengers must use stairs, escalators, and lifts to get from ground level outside the station to the platforms. If the station is elevated (over the tracks), the up and down walking distance becomes significant. This is a major problem for elderly and disabled passengers and even for passengers carrying heavy items. This problem is said

Old ledger-based ticketing system (JR Systems)

Latest MARS terminal for automatic seat reservation and ticketing (JR Systems)

MARS central computer room (JR Systems)



CyberStation home page providing ticketing information (JR Systems)

to be driving passengers away from trains to cars, so it must be solved if passenger services are to be improved.

Ticket Reservation System

The old ticket reservation system was run by people, telephone lines, and ledgers. When there was a reservation request for a train, the station staff would transmit the request to the office that managed the reservation ledger for that train by telephone. The person at that office would then look up the ledger for the train in question, and if there were seats available, would record the reservation in the ledger. If a seat was available, the station staff would hand-write a ticket. The photograph on p. 50 shows a turntable used to switch between ledgers quickly. Although this system was designed to allow more seating reservations to be handled, there are clear limitations on how far a manual system can be taken.

In the 1950s, the Japanese National Railways' research institute—the predecessor of today's Railway Technical Research Institute (RTRI)—began researching a computerized seat reservation system. An online system was built whereby computer-managed files replaced ledgers, and computer terminals replaced telephones, but at the time, there was nothing similar in all Japan. In fact, this system represented a world first. The research started with the most fundamental aspects of the system, including the computer hardware. As a result, the first ticket reservation computer made up of 12 terminals called MARS 1 was installed in the ticket office of Tokyo Station in June 1959. At that time, the system could only be used to make reservations and could not issue tickets, but it was subsequently improved, and when the Tokaido Shinkansen started operations in 1964, MARS 101, a full-scale system including automated ticketing, was put online.

Continuous improvements yielded increasingly better performance and when JNR was split up and privatized in 1987, the Railway Information Systems Co., Ltd. (JR Systems) took over operation and management of the system. The latest seat reservation system consists of MARS terminals and the central computer room issuing 1.5 million reserved and open-seating tickets each day. It also handles hotel reservations and tickets for a wide variety of events, and allows payment by credit card. The man-machine interface using touch screens was designed to allow operators to conduct many complex actions quickly. There are also machines in stations that can be operated directly by passengers. JR Systems Co., Ltd. also allows passengers to access train ticket information from their home computers.

Automatic Fare Collection System

In the past, tickets were issued by station staff from ticket windows, and tickets were checked by a guard at the ticket barrier. Ticketing and ticket collection are now mostly handled by machines in order to improve efficiency and free employees from this laborious task. Ticket sales were automated first. Currently, almost all tickets except reserved seats, long-distance tickets, and special discount tickets are sold by automatic ticket machines. Early machines could only sell single-fare tickets, but they were improved and one machine can now sell many different fares. Similarly, the first machines could only accept coins, but they can now handle banknotes of all denominations. When a passenger inserts money into the machine, every button for less than the inserted amount lights up. When the passenger presses a button, the ticket is issued and change is given if the inserted money exceeded the fare. However,

before using this type of ticket machine, the passenger must look up the cost of the ticket on a fare chart. More recently, a touch-screen interface is used to reduce the burden on the passenger by allowing passengers to choose stations rather than monetary amounts. The photograph below shows this type of automatic ticket machine, operated by JR East. There is also a prepaid fare system that frees passengers from the need to purchase tickets. With this system, the passenger inserts a prepaid card into the automatic ticket gate at boarding and the fare is deducted automatically later when the passenger passes through the exit gate. There are also extremely popular stored fare (SF) cards that can be used on lines of several railway companies.

As mentioned earlier, in Japan, tickets are checked at the ticket gate. Any automatic gate to take the place of human ticket checkers must be able to handle large passenger volumes accurately and quickly. Automatic ticket gates were first used widely in the 1970s, mainly by private railways in the Kansai region. The information on the ticket must be machine-readable, so systems of punching holes and magnetic bar-code systems were tried, but the final system settled on using a magnetic coating on the back of the ticket to store information.

Japanese ticket gates are set up so that passengers insert their tickets while walking through the barrier. When the passenger inserts a ticket on the near side, a belt carries it through the machine to the point where the information is read. After determining the ticket validity, the machine writes necessary information on the ticket, and if the passenger requires the ticket for further parts of the journey, another belt carries it to the far side of the barrier to be taken by the passenger. If the ticket is invalid, a barrier blocks the way, preventing the passenger from passing. In order to speed up passage through the gate, two tickets can be inserted in quick succession. The machines can also recognize and handle commuter passes and SF cards by the size and information stored on them. Moreover, passengers can insert tickets either face-up or face-down, forwards or backwards.

JR East automatic ticket vending machine (JR East)

Contactless IC Card System

The automatic ticket-checking system described above is a showcase of leading-edge technology, but has the following problems:

- Before adoption of automatic ticket-checking machines, passengers only needed to show their commuter passes to station personnel, but now they must remove the pass from its holder and insert it into the machine.
- Because the passenger releases the ticket and picks it up at the other side of the ticket barrier, passengers may mistakenly take other people's tickets.
- The high-performance machines cost a lot of money and have many moving parts, making maintenance very time consuming.
- The tickets do not have a very high level of security. Since information is stored in a magnetic strip, anyone with specialized knowledge can read (and change) the stored information.

Latest magnetic automatic ticket gates (JR East)

Design of contactless IC card (JR East)


Contactless IC card in field testing (JR East)

R&D on a new automatic fare collection technology—the contactless IC card—aims to resolve these problems. These cards have an embedded IC chip that can store vast amounts of data. Since these cards have their own data processing functions, they are also called smart cards. Ordinary IC cards have a contact that is used to transfer data, but contactless IC cards communicate with the automatic ticket-checking machine via an embedded antenna, obviating the need for contact. This type of card allows passengers to pass through the automatic ticket-checking machine while holding their cards. The card security is also vastly improved, because third parties cannot easily read the information contained in them. And because they can store large amounts of information, they can more easily be used to begin new business services as well as be put to non-railway uses.

R&D mainly by RTRI and JR East on ticket-checking machines for contactless IC cards has been underway since the JR group was first established in 1987. Several prototype cards and ticket checking machines have been made, and evaluated by JR East employee monitors several times. The first real-life test was in 1992 at Ueno Station. JR East went on to develop ever more successful systems, making it feasible to meet the stringent requirements of Japanese railways. The company plans to commercialize the cards in 2001. The automatic gates used in tests can handle both magnetic tickets and contactless IC cards. The new contactless Super Urban Intelligent Card (Suica) combines a commuter pass and an SF card into one. When a passenger travels outside the section covered by the commuter pass, the ticket gate automatically calculates and deducts the excess fare from the SF part of the card. This enables replacement of the present fare adjustment machines that must be used to purchase a separate excess fare ticket.

Use of contactless IC cards will not only make tickets easier to use, it will also reduce the number of mechanical parts, making automatic ticket-checking machines simpler and reducing manufacturing and maintenance costs. Although some way off in the future, passengers will be one-day able to use a single card to ride on trains and buses, paying fares with electronic cash. This type of system depends on reliability and security and the contactless IC card is well suited to this purpose.

Barrier-free Access

Most Japanese train stations cannot be accessed without some vertical movement. This is a huge impediment to people with physical disabilities. Moreover, many stations do not have sufficient room to retrofit elevators or escalators without altering the construction of the building at great cost. However, awareness of the need to create a barrier-free environment has increased recently and subsidies from national and local governments have given a great boost to station improvement. New types of lifts have been developed for stations where it would be impossible or prohibitively expensive to construct normal elevators or escalators. The photo on p. 54 shows a lift that can be installed

on stairs to carry a wheelchair up and down. It is designed to fold away when not in use, keeping out of the way of people passing on foot. In addition, an escalator has been developed that can extend three steps horizontally flat if the mode is changed, allowing wheelchairs to be carried safely.

Another indispensable service for passengers is information. Japan's urban railways have a mind-boggling number of lines and fares, sometimes confusing people unused to the system who are trying to figure out how much it will cost to get to their destination as well as how to get there. In addition, complaints are sometimes heard that accurate information is not given when there are delays or other problems. Railways have installed a variety of signboards and computerized display screens in response to these problems, and various improvements have been made, including linking computerized display screens directly to the transport management system, in order to provide information instantaneously. And as the personal computer makes its way increasingly into the home and office, software is appearing that calculates optimum routes and fares. However, even with all these improvements, information services are still far from perfect.

Until now, all railway information was only announced or displayed on screens; passengers have to listen to or view all this information, and select the information relevant to them. This type of system makes it nearly impossible to provide the kind of attentive service that will gain passenger satisfaction. The best choice would probably be to give everyone individualized guidance, but it is not possible for station employees to attend to every passenger individually. We feel it is necessary to develop machines and computer systems that give individualized guidance with a conversational interface, even though they may not function as well as a person. A guide system for visually impaired people is currently being developed by RTRI (Figure 1). Since information is often presented visually, people with impaired vision often have a difficult time getting information. With this system, IC chips programmed with location information are embedded in tactile tiles used to mark paths for visually impaired people; this information is read by a cane with an embedded antenna, and verbal directions are given by a pocket-sized portable machine. For instance, if the user tells the device 'I want to take a train to Tokyo', the machine will guide him or her to the right platform by voice instructions. The machine can also be used to inform the person of their present location. We are also looking into equipping the machine with a wireless device that can pick up information from trains and tell the user whether to get on a particular train arriving at the platform. We plan to continue our research in order to extend this service to provide personalized information to people with other disabilities, and to ordinary passengers as well.

A holistic approach to a barrier-free environment is universal design—in this concept, barrier-free does not mean providing facilities for specific types of

Stair wheelchair lift (JR East)

Latest computerized timetable display screens (JR East)

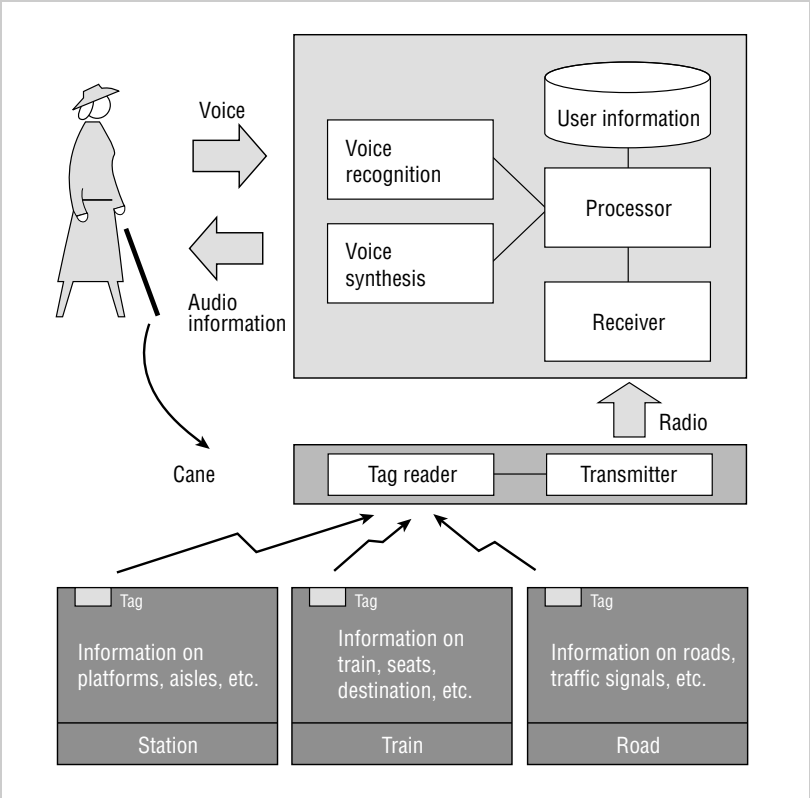
Guide system for visually impaired persons (RTRI)

people, but instead aims to design stations that are easy to use for everyone. Japanese train stations still have a lot of construction and environment issues, but I think we are making rapid improvements in these areas.

Conclusion

This paper has outlined passenger service technologies on Japanese railways. These services are closely intertwined with new information technologies, and the breakneck pace of change will transform railway passenger services in many ways. Japan's railway engineers are working to contribute to society by making railways even more passenger-friendly. ■

Figure 1 Guide System for Visually Impaired Persons



(RTRI)

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