COSMOS (computerized safety, maintenance and operation system of the Shinkansen)
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Abstract

We have developed and begun to use a new integrated computer system named COSMOS for the operation and management of the Shinkansen. The trigger to have developed this system was that the previous computer systems named COMTRAC and SMIS became out of date so that they could not cope with the extension of the Shinkansen network. However, we did not simply intend to replace these systems. Taking advantage of the latest computer and communication technologies, we have aimed at restructuring of the whole work on the operation and management of the Shinkansen in this opportunity.
1 Introduction

The Shinkansen network in East Japan Railway Company (Fig. 1) has extended and is still now extending. In 1982, we have begun commercial operation of Tohoku Shinkansen from Omiya to Morioka (500km) and Joetsu Shinkansen from Omiya to Niigata (300km). Afterward, this network has been extended from Omiya to Tokyo (30km). We have restarted operation of a conventional line from Fukushima to Yamagata (90km) in 1992, that was renewed from narrow gauge to standard for a direct link to the Shinkansen network (The first mini-Shinkansen). We have opened the second mini-Shinkansen from Morioka to Akita (130km) in the spring of 1997. Also, we have begun to operate full size Nagano Shinkansen between Takasaki and Nagano (120km) in October 1997 followed by the Nagano Winter Olympic Games in 1998. Other than the extension of the Shinkansen network, we have made our Shinkansen substantial by adopting the following measures. We have developed new types of train sets (400, E1, E2 E3 and E4 series). Also we have opened new railway stations on Tohoku Shinkansen. Furthermore, we have increased maximum speed from 210km/h to 275km/h. As a result, passengers have increased and our Shinkansen network has been established as safe, speedy and comfortable transport system.

The previous computer systems named COMTRAC (COMputer aided TRAffic Control system) and SMIS (Shinkansen Management Information System) had contributed so much to the operation and management of the Shinkansen. However, there arose the following six

Fig.1 The Shinkansen network in East Japan Railway Company
problems in these systems because they had already been out of date. First, they had been unable to cope with the extension of the Shinkansen network to Nagano and Akita. Secondly, they had been unable to deal with the increase of new transport patterns such as speedup, headway cut, coupling and uncoupling at branching stations. Thirdly, we had been unable to make good use of data on rolling stocks and infrastructures for the maintenance because of a lack of systematic database. Fourthly, transport planning and data input had been performed still by hand. Also, the notification of these information to railway stations had been carried out by telephone or paper. Fifthly, staffs in railway stations had not only dealt with passengers but also involved themselves with the operation of trains and the management of maintenance work. Lastly, the dispatch system of the management on infrastructures had been inefficient because it had consisted of three layers of stations (A central dispatch station, five local dispatch stations and several tens of maintenance stations). In order to overcome these defects, we have developed a new integrated computer system named COSMOS for the operation and management of the Shinkansen.

2 Target of the COSMOS

In the development of this system, we did not simply intend to replace the previous systems. We have aimed at restructuring of the whole work on the operation and management of the Shinkansen in this opportunity. We have surveyed what kinds of work could be systematized. Taking advantage of the latest computer and communication technologies, we have developed an advanced operation and management system that is suitable for the 21st century. This is the ultimate operation and management system for the long-distant, high-speed and small-headway railway.

We have aimed at realization of the following subjects in the development of this new system. The first subject is authorization of the central dispatch station and shutdown of the local dispatch stations. We think trains must be operated only by onboard train crews and dispatchers in the central dispatch station. Also, schedules on maintenance work have to be managed only by dispatchers in the central dispatch station and staffs in maintenance stations. Moreover, we should prepare database on the train operation and the maintenance management, that are commonly shared by dispatchers and maintenance staffs. Furthermore, man-machine interface of the new system has to be easy to understand and easy to treat for dispatchers by taking
advantage of the graphical user interface. The second subject is systematization of the operation and management work. We should systematize transport planning work and automate notification of train schedules to railway stations and crew stations. Also, we should prepare roll calls and riding plans automatically for crew stations. Moreover, staffs in railway stations should concentrate on treatment of passengers. They should not be involved in the train operation or the maintenance work. Furthermore, we should systematize management of schedules on the maintenance work. Also, we should introduce a programmed route control (PRC) system and a job schedule management system in each depot. The third subject is improvement of information service to passengers. We should offer appropriate information on train operation to passengers. Also, we should offer information on delay quickly in case of some troubles.

In order to meet these requirements, we have designed reasonable system structure regardless of the previous one. The new system consists of the following eight subsystems.

1. Transport planning system
2. Traffic control system
3. Rolling stocks management system
4. Infrastructures management system
5. Maintenance work schedule management system
6. DECS (Electric power supply control system)
7. CMS (Centralized information monitoring system both for signaling and communication devices and for wayside disaster detectors)
8. Depot system which consists of a local PRC system and a job schedule management system

3 The traffic control system of the COSMOS

This subsystem aims at the following three functions. The first one is automatic route setting for trains and automatic information service to passengers. The second function is train operation only by drivers and dispatchers in the central dispatch station even in unusual case. The last one is management of the maintenance work on infrastructures only by dispatchers in the central dispatch station and staffs in maintenance stations.

In order to realize these functions, we have adopted the following hardware structure in this subsystem. In our design, we
have regarded as important reliability, flexibility to extension and easy maintenance. The first feature is the decentralized system. We have aimed at minimization of response time and flexibility to extension. We have chosen to adopt a decentralized PRC system which consists of a supervision system in a central LAN and PRC system in each railway station and depot. The supervision system consists of dual computers so as not to reduce operation efficiency. The PRC system in the railway station consists of dual train schedule management computers, triple interlocking computers and dual interfaces to signaling devices. The supervision system send train schedules to every PRC systems. Each PRC system keeps two days of train schedules on that station. According to these schedules, the PRC system automatically sets a route for each train and automatically announces and displays arrival and departure information to passengers. Even if there are troubles in the communication lines, isolated PRC system continues to set routes for two days. The second characteristic is the network structure (Fig. 2). We have adopted high transmission rate (100Mbps) optical fibers as a local area network (LAN) of the central computer complex. Each subsystem is connected with the other through this LAN. We have also adopted a set of gateway computers on the LAN. Each PRC system in railway station is connected through high-speed digital exclusive telephone line (64kbps) from these gateway computers. We have also prepared high-speed digital public exchange telephone lines (64kbps) as a backup. Thirdly, we have determined to use standard devices. We have adopted standard computers (UNIX workstations etc.) and standard networks (Ether-net, RS485 etc.) for cost down, easy maintenance and future extension. Lastly, we have adopted a health check system and remote maintenance methods. The computers in the traffic control system are widely distributed both in the central LAN and many railway stations and depots. We have prepared a health check system for these computers. Also we have adopted remote maintenance methods for the software on these computers.

The supervision system in the central LAN has the following functions. In the central dispatch station (Fig. 3), there are two types of graphic terminals for the supervision system. One shows train positions and wayside disaster information (Fig. 4, 5). We had used a large panel for this purpose instead of video terminals in the previous system. The other shows diagrams that enable dispatchers to rearrange train schedules easily (Fig. 6). Dispatchers grasp real-time situation through these terminals. In the previous system, all of the work for rearrangement were
Computers in Railways

Fig. 2 System structure of the COSMOS

Fig. 3 The central dispatch station of the COSMOS
Fig. 4 Picture on graphic terminal: Joetsu Shinkansen gross view

Fig. 5 Picture on graphic terminal: Ueno station enlarged view
performed by hands. In the present system, the supervision system automatically predicts a new schedule and displays it on the terminal in case of delay. Dispatchers have only to check and approve it. By this automatic prediction system, a recovery time has been reduced by about 30%. Furthermore, we have added the following two functions in the present system. Temporary speed limits are set by the central dispatchers while they were set by station staffs in the previous system. Other than ATC routes, points and wayside signals for shunting can be also controlled by the central dispatchers in the present system. Both transport dispatchers and infrastructure dispatchers stay in the same room and share same information in order to respond quickly to any troubles.

The PRC system in the railway station has the following three functions. The first one is route setting for trains and maintenance cars. During the operation period, this system automatically set a route for each train according to the train schedules. During the maintenance period in the night, maintenance staffs directly switch points themselves with a help of portable wireless terminals. The second function is information service to passengers. Based on train schedules in the PRC system, this system automatically displays arrival and departure
information on indicators and announces them to passengers. In case of delay, information on delay is displayed on indicators. The last function is control on stopping position indicators. Stopping position for each train set in the railway station differs according to its composition (5, 7, 8, 10, 12, 13, 15, 16 and 17 cars). We have prepared stopping position indicators for drivers and control them to show where to stop.

4 The other subsystems in the COSMOS

First, we start with the transport planning system. This subsystem helps us to make core, weekly, seasonal and temporary transport plans and helps us to determine rotation of drivers, conductors and train sets. Based on a long-term maintenance schedule on rolling stocks, this subsystem also helps us to assign train sets to the transport plans. This system automatically sends train schedules to railway stations and also sends roll calls and riding plans to crew stations. Onboard salespersons and cleaning staffs also make good use of this information. Train schedules are also used to make schedules on the maintenance work and electric power feeding. The operated results for all rolling stocks are accumulated and statistical treatments are performed every day. Theses results are used for the management of the maintenance on rolling stocks and infrastructures. Secondly, we explain the rolling stocks management system. In order to modernize the management of the maintenance work on rolling stocks, we have developed a subsystem to manage components stock, inspection history and troubles on all rolling stocks. The central system manages inspection history, troubles and treatments on rolling stocks as on-line data that are shared in all the depots. The local system in each depot manages jobs and components stock as a local information. It is available to transfer data on the local system between depots. Accumulated data are used to make maintenance schedules. Thirdly, we mention the infrastructures management system. This subsystem consists of a central system and local systems in maintenance stations. The local system manages databases on maintenance history of infrastructures. The central system treats data from inspection train named "Doctor Yellow" and sends them to maintenance stations. In each maintenance station, staffs issue maintenance work based on these data. Both head office and branch offices share these databases through network. Fourthly, we refer to the maintenance work schedule management system. Schedules on maintenance work are
registered on a terminal in each maintenance station. They are stored on the maintenance work management system in the central LAN. Maintenance workers send proposals and receive permissions at the beginning and at the end of their maintenance work through portable wireless phones from the wayside. They are checked automatically. Dispatchers are able to communicate directly with maintenance workers through these wireless phones. Fifthly, we note the DECS (Electric power supply control system). This subsystem monitors and controls transformer substations and manages electric power feeding schedules. In the previous system, this system consisted of a central and five local dispatch stations. The local dispatch stations controlled each transformer substation and the central station only monitored and managed these local stations. In the present situation, the central station directly controls transformer substations in Tokyo area and in Nagano Shinkansen. In near-future, local dispatch stations will be eliminated. Sixthly, we touch on the CMS (Centralized information monitoring system). We have developed a centralized monitoring system both for signaling and communication devices and for disaster detectors. Through exclusive lines, this subsystem monitors ATC signal levels, actions of inter-locking devices and information on winds, rains and earthquakes along the wayside. Both transport dispatchers and infrastructure dispatchers share these information. Lastly, we introduce the depot system. Based on train schedules on the main lines and maintenance and cleaning plans on rolling stocks in each depot, this subsystem helps us to determine job schedules in each depot. The depot PRC system automatically set routes for incoming or outgoing trains. Depot drivers set routes themselves for shunting with a help of portable wireless terminals.

5 Brief construction history of the COSMOS

We have organized a project team and begun to develop the COSMOS in December 1990. We have started construction in the summer of 1992. We have accomplished traffic control system of Tohoku and Joetsu Shinkansen in the spring of 1995. We have started to operate this system on 10th, November 1995. We have continued to construct the COSMOS for two more years. We have installed a new system that was improved for the opening of Akita Shinkansen in January 1997. We have experienced a large scale of system change for the inauguration of Nagano Shinkansen in June 1997. We have finished to introduce the last (fourth) depot system in January 1998. The COSMOS has been accomplished.