Overview of the Development of a Transport Work Support System

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Improving transport stability is an important theme to strive for in “heightening customer satisfaction even further” in the JR East group management vision, “JR East 2020 Vision—Challenge—”. It is a major theme that goes beyond divisional boundaries.

With an aim of improving transport stability, the Research and Development Center of JR East Group has developed a system that supports early recovery after train service disruptions. We have collectively developed an operation rescheduling system that supports planning of train schedule changes, a vehicle and crew operation rescheduling support system that supports operation management changes of vehicles and crew and an operational notice transmission system that transmits operational change information.

This article will give an overview and cover features of those systems and introduce the connections between the individual systems.

1 Introduction

Transport-related systems that JR East has developed and put into practical use are the Integrated Railway Operation System (IROS) that prepares, transmits and manages the transport plan, the Autonomous decentralized Transport Operation control System (ATOS) that handles transport management for the greater Tokyo area and Programmed Route Control (PRC) per line or section for conventional lines outside the greater Tokyo area. For the Shinkansen, too, we have put into practical use COMputerized Safety Maintenance and Operation Systems for Shinkansen (COSMOS) that has both transport planning and transport management functions. Those systems are used in schedule revision and day-to-day train operation, bringing about major improvements in how transport work is done.

One of the important functions of transport-related systems is to support quick recovery to the normal schedule in case of train operation disruptions such as accidents. But such support work is unfortunately not yet sufficiently systemized.

We have thus developed systems to minimize the effect on passengers and restore to the normal train schedule as soon as possible in operation disruptions.

Systems developed include an operation rescheduling system that deals with train schedules, a vehicle operation rescheduling support system that deals with vehicle scheduling (assignment of vehicles), a crew operation rescheduling support system that deals with scheduling (onboard duties) of drivers, conductors and other crew members and an operational notice transmission system that transmits scheduling change information.

Some of the systems are already in practical use, and the remaining systems are entering the final stages of development.

This article explains “transport planning” and “transport management”. It also gives an overview of systems that support transport work at JR East.

2 Transport Planning and Transport Management

2.1 Transport Planning

Transport planning consists of timetabling (train timetable) as the core of planning, as well as work such as vehicle scheduling planning, crew scheduling planning and yard work planning. We collectively call those “transport planning” (Fig. 1).

Especially, train timetables are products for railway business, and the quality of the timetable greatly affects use by passengers. To prepare the timetable, we use the scheduling system of IROS. Branch office planners prepare the vehicle operation plan and the crew operation plan in addition to the train timetable in an interactive format on a monitor screen. With systemization, train data, vehicle operation data and crew operation data of all lines of the JR East operation area have been compiled in a database where those are managed in a consolidated manner.

A subsystem that delivers the prepared transport plan to crew offices, stations, maintenance depots and other locations is the schedule transmission system. In the past, the information of the transport plan was distributed to sections and depots involved as printed material called the “instruction paper for train operation”. Systemizing enables work such as extracting data, and it also enables output of forms that were prepared manually in the past.

2.2 Transport Management (in Normal Operation)

The transport plan prepared with IROS is transmitted to ATOS...
and PRC transport management systems along with the daily train timetable and vehicle operation data.

Transport management systems add data required for entry to and exit from locations such as stations and depots based on that timetable and vehicle operation plan data. They also prepare daily route control data.

In normal operation, cars and crews are thus arranged based on the transport plan made out by branch offices. At stations, devices connected to the transport management system control routes for train operation

3.1 Operation Rescheduling
In normal operation, routes are controlled and trains are operated as specified by the timetable. But in accidents or mechanical failures, trains stop and operation is disrupted.

The dispatcher’s office makes changes in the transport plan according to the situation, such as issuing instructions to turn back at a certain station or cancelling operation of some trains to secure transport capacity at the time. After restarting operation, it prepares a changed plan to return the operation schedule to normal as soon as possible. We call this work “operation rescheduling”.

In current operation rescheduling work, dispatchers collect information such as on the severity of the accident, the passenger congestion level and the on-site situation, and they prepare rescheduling proposals in a short time based on experience and knowledge. At the same time, they coordinate vehicles and crew schedule planning with personnel such as individual dispatcher’s office and depots involved, and they input finalized changes in the transport management system. Inputting those changes instantly revises the train timetable. Based on the changed timetable, route control and guidance displays of individual stations are automatically changed too.

Such timetable change data is not automatically delivered to stations and crew offices, however. Rather, it is transmitted by dispatchers via means such as fax from the dispatcher’s offices.

This situation demonstrates that operation rescheduling is conducted based on the experience and knowledge of dispatchers. At present, support and proposals by the system are not made (Fig. 2).

3.2 Operational Notice
When changes such as route and track change or turn-back occur for running trains due to operation rescheduling, these changes have to be notified to the drivers and conductors. We call this “operational notice”. Stations receiving instructions prepare “operational notice cards” based on the change information received via means such as fax from the dispatcher’s office, and they hand the cards to the crew members of the trains involved. On lines without personnel to do that job, operational notice is done via train radio. In both methods, time and labor is required for jobs such as entering “notice receipt cards” or for confirming the change by verbal repetition.

3.3 Vehicle and Crew Operation Rescheduling
When the train timetable is changed due to operation rescheduling, the scheduling of vehicles and crew is changed greatly from the original schedule. We call the arrangement for the quick return of the vehicles and crew to the original plan the “vehicle and crew operation rescheduling”.

Crew offices prepare the change proposal for onboard duty route based on the change information sent via means such as fax from the dispatcher’s office and instruct that change to the crews involved by means such as telephone. At the same time, the operation schedule for the new train that the crew will be serving aboard is sent via fax to the crew standby location for long-distance commuter trains. We call such work for crew “crew operation rescheduling” and for vehicles “vehicle operation rescheduling”. At present, dispatchers and persons in charge at crew offices do this work in cooperation and coordination, but no support or proposal is given by the system.

4 System Support for Early Restoration to the Normal Timetable

As previously explained, we currently perform transport work ranging from transport planning to day-to-day transport management using the system in normal operation. But, once operation disruption has occurred, almost no system support for restoration to the normal timetable is given. Dispatchers prepare rescheduling proposals, input those to the devices for transport management and inform concerned depots of the changes. The situation is also the same at other railway companies.

In order to recover from operation disruption earlier, we must quickly and appropriately implement the following five jobs.
1) Accurately identify the on-site situation
2) Prepare the rescheduling proposal appropriate to that situation
3) Confirm the arrangement of vehicles and crew according to the rescheduled timetable
4) Input the rescheduling proposal to the devices for transport management
5) Quickly transmit the change information to persons and sections involved

We have thus conducted development of an early operation restoration support system to find solutions to enable those jobs.

We have already developed an operation rescheduling system to support operation rescheduling work of dispatchers, a vehicle operation rescheduling support system and a crew operation
rescheduling support system to support such rescheduling work based on timetable changes and an operational notice transmission system to support operational notification such as on changed timetables and operation control. The following gives overviews of the individual systems and introduces features of them (Fig. 3).

4.1 Operation Rescheduling System

When the train schedule is disrupted due to rolling stock failure or injury accident, dispatchers have to make many operation rescheduling arrangements in a short time. In places where many trains are operated such as in the greater Tokyo area, schedule recovery to normal will take even longer without appropriate and quick operation rescheduling.

Thus, in order to restore the timetable to normal, we often use methods such as canceling trains and turning back trains before reaching the end of the line to make up for the delay.

While canceling and turning back many trains allows quicker restoration to the timetable, many passengers have to wait long at stations and trains become highly crowded. That increases dissatisfaction of passengers. Moreover, time required for getting on and off at stations takes longer, in fact worsening the delay.

In this context, we have to rely on the knowledge and skill of experienced dispatchers in operation rescheduling to determine which trains at which stations to reschedule by canceling and turning back trains.

We have already developed a system to support operation rescheduling work of dispatchers. The system provides the support by means such as forecasting the timetable a few hours in the future according to the timetable results accumulated in the PRC system and displaying a warning for locations that might be a cause of longer delay based on such forecast.

Such a support system that displays limited warnings can solve the delay at a specific time and location. But arrangement by the system sometimes causes other delays at other locations, increasing overall delay. This is because the system can determine arrangement for early timetable recovery only based on rationality of a particular part; it does not take into account the overall timetable.

Moreover, the train timetable can be implemented only when vehicles and crew are available. An operation rescheduling proposal that does not take into account scheduling of those trains and crew could not stand as operation rescheduling and may have been redone. In some cases, such loss of time by redoing the proposal even worsened the delay.

We have thus proceeded with development of a system that supports operation rescheduling planning and that works in conjunction with the vehicle and crew operation rescheduling support system.

This system is characterized by it taking into account the following.

1) Operation rescheduling adjusted for use by passengers
   - Taking into account transport volume at the time of day based on the passenger volume of each train
2) Operation rescheduling based on the policy of dispatchers
   - Function to designate the time to timetable restoration
3) Operation rescheduling that takes into account scheduling of vehicles and crew
   - Checking vehicle inspection and lines on which drivers are approved to drive
4) Operation rescheduling planning from operation restart to timetable restoration
   - Total operation rescheduling planning instead of partial planning

With those advantages, the system can suggest overall well-balanced operation rescheduling plans (Fig. 4).

4.2 Operational Notice Transmission System

The operational notice transmission system is a system to automatically prepare information required for operational notification and to display that on the cab monitor of the trains involved without manual work. That task is done based on the change information input to ATOS for operation rescheduling. A major feature of the system is ability to monitor whether or not trains receive the transmitted information and crew members read that information. Furthermore, the system can give warnings when necessary to ensure that information is transferred and that the crew checks the information. We have also developed a function to call attention of drivers to the cab monitor using a function to prevent operational notices from being overlooked. Attention is called before reaching the location where the notice is issued based on the importance of operational notices.

This operational notice transmission system was gradually deployed in the greater Tokyo area along with the switch to digital train radio for conventional lines. At that time, we improved the function to notify of operation control information such as that for rain and wind from the disaster prevention information system (PreDAS).
4.3 Vehicle and Crew Operation Rescheduling Support System

4.3.1 Vehicle Operation Rescheduling Support System

In train timetable disruption, vehicle scheduling and planning is greatly changed from the original. In some vehicle and crew operation rescheduling (to restore to the operation schedule on that day), more time may be required to restore to the normal schedule, and the operation rescheduling on the following days (to restore to the original monthly vehicle management schedule) might involve more work. In light of that situation, we have developed a system that supports rescheduling of disrupted timetables, giving information required for vehicle scheduling to dispatchers and persons in charge of the sections and depots involved and making proposals on rescheduling plans.

With that support system, we can constantly monitor train numbers and train set numbers (base train set + auxiliary train set) corresponding to those. To deal with timetable disruption, we have added two functions to the system. Those are the vehicle operation rescheduling function and the monthly vehicle operation rescheduling function. The former is the function to output operational warnings of the day (checks such as restrictions on allowable vehicles and return for inspection) and make suggestions to avoid those based on limitations by type of car and required inspection. The latter is the function to make suggestions to restore to the original monthly operation schedule from the following day. We have developed the system on the Chuo–Sobu Line. Some of the functions were introduced to the Chuo rapid line at introduction of the digital train radio for conventional lines.

4.3.2 Crew Operation Rescheduling Support System

Crew members—drivers and conductors—have to be allocated to trains. In train timetable disruption, allocation of crew members is changed such as crew members allocated with onboard duty being changed. Dispatchers in charge of scheduling and crew managers at the depot make arrangement for and give instructions to crew members on allocation change when the original crew member cannot arrive in time at the next allocated train due to a train delay. After timetable restoration, they also arrange rescheduling to restore the changed route to the originally scheduled one. Any delayed or overlooked arrangement might worsen the transport disorder. The crew operation rescheduling support system is thus a system to check crew arrangements, give warnings if necessary and make proposals for onboard duty allocation to prevent overlooked arrangements (Fig. 5).

That support system consists of four major functions.

The first function is the crew location identification function. The system can see the location of crew members, for example waiting at the crew office or at onboard duty. This function uses technologies such as RFID and GPS.

The second function is the scheduling alarm function. If no crew member is allocated (non-allocation) due to delay or cancellation of trains or change of turn-back operation, the system displays an alarm and warns to make arrangements.

The third function is rescheduling suggestion function. If no crew member is allocated (non-allocation), the system makes out rescheduled onboard duty allocation proposals based on the crew location information.

The fourth function is the function to transmit the timetable to cab monitors. Crew members of JR East carry a timetable and an IC-equipped smart card (a work schedule card) to perform operation jobs. But, when instructed to change onboard duty allocation in operation disruption, they do not have the timetable for the newly allocated trains. Thus, at present, we send the necessary timetable via fax to the crew office or the station where the crew members involved are waiting and hand that to the crew members. The support system transmits using WiMAX the timetable requested by the cab monitor and displays that timetable (Fig. 6).

The Research and Development Center of JR East Group is aiming to develop a next-generation greater Tokyo railway system to achieve further innovations in transport work. In future transport in the greater Tokyo area, we will need to offer flexible transport according to use by passengers and provide timely and appropriate information to passengers. And that is needed in both normal operation and at operation disruptions. We are thus aiming to achieve transport trusted by passengers, using the next generation transport management and an operation control system based on elemental technologies developed up to now.

Reference: