Research on Dispatching and Commanding Emergency Auxiliary Decision-Making Platform of Shuohuang Railway

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Abstract. To further improve the efficiency and accuracy of Shuohuang Railway dispatch command in responding to emergency situations such as equipment failures, sudden accidents, and natural disasters, this paper is based on Centralized Traffic Control (CTC) system and network, integrating advanced technologies such as data collection and intelligent decision-making, and constructing a centralized and unified management dispatching and commanding emergency auxiliary decision-making platform of Shuohuang railway. This platform covers the entire process of emergency event information retrieval, response plan generation, and normal operation recovery. It has functions such as automatic editing, management, dynamic deduction, emergency response warning, and integration of historical records. It can provide comprehensive emergency decision-making support for dispatchers to enhance their emergency response capabilities.

Keywords: Railroad dispatching and commanding; emergency response; auxiliary decision-making system; application analysis.

1 Introduction

Railway emergency dispatch command refers to the process in which dispatchers use relevant equipment, facilities, and support systems to develop emergency response plans, direct emergency response, restore transportation order, and reduce the impact and consequences when railway lines, communication signals, power supply, locomotives, and vehicle equipment malfunction, as well as when encountering adverse weather, sudden passenger flow, and other events. Railway dispatch emergency response is not only related to the continuity and safety of train operation, but also to the quality and image of railway transportation services. Therefore, it is very important. At present, China's railways have established a three-level emergency plan system consisting of China Railway Group, Railway Bureau, and stations, as well as an emergency dispatch command center, forming a relatively complete dispatch command emergency response system [1].

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At present, due to the lack of an effective dispatch command emergency decision-making system, Shuohuang railway still relies mainly on manual labor for emergency events and handling information, which can easily lead to deviations in the judgment and handling of emergencies. Moreover, due to the various key information data of Shuohuang railway, such as line vehicles, track occupancy, stage plans, etc., being scattered in different application systems, the entire dispatch and command emergency response process cannot be centralized and unified, and dynamic response plans and emergency auxiliary decision-making plans cannot be generated based on the actual situation on site, which affects the efficiency of response. Therefore, the construction of dispatching and commanding emergency auxiliary decision-making platform of Shuohuang railway and the use of information and integration technology to improve the level and efficiency of railway dispatching command emergency response are important issues that need to be solved by the dispatching department at present.

2 Research Status

Railroad operators, experts and scholars at home and abroad have developed a series of dispatching and commanding emergency decision-making systems or auxiliary decision-making platforms to realize intelligent decision-making in railroad dispatching and commanding emergency. The European Railway Transportation Management System (ERTMS), as a comprehensive railroad operation and management platform created and widely adopted by railroad operators in Europe, has its basic framework shared by the core national railroad organizations in the European Union. On this basis, national railroad operators continue to optimize and upgrade ERTMS according to their own unique operational needs and characteristics, in order to achieve careful scheduling of train operation plans, efficient station operation control, refined maintenance management, comprehensive vehicle scheduling and maintenance, as well as in-depth integration, management and analysis of data and information. The system also strongly supports the work of dispatchers, enabling them to flexibly adjust train operations to ensure the smoothness and safety of the rail network [2]. The Italian ROMA system is a laboratory version of an auxiliary dispatching tool designed to assist dispatchers in calculating and evaluating solutions for real-time dispatching [3]. Peng Qiyuan design a high-speed railroad dispatching risk analysis and early warning system based on the risk influencing factors and risk evolution laws of dispatching command decision-making and traffic safety, integrating the use of existing railroad early warning information platforms, and obtaining real-time risk information about the external environment. Through the dispatching command event prediction technology to analyze the type of risk, severity and impact on train operation, the use of emergency response management technology to intelligently match the current event emergency response process, and to assist in standardized management in order to improve reliability and efficiency [4]. Niu Jian and others in the elaboration of the railroad scheduling emergency command business status quo, business scope, business process based on the railroad scheduling emergency command system demand analysis, from the existing information system support, scheduling emergency command system architecture, scheduling emergency

command system functional architecture of three aspects, the proposed railroad scheduling emergency command system overall program for the construction of the railroad scheduling emergency command system to provide support, accelerate Improve the level of scheduling emergency command [5].

Starting from the emergency command business process, Liu Jie sorted out the basic processes of early warning to response and fault to recovery, and then constructed the basic structure of the urban rail transit intelligent emergency command system. He determined the basic functions of the system, including passenger flow and traffic monitoring, fault warning, information collection and dissemination, and duty log recording. Finally, he proposed three detailed functional designs: dispatch command, information reporting, and emergency duty [6].

3 The Construction of Railway Dispatch Command Emergency Auxiliary Decision-making System

3.1 System Goal

The Shuohuang railway dispatch command emergency response auxiliary decision-making platform studied in this paper provides emergency command auxiliary decision-making functions for various production safety accidents such as equipment failures, sudden accidents, and natural disasters that occur in production and transportation organizations. The system objectives include:

(1) Develop emergency plans

On site dispatch personnel play a crucial role in the field of railway transportation. They must rely on years of accumulated experience and professional knowledge to quickly make judgments and decisions, and handle dispatch and command work in various emergency scenarios. In order to further enhance the scientific and systematic nature of dispatch and command, the dispatching and commanding emergency auxiliary decision-making platform of Shuohuang railway developed in this paper will organize and extract the knowledge and experience of on-site dispatch personnel, as well as historical cases, to identify and summarize effective strategies in various emergency situations. These strategies are further solidified into a series of method rules and stored in the system method rule library. This is equivalent to forming a system "brain", which contains preset solutions for different scenarios and problems. When an emergency situation occurs, the system can quickly retrieve the most suitable dispatch command emergency response strategy from the method rule library based on the specific situation at that time, providing real-time auxiliary decision support for dispatchers[7].

(2) Rapidly provide emergency disposal program

When an emergency situation occurs, the system first collects and analyzes the current traffic flow of the line, including key information such as the train's operating status, position, speed, and expected arrival time. At the same time, the system will also obtain stage plan data and track occupancy status to understand the status of each train and line. Based on the above information, the system will quickly generate an emer-

gency response plan. These plans include but are not limited to measures such as temporary train parking, changing operating routes, adjusting schedules, activating backup vehicles, and implementing rescue operations.

(3) Constructing information notification and sharing mechanism

The platform system has designed an efficient information reporting mechanism, allowing dispatchers to quickly report the detailed situation of events to higher-level leadership departments through the system. The content includes key information such as event type, time of occurrence, scope of impact, measures taken, and required support. Through a systematic reporting process, it can be ensured that the transmission of information is not only structured, but also fast and complete, making it easy for the leadership to quickly understand the real-time situation and make decisions. At the same time, the system also has the function of information dissemination, allowing dispatchers to send various notifications or arrangements to subordinate units or relevant personnel based on the nature and urgency of the event[8].

(4) Assist in dealing with emergency situations

Firstly, the system can automatically identify emergency situations and trigger warning mechanisms by monitoring and analyzing the status of the railway network in real-time; The system prompts dispatchers through an intuitive user interface, and dispatchers use the system's auxiliary decision-making tools to quickly assess the severity and scope of the problem, thereby determining the preliminary measures that need to be taken; Then, the system will provide real-time track occupancy information and train position data to assist dispatchers in making accurate decisions, ensuring that trains can safely pass through the affected area, or re plan train routes. The system will also assist dispatchers in adjusting the stage plan, including rearranging the departure time, arrival time, and stopping stations of trains to adapt to new operating conditions. In addition, the system also supports functions such as rapid issuance, recording, and tracking of scheduling commands.

3.2 System Application Architecture

The dispatching and commanding emergency auxiliary decision-making platform of Shuohuang railway covers the entire process of emergency event retrieval, information notification, disposal plan generation, and restoration of normal operation. The system architecture is shown in Figure 1.

(1) Emergency response of dispatch command center

This section includes three stages, namely emergency event information retrieval, generation of emergency response plans, and auxiliary emergency dispatch command. Emergency event information retrieval is a prerequisite for effective emergency dispatch and command. Only by manually inputting emergency event information can accurate matching of events with relevant information in the emergency response plan library be achieved; The generation of emergency response plans is the core of the entire system. After fully grasping the relevant information of emergency events, dispatchers refer to the matching plans in the emergency response database, combine their own experience and professional knowledge, and decide on the final response plan; The auxiliary emergency dispatch command is the final stage, where the system provides

real-time track occupancy, train position, departure time, arrival time, stopping stations and other data to assist dispatch personnel in making accurate decisions for disposal.

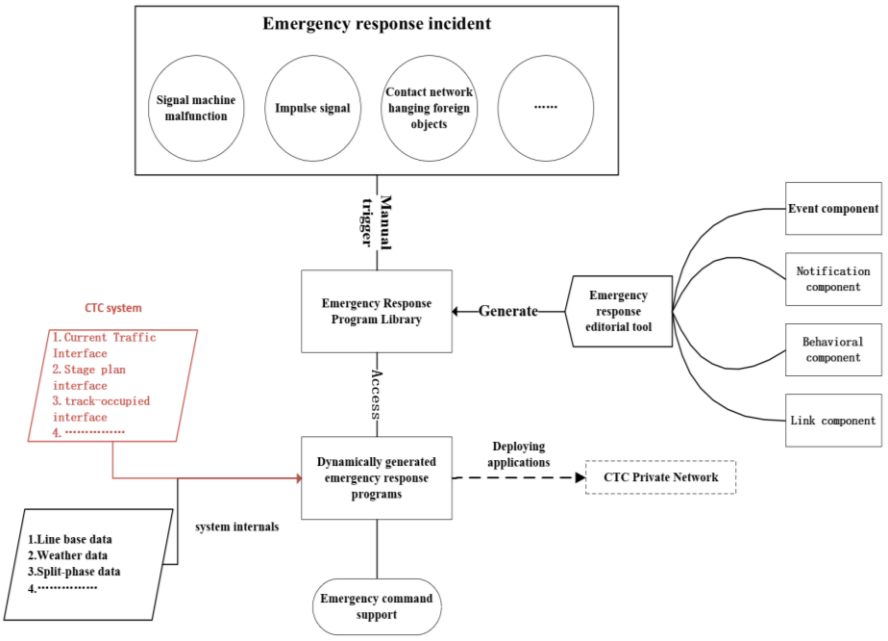

Fig. 1. Dispatch Command Emergency Decision Aid System Application Architecture

(2) Basic data processing

The system collects various basic data, such as line basic data, weather data, and phase separation data, and realizes electronic storage and real-time updates to ensure the effectiveness of the generated dynamic emergency response plan.

(3) Application of CTC system and private network

The system obtains the necessary information for developing dynamic emergency response plans through various CTC interfaces, such as obtaining train phase plan information and train reporting information through CTC operation diagram interface, obtaining train track occupancy and station track status information through CTC track occupancy interface, and obtaining section and station signal status information through CTC signal status interface[9-10].

(4) Event Recording

The system identifies the disposal records of different types of emergency events, organizes and classifies them, forms cases, and provides reference for the disposal of similar events in the future.

3.3 System Core Function Design

Based on the existing CTC system and network, supplemented by advanced technologies such as data collection and intelligent decision-making, establish a centralized and

unified management dispatch command emergency decision-making system, which mainly includes the following three parts.

(1) Emergency response process editing function

Through the process editing tool, it is possible to graphically edit the operations of each stage of emergency response, and generate an emergency response process diagram after completion. The editing component includes the following parts, as shown in Figure 2.

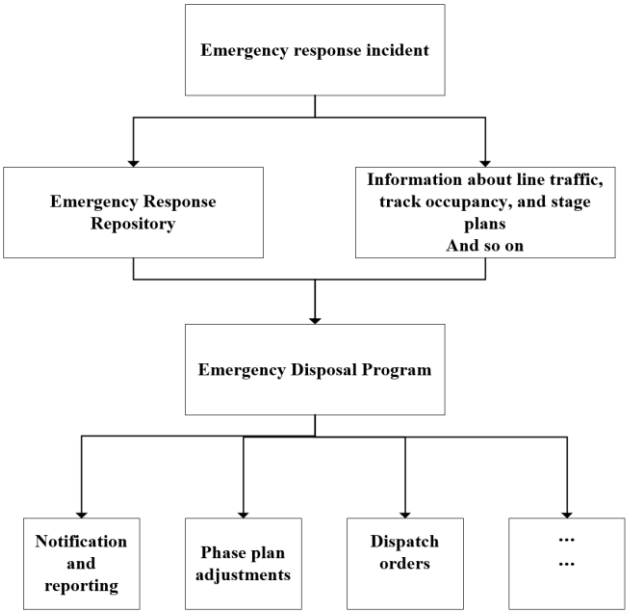

Fig. 2. System business processes for dynamic rehearsal functions for emergency response processes

Emergency response events: Provide various common types of driving faults.

Emergency measures and conditions: There are various on-site situations during emergency response, so a condition template is provided when constructing the emergency response process to cover the response process under different conditions.

Report notification: The notification component includes duty director notifications, driver notification templates, in vehicle notification templates, etc.

Disposal plan and implementation: The emergency response process usually includes operations such as route handling, stage plan adjustment, and dispatch command issuance.

Reference link: The basis for developing emergency response procedures, such as railway technical management regulations and train operation organization rules.

Emergency response process management function

After importing the emergency response process for sudden events into the emergency auxiliary decision-making system, tags related to the type of accident can be added to these emergency response processes. Dispatchers can quickly view the emergency response processes for various accidents by searching [11]. This feature also

supports system administrators to manage and operate the emergency response processes of the management database.

(3) Dynamic deduction function of emergency response process

In case of an emergency, first retrieve the type of disposal process template from the emergency repository, and then obtain the current line traffic flow, stage plan data, track occupancy and other information from the CTC system. Based on the emergency response process template and traffic situation information, dynamically deduce the emergency response process and convert the response process template into a response process implementation plan. This function relies on emergency response events as system triggering conditions, relies on real-time data such as emergency response libraries and line traffic flow, and dynamically generates response plans based on emergency response plan templates. The system business process is shown in Figure 3.

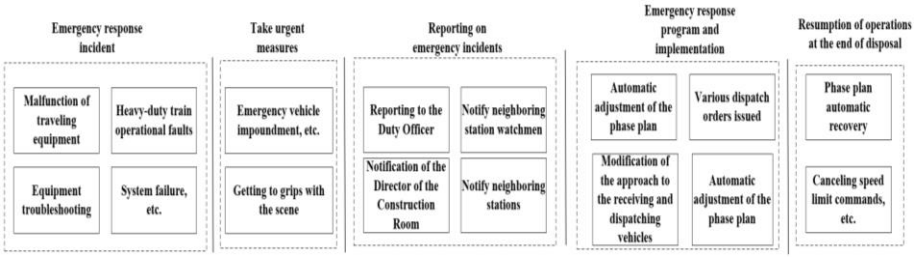

Fig. 3. Components involved in each stage of event handling

(4) Emergency response warning function

This functional module consists of two parts: one is the standby warning event, which displays the emergency events automatically detected by the system and can be directly activated by the user; The other part is the historical warning record, which includes ignored warnings and records initiated by operators.

(5) Emergency response history recording function

The history of emergency response includes fields such as time (start time, end time), emergency event name, template name, instantiated template, duty officer, on duty team member, duty station master, trigger method, replay, etc.

4 Dispatch Command Emergency Decision Aid System Application Analysis

At present, the dispatching and commanding emergency auxiliary decision-making platform of Shuohuang railway has been completed, with a total of more than 40 auxiliary decision-making and disposal processes developed for typical emergency scenarios such as railway brake, foreign objects hanging on the pantograph, split operation, train shaking, contact network faults, locomotive faults, CTC system faults, flood control, earthquake, etc(as shown in Figure 4).

4.1 Activation of the Emergency Plan

At present, there are two ways to activate the emergency decision-making system. One way is to manually start, where on-site personnel report specific information about the event, such as disaster weather, locomotive and vehicle failures, and dispatch and command personnel search by adding corresponding tags or view emergency plans by event type and name. This method is suitable for situations where the system fails to automatically identify and requires staff to manually search for the target emergency response template to activate the emergency response plan assistance decision-making system. Another way is automatic start, which relies on the CTC system to obtain recognition of occupancy loss, non train occupancy of red light strips, and other situations through interfaces. Combined with real-time train position, block zone kilometer signs, and other information, it automatically enters the emergency response plan auxiliary decision-making system through warning confirmation.

4.2 Example Analysis - Taking Foreign Objects Hanging on Pantographs as an Example

(1) Process framework diagram

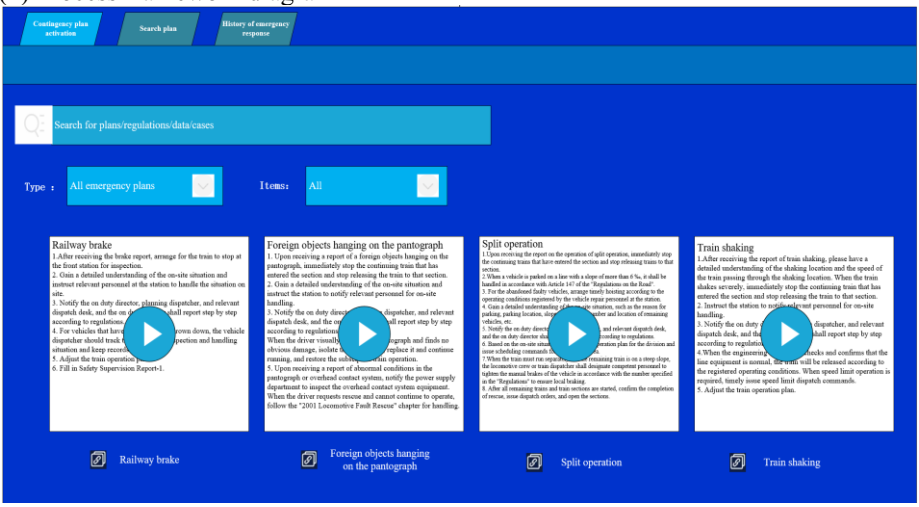

Fig. 4. Emergency plan activation interface and some typical emergency events

After receiving the report of a foreign object hanging on the locomotive pantograph and stopping, the staff entered emergency event keywords for retrieval. The platform system matched the emergency event from the emergency response database and automatically generated the corresponding disposal process framework diagram (as shown in Figure 5). The disposal process includes: on-site report on whether it affects the adjacent line, whether to stop the train on this line (adjacent line), notification report, driver visually inspecting the damage of the pantograph, whether to notify the power supply department, on-site feedback (whether to inspect the top and handle the fault),

adjusting the train plan, filling out safety supervision reports and other emergency disposal processes.

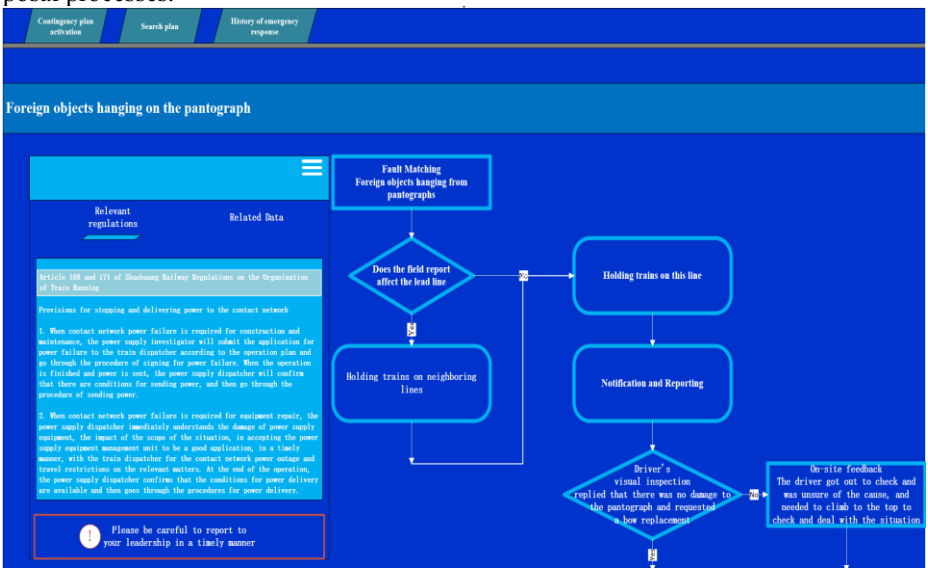

Fig. 5. Components involved in each stage of event handling

(2) Associated regulations.

The platform provides railway technical management regulations and train operation organization rules related to emergencies or failures, guiding dispatchers to quickly respond to emergency situations in accordance with specific requirements stipulated by regulations. For example, the regulations related to foreign objects hanging on pantographs are article 473 and 477 of Guoneng "Railway Transport Management Regulations", and article 168 and 171 of Shuohuang Railway "Operation Organization Rules".

(3) Associated data

After the occurrence of a foreign object hanging from the pantograph causing a stop, the system will provide data information related to the event, such as train location information, accident location, basic line data, and weather data. Dispatch and command personnel will refer to these data information to develop the final emergency response plan.

(4) Emergency response

Dispatch and command personnel gradually complete various emergency response tasks based on real-time feedback from on-site drivers, train conductors, or maintenance personnel, and according to the prompts in the emergency response flowchart

(5) End of disposal

After the emergency disposal task is completed, the dispatcher can click the End button and form a history record. This historical record not only preserves the entire emergency response process, but also allows operators or managers to view and analyze it afterwards through replay function, thereby continuously optimizing and improving emergency response plans.

5 Conclusion

Based on the practical needs of emergency decision-making in railway dispatching and command, this paper extracts the knowledge and experience of relevant personnel in Shuohuang railway dispatching and command, solidifies them into specific procedures for emergency response in various scenarios such as equipment failures, sudden accidents, and natural disasters, and forms a method rule library. Based on this, the functional architecture design and application software development of the dispatching and commanding emergency auxiliary decision-making platform of Shuohuang railway are carried out. Through practical application, it has been shown that the system can effectively integrate the knowledge and experience of relevant personnel, rules and regulations, as well as historical disposal cases and other resources. Through the data interface with the CTC system, it automatically identifies and obtains the current status of railway equipment, instantiated emergency disposal templates, automatically generates specific emergency disposal processes, and assists dispatchers in handling emergency events to ensure railway traffic safety and enhance their emergency response capabilities for emergencies and sudden incidents.

Acknowledgments

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