Research on Automatic Test Method of Radio Block Center Based on Script Technology

Jingjing Zhao¹, Wei Zheng²

¹Beijing National Railway Research & Design Institute of Signal & Communication Group Co. Ltd, South Road of Automobile Museum, Beijing, China.
²National research center of railway safety assessment, Beijing, china.
Email: zhaojingjing2165@crscd.com.cn

Abstract. Radio Block Center (RBC) is the wayside core equipment of high-speed railway train control system, which is the key to achieve the safe operation of trains. In order to ensure the correctness of the function of RBC equipment and to send movement authority information to the train correctly, it is necessary to verify the consistency of RBC function with the RBC requirement specification. Therefore, the RBC functional testing is the basis and key to ensure the safety of train operation. The execution of testing cases has a great impact on testing efficiency. How to automatically execute testing cases and fully cover the system specifications is the key issue of RBC functional testing. Aiming at the shortcomings of traditional RBC functional testing, such as low efficiency, long time consuming, huge workload, and low accuracy of fault simulation, by studying the preparation of automatic test environment and the execution of automatic testing cases, this paper proposes a script based automatic functional testing method, and takes the RBC functional testing as an example to verify the correctness and effectiveness of this method. The practical application shows that the description ability of the test script language and the automatic testing environment meet the RBC testing requirements. The timeliness and the safety of RBC functional testing can be improved by using this method.

1. Introduction
Radio Block Center (RBC) is the wayside core equipment of high-speed railway train control system. According to the information provided by the computer based interlocking (CBI), the temporary speed restriction server (TSRS), the adjacent RBC, the centralized traffic control (CTC) and the on-board equipment. It generates control command such as a movement authority, and sends it to on-board equipment through wireless communication network to ensure the safety of train tracking operation. [1] The safety of RBC system has reached the international highest safety integrity level SIL-4. RBC has the characteristics of high safety, high performance and high reliability. It is the key equipment to ensure the safety of train operation and improve the transportation efficiency. Therefore, the complete and rigorous safety functional testing of RBC is one of the important means to verify whether the function of RBC is implemented correctly and whether the RBC performance meets the design requirements.

The execution of test cases will have a great impact on test efficiency and test results, which is the core of test process. The traditional functional testing is mainly done manually, which is inefficient, time-consuming, and low accuracy of fault simulation, so it is difficult to achieve for special complex test scenarios. For the shortcomings of traditional testing, combined with the characteristics of RBC
functional testing. This paper proposes an effective and complete automatic test method for RBC testing, which automatically executes test cases and makes log records. [2]

In this paper, taking the RBC subsystem of train operation control system as the research object, an automatic testing method based on script technology is proposed. Firstly, according to the in-depth analysis of the requirements, the architecture and functions of the system test environment are defined, and the visual automatic test of RBC is achieved. Secondly, this paper proposes a test strategy suitable for the complex characteristics of RBC, from system top-level design, platform development, environment deployment to the completion of automatic testing. Finally, the RBC automatic testing is successfully applied to the RBC functional testing of Qinghai Tibet railway. After statistical analysis of the test data, the automatic testing shortens the test time, greatly improves the test efficiency and reduces the labor cost.

2. Test environment and function

RBC automatic testing uses script-based automatic testing approach, and supports manual operation of simulator interface to issue / cancel speed restriction, route setting and other operations. The simulation environment supports starting multiple simulators of the same type by modifying the configuration. The test architecture is shown in the following figure.

RBC test environment has the following functions:
- User interface.
- Physical simulation of simulator.
- Visual editing of test script.
- Test script automatic execution.
- Analysis and record of test result.

The function of user interface is to achieve the interaction and information exchange between the system and users. The visual user interface is used to edit the scripts before the testing, display the
process during the testing and query the historical data after the testing. User-friendly interface is an important part of RBC automatic test.

The physical simulation function of the simulator is mainly to simulate the physical devices that interact with the RBC, including the interlocking simulator, the TRS simulator, the CTC simulator, the adjacent RBC simulator, and the ATP simulator. CBI simulator simulates interlocking equipment, mainly performs the function of route control, as well as the interaction information with the RBC. The Interaction information includes the state of the track section, the direction of the interval block, the zone of the interval block, the train approach in the station, the disaster area, the turnout and the state of the signal. TSRS simulator simulates temporary speed restriction server, mainly performs the functions of issuing and cancelling temporary speed limit, and interacts with RBC, such as TSR refresh request, TSR verification command, TSR execution command, initial confirmation command of line speed limit state, TSRS life signal. CTC simulator simulates centralized traffic control equipment, mainly performs the functions of emergency stop command issuing, etc., and interacts with RBC in emergency stop command, text information, virtual section command and train end command. The adjacent RBC simulator simulates the adjacent RBCs, mainly performs the functions of RBC handover, etc., ATP simulator simulates ATP on-board equipment, mainly performs the function of sending train position information to RBC in real time, and exchanging other data with RBC.

The visual editing function of test script mainly performs the editing, modification and deleting of test scripts. The script status list area in the visualization page displays the specific element information of the script in a tree structure. Click the tree structure node to display the specific information of the node and support editing. It is convenient for testers to operate through the visual interface.

The automatic execution function of test script mainly achieves the automatic execution, pause and termination of the script. The system starts the script executor and executes the script. In the process of script execution, the script information editing interface will mark the executing status and the executed status with different colours. It can display real-time information interaction with RBC during the test process, and support pause, resume of real-time display.

The function of test result analysis and record mainly performs the historical inquiry. It can read the database that stores the historical communication data and display the historical data on the monitoring interface. After the completion of the test, the historical data can be downloaded and saved for the analysis purpose.

3. Testing Architecture and Testing Strategy

3.1. Testing Architecture
RBC testing scenario is complex. It is necessary to analyse different scenarios of RBC functions and define the testing scope and the testing object for the RBC functional testing. Next, several cases will be combined into a test suite according to the test business, and a concise and intuitive automated testing script will be created. After that, the testing logic and process will be controlled by scenario transformation to perform the functional and safety testing of the RBC system.

The RBC automated test system is divided into four layers, including interaction layer, function layer, support layer and interface layer, as shown in Figure 2.
Figure 2. Architecture diagram of automated test system.

The first layer is the interaction layer, which mainly interacts with users through UI. The second layer is the function layer. The function layer completes the functions required by automatic and manual testing through the executor, proxy, result analysis module and associated field query. The third layer is the support layer, which includes the database and Sim Framework. The database supports the storage of basic simulation parameters and the recording and reading of interactive information. Sim Framework provides support for communication between various modules of the system. The fourth layer is the interface layer. The interface layer mainly provides security protocol verification and communication with the device to be tested. It can be integrated into the proxy or an independent interface platform application program to provide relevant support for security protocols and network communication protocols.

3.2. Testing Strategy

According to the functional requirements defined by the RBC system, in order to achieve the complete safety test objectives, it is necessary to adopt the dynamic description mechanism to create all possible operation scenarios, and verify whether the response output of RBC to train operation is correct. Therefore, this paper proposes an automatic testing strategy, as shown in Figure 3.

Figure 3. Automated test strategy of RBC equipment.
- System design. The system design stage includes the following steps: system requirements analysis, outline design and detailed design. The outline design needs to be completed on the basis of in-depth analysis of system requirements to form the outline design specification. Finally, the system module function is refined based on the outline design, and the detailed design specification is created.

- Testing platform development and environment deployment. According to the system requirement analysis, the development of automatic testing platform based on script should be achieved. The test script language is used to describe the normal and fault scenarios of RBC function, and the software and hardware environment are deployed at the same time.

- Test environment setup. Test workstation deployment, software deployment, and software configuration need to be completed. The software required for the system testing is installed on a workstation, which is connected to the RBC via a switch. The test environment can support RBC automatic testing.

- Test scenario analysis and script preparation. Testing cases should be based on test scenarios, and achieve the full coverage of system requirements. The testing scripts should be compiled according to the test cases, and then the testing scripts will automatically perform the safety function testing of RBC.

- Automatic testing execution. The specific testing process is shown in Figure 4. During the testing, it is necessary to record and analyse the testing process to verify the correctness of the testing results.

4. Application
In the process of RBC automatic test preparation, the possibility of error due to manual test environment is reduced, the test efficiency is improved, and the fault simulation accuracy is improved. At present, RBC automatic test has been successfully applied to RBC function testing of Qinghai Tibet railway, and the safety testing of all functions has been completed.

During the testing phase, manual testing and automatic testing were carried out at the same time. The testing time statistics are shown in Table 1. The total time taken by manual testing to complete a single round of testing was 54.5 hours, while the total time taken by automatic testing to complete a single round of testing was 38.8 hours, which was 20% lower than the manual testing cycle. It can be seen that automatic testing shortens the testing time and greatly improves the testing efficiency.

The statistics of cumulative five rounds of test resources are shown in Table 2, unit: person / day. The total number of manual testing preparation for five rounds is 18 persons / day, and the testing time is 27 persons / day. Using the automatic testing method, manual testing preparation is 7 people / day, and testing time is 9 people / day. Labour costs have been reduced by 65%. Automatic RBC testing team of Qinghai Tibet railway consists of 6 persons. After adopting automatic testing method for half
a year, the total number of completed automatic testing projects was 25. In the same period, the total number of projects completed by the manual testing team is 14. Compared with the traditional manual testing, the total number of projects completed by automatic testing is greatly improved, which brings huge economic benefits.

Table 1. Test time statistics.

| Test method                | Case preparation | Environment construction | Test execution | Total time / h |
|----------------------------|------------------|--------------------------|----------------|----------------|
| Content of Manual test     | Develop test scenarios | Case preparation | database | Ate system configuration | Hardware and software deployment | Interface platform debugging | Construction of network environment | Start test environment | Execute test case | Log analysis |
| Time / hour                | 3                | 12                       | 4           | 4               | 3               | 8            | 2                | 0.5             | 16             | 2            |
| Content of Automated test  | Develop test scenarios | Script                  | database | Ate system configuration | Hardware and software deployment | Interface platform debugging | Construction of network environment | Start test environment | Execute test case | Log analysis |
| Time / hour                | 3                | 24                       | 0.2         | 2               | 2               | 4            | 1                | 0.1             | 0.5            | 2            |

Table 2. Test resource statistics.

|                      | Manual test preparation (person / day) | Manual test execution (person / day) | Automatic test preparation (person / day) | Automatic test execution (person / day) |
|----------------------|---------------------------------------|--------------------------------------|------------------------------------------|----------------------------------------|
| Round 1 Test         | 4                                     | 6                                    | 2                                        | 2                                      |
| Round 2 Test         | 3                                     | 4                                    | 1                                        | 2                                      |
| Round 3 Test         | 4                                     | 6                                    | 2                                        | 1                                      |
| Round 4 Test         | 4                                     | 5                                    | 1                                        | 2                                      |
| Round 5 Test         | 3                                     | 6                                    | 1                                        | 2                                      |

5. Summary
As one of the core technologies of high-speed railway train control system testing, the research on RBC automatic testing method in this paper can verify the safety of RBC function more effectively and further improve the execution efficiency of RBC testing. The application example shows that the automatic testing of RBC equipment on Qinghai Tibet Railway shortens the test cycle, reduces the labor cost, greatly improves the testing efficiency, and provides more reliable technical support for the safe operation of high-speed railway.

In the next stage, based on the results and experience of this research, combined with the development trend of intelligent automatic test, the research and development of automatic testing of railway signal equipment will be carried out with the research direction of batch execution of scripts and automatic analysis of testing results.

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