A Study on the Method with Design Criteria of KRTCS using LTE-R Radio Network for Conventional & High Speed Railway Through the Analysis of Design Criteria of the Trackside System

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Abstract

KRTCS (Korean Radio based Train Control System) for Conventional & High speed railway is divided into the on-board system and the trackside system. In this paper, it presents the design criteria of the KRTCS using LTE-R radio network for the interoperability with ETCS (European Train Control System) Level2 on the basis of the analyzed data, in order to transmit the required information to the on-board system and analyzed on design criteria on the each device of the trackside system. The proposed design criteria were applied to the KRTCS for Conventional & High speed railway, and the validity of the design criteria was verified through the performance verification of commercialization. As a way to verify the propriety, design criteria of the trackside system try to ensure that it meets the interoperability with KRTCS of on-board system through the verification of the speed of up to 350km/h in the Honam high speed line Test-bed(Iksan ~ Jeong eup).

Keywords: KRTCS, ETCS, LTE-R, Interoperability, ATP

1. Introduction

1.1 Technical Analysis

Train Control System is pushing ahead with standardization for both wired and wireless interoperability as well as various types of signals for trackside and onboard. The communication of train control system is developing from wire-based control method to radio-based control method with the high-speed large-capacity IT technology. The below shows the current status of the Korean train control system(Fig. 1). For the Gyeongbu High speed Line, The Train Control System is ATS/ATS from Seoul Station to Gwangmyeong Station. And it is TVM430 from Gwangmyeong Station to Busan Station. In the case of Urban railways, the train control system is CBTC (Communication Based Train Control).

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Fig. 1. Communication of Train Control System in Korea
Train radio communications between Seoul station and Gwangmyeong station use the VHF and each downtown zone use the VHF. Train radio communications between Gwangmyeong station and East-Daegu station use a TRS-ASTRO. Because different controlled devices and communication methods are used, Train control system and Train radio communications cannot ensure the safety of train operations. Because the data communication between one train and another trains is impossible, the technical and the economic problems cause by the foreign proprietary technology is occurring.

Fig. 2. The ATP Status of national railway network

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Fig. 2. below shows the ATP(ETCS Level 1) status of the National railway Network in Korea.

The installation rate of a trackside facility is 26.8%. In April 2010 the Honam Line was opened in Korea. In April 2011 the Gyeongbu Line was opened in Korea. In February 2012 the Gyeongchun, JoongAng, Gyeongjeon, Jeonla Line was opened in Korea. The total distance of the four lines(Honam Line, Gyeongbu Line, Gyeongchun Line, Jeonla Line) is 1,031km/h(including currently Gyeongbu line). And the installation rate of on onboard facility is 77.5%. In April 2010 the Saemaul Train was opened in Korea. Commercial operation has become 622 trains in 10 train type(including currently KTX).

Fig. 3 shows the situation of the trackside system. It was a major equipment of the trackside & On-board.

The train control system is necessary for the following reasons. First, the construction costs & maintenance costs have increased due to the demands of various trackside facilities. Second, the increase in wired facilities is a major obstacle to the safe operation of railways. So that, the train
control system using radio communication to solve this problem is required.

It is the requirement analysis for ETCS interoperability. This is about the requirements creation and analysis of integrated test facilities. Application specifications of the integrated test facility have been created through the analysis of CCS(Control Command and Signalling) TSI(Technical Specifications for Interoperability) regulation. The test specifications related to train control in the essential reference specification were analyzed over 11 types.(except communications) Application specifications of the integrated test facility have been created through the analysis of CCS TSI guide. The test specifications related to train control in the reference specifications were analyzed over 16 types.

2. Presents the design criteria of the KRTCS

2.1 Communication interface diagram of the KRTCS

This is the design criteria presented in the KRTCS. The below Fig. 4 is about the KRTCS device-to-device interface.

On-board devices have a KRTCS, STU, TCI, JRU and STM. The KRTCS of the on-board device interfaces with the STU. The STU device interfaces with TCI. The train information uses LTE-R radio communications and communicates with the RBC at the Trackside. The trackside device has a RBC, STU, balise, station information processing equipment, interface conversion equipment and more. The RBC at the trackside is communicating with the KRTCS of the on-board device through the STU. The KRTCS design criteria was established on the basis of the device-to-device interface at the trackside and on-board the train.

The RBC on the Trackside devices communicates with the STU via UDP. The KRTCS in the on-board devices communicates with the STU via RS-422. The STU equipment on the trackside devices exchanges necessary information with the KRTCS through the EPC, DU and the RRU by the LTE-R radio communication.

2.2 Configuration of RBC~STU & STU~KRTCS communication

The left side of the Fig. shows the RBC~STU communication configuration of the trackside, and the right side of figure shows the STU~KRTCS communication configuration of the on-board.(Fig. 5)

The RBC on the trackside is a communication for a safety connection request with STU 1. The STU 1 on the trackside verifies the communication connection session through the LTE-R radio communications, and STU 1 of the on-board confirms the safety connection with KRTCS. The STU 1 of the on-board confirms the safety connection to communicate with KRTCS No 1 and KRTCS No 2.

The table at the bottom of the figure(Fig. 5) shows the physical communication connection specifications of each STU unit installed on the trackside and the train.

2.3 Position information that train sends to RBC

The moving train uses the LTE-R radio communication to send the position information of the point where the train is located to the RBC on the trackside.

The message structure sent by the moving train is shows...
below. (Fig. 6) The KRTCS and ETCS message structures are shown on the left of Fig. 6. The message structure of the KRTCS was designed in a similar structure that complies with the standard ETCS.

The sequence of messages sent by the KRTCS of train to the RBC on the trackside is as follows. The KRTCS reads the RBC ID code & the National ID code (Pk 42: Session Management) stored in the balise group A and to starts a communication session (Msg 156: Initiation of Communication Session) with the RBC on the trackside. The KRTCS completes the communication setting with the RBC on the trackside (Msg 159: Session Established), the KRTCS reports the train’s position (Msg 136: Train Position Report) to the RBC. The KRTCS sends validated train data (Msg 129: Validated Train Data) to the RBC and the KRTCS receives the train data response (Msg 8: Acknowledgement of Train Data) from the RBC. After sending the MA request (Msg 132: MA Request) to the RBC, the KRTCS receives a MA from the RBC (Msg 3: Movement Authority).

3. Performance verification of KRTCS

3.1 Performance verification of KRTCS

The test verifies the interoperability of equipment installed on the trackside, and devices mounted on the onboard in order to verify the performance of the KRTCS in the integrated laboratory.

The below Fig. 7 is shows the configuration of the integrated test between the trackside and the onboard. The integration test to validate system performance follows a test sequence (ETCS subset-076) defined by the European standard. The integration test implements an environment to verify the function of each device between the trackside and the onboard, and performs the tests according to the procedure of the test sequences.

The integration test can verified the interoperability and a system performance between each device. After completion of the integration test, some modifications and further
work are required to perform functional test on the test train(Fig. 8).

An additional balise antenna(BTM : Balise Transmission Module) was installed at the bottom of the test train to read information from the balise installed on the tracks. One antenna was already installed at the bottom of the test train and two additional antennas were installed. The onboard signal equipment transmits the necessary information to the onboard KRTCS via the interface equipment.

The test environment infrastructure was built on the Honam High Speed Line, and dynamic tests were conducted mainly(Fig. 9). It was built test-bed the high speed railway line between Ik-san station and Jeong-eup station. The test items were maximum speed(350 km/h) test, RBC handover test, interface test and interoperability test.

For another test, we built a test environment on conventional line between Seo-wonju station and Gang-neung station(Fig. 10). The test items were Level transition(Level 1→ Level 2) test, 250km/h performance verification test, Linking test of the signal between equipment and other equipment.

3.2 KRTCS Level 2 proceed step

This is a description of the steps needed to convert ATS into KRTCS Level 2(in the case of trackside equipment).

The RBC must be newly installation to convert into KRTCS Level 2. The balise existing at the trackside is still used. If ATS is already installed, the new ATP is added to the existing ATS section. Then the existing ATS is removed after a certain period of time.

The new installed KRTCS was then added, and operates together with the ATP for a certain period of time. The ATP was also removed, and only the KRTCS remains operational. ATP and ATC equipment was converted in a similar method.

4. Conclusion

The KRTCS and LTE-R is a future vision of national railway network. Currently, The train communication is operated through “VHF”, “TRS”, “TETRA” and “Wireless LAN” In the future, It will be integrated with LTE-R. Currently, The train control system is “ATS”, “ATP”, “ATC”, “TVM430” and “ETCS Level 1”. In the future, This train control system will be replaced by KRTCS. At that time, “Increased maintenance cost” and “Increased operational difficulty” is expected to be replaced with “reduces maintenance costs” and “Increase operational efficiency”.

It will be realize the commercialization of LTE-R radio communications and KRTCS. Our goal is to make them available and internationally compatible.

We are expecting to realize the following four items. First item is “Railway construction improvement management”, Second item is “Expending Exports of domestic railway Co.”, Third item is “Realization of high-value-added of domestic railway industry”, and Fourth item is “Oversea railway powerhouse entering”.

Finally, LTE-R based KRTCS development will be to realize the commercialization as follows. First, It is suitable for both conventional and high speed railway envi-
ronments. Second, It is an excellent use of domestic wireless communications technology and infrastructure. Third, It is designed to be compatible with the most commonly used ETCS.

Review

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