Development of LTE based Railway Wireless Communication Systems: Preliminary Experimental Test Results

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***Abstract*— In this paper, we examine the experimental test results of LTE based railway wireless communication systems. First, the overall system architecture is introduced for railway wireless communication systems. Then, the several performance measurement results, which include Reference Signal Received Power (RSRP), communication coverage, call setup time, handover success rate, data delay time, and successive packet loss rate are introduced. Based on the measurement results, the compatibility of LTE based communication systems in railway environments can be verified.**

Keywords-railway wireless communications; LTE based system; experimental test;performance.

I. INTRODUCTION

In South Korea, several wireless communication schemes, i.e., Very High Frequency (VHF), Trunked Radio System-ASTRO (TRS-ASTRO), and TRS-TETRA, are applied in railway communication systems depending on the region. Therefore, several mobile terminals are equipped with one train to support various communication schemes which may not guarantee seamless communication environments. Furthermore, the maximum data transmission requirements are different depending on communication scheme which makes it difficult to transmit a certain data. To overcome these limitations and support seamless communication environments and deliver high data rate transmission, Long Term Evolution (LTE) based wireless communication systems have been developed. Recently, LTE scheme is considered as next generation of railway communication scheme [1][2]. Some performance results of LTE based railway communication systems are introduced in [3][4]. However, experimental measurement results adopting LTE based communication system in practical railway environments are not thoroughly introduced. In this paper, we introduce the experimental test results of LTE based railway wireless communication systems.

II. SYSTEM ARCHITECTURE

In this section, we consider system architecture. Fig. 1 represents the overall system architecture. In general, the system consists of Evolved Packet Core (EPC), Digital Unit (DU) and Remote Radio Unit (RRU).

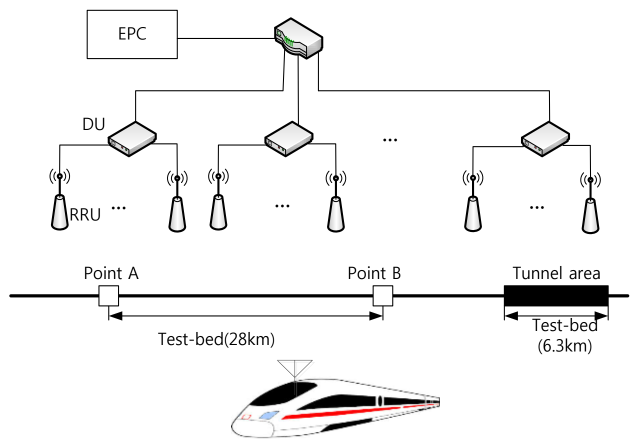

Figure 1. The overall system architecture.

EPC follows the 3GPP LTE standard structure. However, different from the general LTE networks, EPC and DU have dual system for emergency scenarios. RRU has also a dual system, which enables to transmit signal proper when the adjacent RRU is inactive status. Since railway network is directly related to the safety of passengers, the main part of system consists of dual systems. The train is equipped with mobile terminal and on board unit for communication. With this architecture, the performance of wireless communication is measured in two scenarios: one is open area and the other is tunnel area. Then, the Reference Signal Received Power (RSRP), communication coverage, call setup time, handover success rate, data delay time, and successive packet loss rate are measured. The average moving speed of train is 250km/h. The frequency band for uplink and downlink is 718~728MHz and 773~783MHz, respectively. Therefore, each link has 10MHz of bandwidth.

III. MEASUREMENT RESULTS

For experimental measurement, we transmit signal approximately with 46dBm at the end of User Equipment (UE) based on 3GPP standard in [5].

A. RSRP and communication coverage

The reference RSRP value is measured based on 3GPP standard, and the reference criterion is greater than or equal -110dBm. We regard RSRP as "success" if the RSRP satisfies

85% of reference value, i.e., -110dBm. Table I and Table II represent measurement results of RSRP. As we can see, if the distance between RRU and RRU is greater than 3Km, the RSRP is not sufficient.

TABLE I. RSRP MEASUREMENT IN OPEN AREA

Distance between RRU and RRU	Average measured value	Satisfaction rate
1km	-76.10dBm	100%
2km	-88.26dBm	98.8%
3km	-97.18dBm	81.9%
4km	-97.60dBm	77.7%

TABLE II. RSRP MEASUREMENT IN TUNNEL AREA

Distance between RRU and RRU	Average measured value	Satisfaction rate
0.5km	-72.58dBm	100%
1km	-79.05dBm	100%
1.5km	-84.31dBm	100%
2km	-86.61dBm	100%

B. Call setup time

For call setup time we measured call setup time for emergency call, Push to Talk (PTT) call setup time, and group call setup time. We also measured call success rate for each case. Table III shows reference value and its corresponding measured value. The table indicates that all cases represent successful results

TABLE III. CALL SETUP TIME

Test Condition	Reference value	Measured value
Emergency call setup time	Less than 2 sec	0.109sec
PTT call setup time	Less than 2.5sec	0.108sec
Group call setup time	Less than 2.5sec	0.151sec
Emergency call succe rate	Greater than 99%	100%
PTT call success rate	Greater than 99%	100%
Group call success rate	Greater than 99%	100%

C. Handover success rate

We measured handover success rate with the same condition of RSRU measurement condition. The criterion for successful handover rate is greater than 99%. Tables IV and V show that all cases fulfill the handover success rate.

D. Data delay time

Data delay time is measured to test the buffering time which is caused by several signal flow steps. The successful delay time is less than 600ms, where the measured average delay time is 28ms. Therefore, the measured data satisfies the data delay time criterion.

TABLE IV. HANDOVER SUCCESS RATE IN OPEN AREA

Distance between RRU and RRU	# of trial	# of success	Success rate
1km	6	6	100%
2km	6	6	100%
3km	6	6	100%
4km	6	6	100%

TABLE V. HANDOVER SUCCESS RATE IN TUNNEL AREA

Distance between RRU and RRU	# of trial	# of success	Success rate
0.5km	2	2	100%
1km	2	2	100%
1.5km	2	2	100%
2km	2	2	100%

E. Successive packe loss rate

Successive packet loss rate measures the loss rate when the long data packet rate (6000bytes) signal is transmitted. The measurement results show that there is no loss although long packet is transmitted.

IV. CONCLUSIONS

In this paper, we discussed the measurement results of LTE based railway wireless communication systems. The measurements are carried out by considering various performance parameters with practical implementation. The results reveal that the LTE based system can support reliable communication link in railway environments.

ACKNOWLEDGMENT

This research was supported by a grant (17-RTRP-B089546-04) from the Railway Technology Research Project funded by the Ministry of Land, Infrastructure and Transport (MOLIT) of the Korean government and by the Korea Agency for Infrastructure Technology Advancement (KAIA).

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 ISBN: 978-1-61208-573-9