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ITU-APT Foundation of India (IAFI)[1]

FURTHER UPDATES TO THE WORKING DOCUMENT TOWARDS A DRAFT NEW APT REPORT ON OPERATIONAL SCENARIOS AND RELEVANT NATIONAL REGULATORY EXPERIENCES UPON SYSTEMS OF TRAIN POSITIONING APPLICATION OF RSTT IN SOME APT COUNTRIES

Background

At the 27th meetingagreed tocarry forward the AWG-27/TMP-20to the next meeting and planned to finalize the proposed APT report on Operational scenarios and relevant national regulatory experiences upon systems of train positioning application of RSTT in APT countries

It is noted that the working document was almost stable at the end of AWG-27 and it was decided to carry forward the AWG-27/TMP-20 to the next meeting and planned to finalize this study item by AWG-28. AWG-27 had also encouraged more APT members could contribute to AWG-28 for providing their relevant national experiences on this study item.

Discussions

Indian Railways (IR) operates India's national railway system and manages the fourth-largest railway network in the world by size, with a route length of 67,956 km as of 31 March 2020. It runs 100,000 passenger trains daily, on both long-distance and suburban routes, covering 7,325 stations across India. In the last financial year ending March 2020, Indian Railways carried over 8 billion passengers and transported over a Billion tonnes of freight. Indian railways utilize various train positioning system. Recently Indian Railways has also joined hands with the Indian Space Research Organization (ISRO) to ensure real-time tracking and maintain punctuality of trains.Indian Railways has installed a GPS aided geo-augmented navigation system (GAGAN) based devices on locomotives to acquire train movement data. With the help of the new navigating system, Railways will be able track the real-time data of trains like arrival and departure and run-through timings at the stations in a particular route. As the tracking devices have been installed in the locomotives, the trains hauled by such locomotives can be easily monitored and tracked by the RTIS system.This technology will especially come handy at the time of major rail accidents. The satellite will help to point out the exact location of the trains and topography. This new device will also help railways to secure unmanned level crossings with remote sensing facility. The trials for

[1] ITU-APT Foundation of India (IAFI) is a new Affiliate member of APT. Details of IAFI can be seen at itu-apt.org

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this system have been done on New Delhi-Guwahati and New Delhi-Mumbai Rajdhani trains on six electric locomotives.
Indian Railways aims to provide accurate train running information to all the passengers with this new GPS enabled tracking system. The RTIS system will help to improve the efficiency of train control. The emergency messaging between locomotive and control centre will become easier and hassle-free

Proposal

This contribution proposes further updates to the working document contained in AWG/TMP-20 in the attachment.

Task Group Railway Radiocommunications (TGRR)

WORKING DOCUMENT TOWARDSDRAFT NEW APT REPORT-OPERATIONAL SCENARIOS AND RELEVANT NATIONAL REGULATORY EXPERIENCES UPON SYSTEMS OF TRAIN POSITIONING APPLICATION OF RSTT IN SOME APT COUNTRIES

Editor's Note: APT Members are encouraged to contribute actively to AWG-28 meeting on this study item for providing more information on national experiences on RSTT positioningapplication.

1 Scope

Train positioning is one of the four main categories of RSTT application. This APT report provides information onoperational scenarios of systems of train positioning application of RSTT in some APT countries, as well as their relevant national regulatory experiences.

2 Operational scenarios and relevant national regulatory experiences in Korea

2.1 Overview

The republic of Korea proposes to put train positioning applications operating in Korean Railway Systems and national regulatory experiences including relevant technical standards upon systems of train positioning application of RSTT.

Train position detection technology has been developed mainly for speed control of trains and train protection to prevent from the collision. Train control systems use various positioning technologies such as track circuit, axel counter, Doppler radar, and GNSS, etc and try to incorporate wireless communication technology such as balise, RF tag, etc.

Korean railway uses some train position technologies in the field. Basically, train positioning system on high speed train, e.g. KTX, is based on Balise operating at the 4.234 MHz and the 27.095 MHz which is same as Eurobalise, in KNR (Korea National Railway) and KORAIL. Somerailway systemshavesusedWi-Fi technology and LTE-R system to get more accurate position, especially in subway line and/or Busan Metro.

Table 1List of positioning system used in Korea

Detector	Medium	Positioning method	Transmission	Application	Remark
Infrastructure	Track circuit	Track circuit	Wired	Train control	block based detection
	Axel Counter	Axel Counter	Wired	Sosa-Wonsi line, etc	
	Wi-Fi	Wi-Fi+ Balise (compensation)	Wireless	Kimpo line	
	Loop coil	Loop coil	Wired	Uijeongbu line	
Train Equipment	Balise	Balise + achometer	Wireless	KTCS-3	Detection train movement continuously
	Tag	Tag+ Tachometer	Wireless	Shinbundang line	

	GPS	GPS + Tachometer	Wireless	Korail	
Train Equipment + Infrastructure	Wi-Fi GPS LTE-R	Wi-Fi +GPS+LTE-R	Wireless	Busan Metro(Line 1) (Aid driver)	Ground/Under ground
	Wi-Fi LTE-R	Wi-Fi+LTE-R+ Tachometer	Wireless	Hanam line (TTC backup)	Underground

Table 2 Wireless positioning system in Korea

No.	Name of the System	Frequency bands in use	Standards
1	Balise	3.951-4.516 MHz, 27.09-27.10 MHz	KRCS 043
2	WiFi	2.4 GHz	
3	LTE-R	718-728 MHz (uplink), 773-783 MHz (downlink)	TTAS.KO-06.0438
4	GPS	1.5GHz band	

2.2 Position systems

2.2.1 Track circuit

Many trains operating in Korea is controlled by track circuit. Track circuit is installed by infrastructure and its usage is for train control.

2.2.2 Balise

Korail has developed and operates a standard which is a standardized train control system of the European Traffic Control System (ETCS) based on the European Railway Traffic Management System (ERTMS), which is called APT (Automatic Train Protection Trackside System).

Balise system is a vital system providing position information between train and trackside.

The system consists of the balise and the transmission equipment. Balises can provide fixed or variable content. The on-board transmission equipment consists of the antenna unit and the Balise Transmission Module (BTM). A reader device normally mounted in proximity to the track for communications with passing trains.

The balise is a transmission device that sends telegrams to the in-vehicle subsystem and is a ground device that transmits information in one direction (Up-link). Balise has two types : One is fixed balise always transmits a telegram stored in the balise itself and the other one is transparent data balise or controllable balise is connected to a Lineside Electronics Unit (LEU), which transmits dynamic data to the train, such as signal indications.

Since the balise has not direction dependent with respect to transmission through the air gap, it can be mounted horizontally where the short side of the baliseis parallel to the track as much as possible and can also be mounted vertically.

The mounting surface of the sleeper must be flat. If the surface is not flat, there is a risk that the balise bends during installation, and it may cause the balise to fail. If the mounting surface is uneven, it is necessary to smooth the surface before mounting the balise.

A group of several balisesclose to each other is called a balise group where the balisetransmits information to a higher-level system. Several balises (independently transmitting information) are called a balise group. Within the balise group, the minimum and maximum spacing must be observed between the balise and the minimum gap between the last and first balise of neighboring balise groups must be observed.

Table 3 Distance between balise

Item	Values	Condition (Speed)
Distance between balises in a specific balise group	dmin =2.3 m dmax=12.0 m	Up to 160 km/h
	dmin =3.0 m dmax=12.0 m	160 ~ 300 km/h
	dmin =5.0 m dmax=12.0 m	300 ~ 500 km/h

In order to prevent balise crosstalk with in-vehicle balise equipment on both tracks, the balise must maintain a minimum distance between the two tracks.

The products manufactured in YooKyung Control (Inc) started one by one in a laboratory in Belgium in Europe. As a result, the decision of product acceptance and development documents went through the strict procedure of the final certification body, and finally received the Eurobalise SIL4.TSI certificate, the first in Korea.

Figure 2-1 shows balise produced by YooKyung Control (Inc).

2.2.3 LTE-R

As Busan Metro has developed a positioning system collaborated with SK Telecom, this system has been operating in commercial lines in Busan.

As LTE based 700 MHz band system, LTE based Railway communication (LTE-R), provides position information based on radiocommunication services among railway entities including control centre, base station, or drivers in high-speed train. LTE-R system uses single channel for uplink and downlink.

Positioning information from LTE-R is complementary information to provide more accurate information of trains to control center. Basically, subway or Metro systems use position information from TTC (Telemetry Train Control) to deliver to the location server. At the same time, LTE-R communication module provides speed(distance) information from TCMS to location server. Additionally, LTE-R communication module provides to location server position information through RSRP of RU in LTE-R System to trains. Then, location server decides present train position based on 3 types of information.

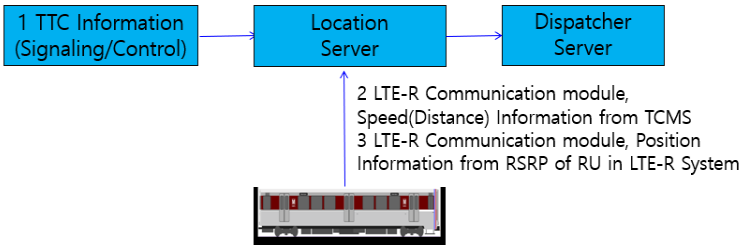

Figure 2-2 LTE based Railway Positioning System Architectural Concept

This LTE system is based on the 3GPP Release 13.

TABLE 4 Technical characteristics of LTE-R system

Parameter	System 1: (LTE-R)
Frequency range (MHz)	Uplink: 718-728 MHz Downlink: 773-783 MHz
Number of channels	1
Channel separation (kHz)	10 MHz
Antenna gain (dBi)	–
Polarization	–
Transmitting radiation power (dBm)	23 dBm (UE), 46 dBm (BS)
e.i.r.p. (dBm)	–
Receiving noise figure (dB)	–
Transmission data rate	Downlink: Max 75 Mbit/s, Uplink: Max 37 Mbit/s
Transmission distance (km)	Above 2 km
Modulation	Downlink: OFDMA Uplink: SC-FDMA
Multiplexing method	Full Duplex FDD

2.2.4 WiFi

Kimpo line, Busan Metro and Hanam line, etcare using WiFi system for positioning of trains with other systems.

3 Operational scenarios and relevant national regulatory experiences in China

3.1 Overview

In Railway industry, obtaining real-time position information of trains is very important to the safe and stable railway operation and organization. Nowadays, the railway networks increase the operational density so as to provide better services. It also brings the heavy burden of train controlling, system monitoring, and dispatching. Therefore, the application of train positioning is very important. In China, typical implementations of train positioning application are Balise system, and Automatic Equipment Identification system (AEI).

3.2 BaliseSystem

China implements Balise system in railway industry. The system hasthebaliseinstalled at intervals along the track and the transmission equipment (reader) installed on the train. When the train passes by the balises, the on-board reader will read and store the position data information so as to realize the train positioning.By using the Balise system, the Chinese Train Control System Level3 (CTCS-3) supported by GSM-R technology can provide real-time train

position information.Theoperating frequency used for this system are:27.095MHz(for on-board equipment), and 3.951MHz/4.561MHz (for balise in the tracks).

Figure 3-1 Balise used in Chinese high-speed railways

3.3 Automatic Equipment Identification (AEI) System

The AEI system in China is mainly designed for the freight rail's automatic identification of train numbers and coach numbers, through which the relevantrailway staff can identify the position of the train.This information provides much help to the railway transportation management system.

The AEI system is also a RFID-like system, and composed of on-board electronic tags, between-track AEI equipment, and other auxiliary elements. The operating frequency of AEI system is 910.1MHz, 912.1MHz, and 914.1MHz, with occupation bandwidth of 5kHz.

Figure 3-2 AEI equipment used in Chinese freight railways

4 Operational scenarios and relevant national regulatory experiences in India

Indian Railways (IR) operates India's national railway system and manages the fourth-largest railway network in the world by size, with a route length of 67,956 km as of 31 March 2020. It runs 100,000 passenger trains daily, on both long-distance and suburban routes, covering 7,325 stations across India. In the last financial year ending March 2020, Indian Railways carried over 8 billion passengers and transported over a Billion tonnes of freight. Indian railways utilize various train positioning system. Recently Indian Railways has also joined hands with the Indian Space Research Organization (ISRO) to ensure real-time tracking and maintain punctuality of trains.Indian Railways has installed a GPS aided

geo-augmented navigation system (GAGAN) based devices on locomotives to acquire train movement data. With the help of the new navigating system, Railways will be able track the real-time data of trains like arrival and departure and run-through timings at the stations in a particular route. As the tracking devices have been installed in the locomotives, the trains hauled by such locomotives can be easily monitored and tracked by the RTIS system.This technology will especially come handy at the time of major rail accidents. The satellite will help to point out the exact location of the trains and topography. This new device will also help railways to secure unmanned level crossings with remote sensing facility. The trials for this system have been done on New Delhi-Guwahati and New Delhi-Mumbai Rajdhani trains on six electric locomotives.

Indian Railways aims to provide accurate train running information to all the passengers with this new GPS enabled tracking system. The RTIS system will help to improve the efficiency of train control. The emergency messaging between locomotive and control centre will become easier and hassle-free

4.1 Train Positioning Systems- Track Circuits /Axle Counters

Regarding Train Positioning, most of India's rail network uses track circuits and axle counters. Axle Counters have been specifically deployed in sections that are either flood prone (particularly the suburban sections of Mumbai) or where the satisfactory ballast conditions are difficult to maintain.

For automatic signaling between block sections, axle counters have now been decided to be used in future to avoid insertion of glued joints in long welded panel rails.

4.2 Balise /Track Magnets

For automatic protection systems (ATP), Balises and Track Magnets have been deployed. Balises are Euro Balises used for ETCS Systems. ETCS Level 1 systems (called Train Protection & Warning Systems) have been deployed in heavy passenger density sections (New Delhi Agra), Kolkata Metro, Suburban Sections of Chennai, etc.

Track Magnets have been used for Auxiliary Warning System (AWS) provided in EMU suburban trains in Mumbai. AWS was commissioned in late 1980s and was the first ATP system on Indian Railways. AWS is still working satisfactorily for more than three decades. The AWS is proposed to be replaced with CBTC (Communication Based Train Control) in next 4-5 years to meet the requirements of reduced headways and enhancing safety.

For metro rail projects, CBTC is now a defacto standard and Euro balises are provided as position markers for correction of odometry errors.

AWS Engine Magnet and Track Magnet

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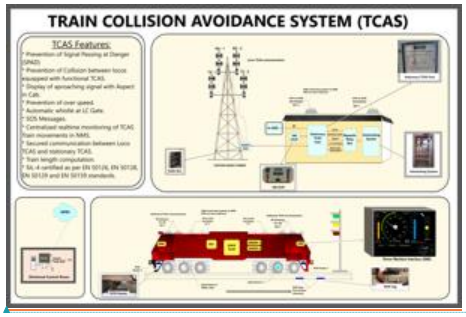
4.3 RFID

RFID (Radio frequency Identification) Tags have been deployed as a part of India's indigenous ATP system **Train Collision Avoidance System (TCAS).** The train position is transmitted through the passive RFID tags installed along railway lines/stations as train loco passes over the RFID tags. A RFID reader is installed beneath the Loco.

The TCAS has been developed for prevention of collisions, SPAD prevention and over speeding. TCAS uses GPS also for clock synchronisation.

For radio communication from Loco to the way side stations, spot frequencies in UHF in 400 MHz band are used. Presently, TCAS does not have voice communication.



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RFID Reader beneath Loco RFID Tag on Sleeper

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4.4 LTE in Indian railways

Indian Railways have been recently allotted spectrum of 5 MHz in 700 MHz for deployment of LTE. The 700 MHz spectrum shall be used for Railway Signaling, MCPTT Train Radio Communication, IoT based On-board Diagnostics, Passenger Information Systems, and limited Video transmission from Train to Stations & Control Room. TCAS may alsoconsider the use of LTE in future rail projects.

TCAS is being developed as a modern ATP system with ETCS Level 2 like functionalities. It has an advantage over ETCS Level 2 that it can be easily interfaced with both Electronic Interlockings as well as Relay Based Interlockings.

~~4~~5 Summary

The knowledge of the positions of all trains and other vehicles on the tracks in normal and high-speed operations is one of the essential information to provide for railway traffic control, passenger safety, and security of train operations. The information in this report are examples of APT Members' implementation of train poisoning application, for reference.

~~5~~6 Reference

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