Study on the Plan of the KRTCS technology development unrelated to Speed and Operational Environment

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ABSTRACT

In 21st century, many countries made more efforts to develop the railway transportation which is easily accessible under the slogan of Railway Renaissance. Meanwhile, the France TGV trains made a new record of the maximum operational speed of 574.8km/h on June 10th in 2007. And the study on safe Train control systems according to speed improvement was on the rise based on radio communication.

In this paper, we analyze the plan on KRTCS(Korea Radio Based Train Control System) technology development unrelated to speed and operational environment, which meet the demands of the times, and review the directions for R&D technology of future high-speed railway Train control systems

Key-Words: Railway Renaissance, Safe, Train control systems, Radio communication, KRTCS, Future high-speed railway Train control systems

1 Definition of Train control system

Some signal flags were used for train control system according to initial railroad traffic of low speed and low density, but train control system(Ground signaling) was performed by traffic light which is similar to road traffic according to increasing of train operation speed and the number of operational trains more and more. This train control system accords with technology development and developmental period, its study development is expanding into the field of train control on the vehicle(onboard signaling) for train safety and train speed automatic control, automatic train control based on radio and implement of manless driving system, RBTC(Radio Based Train control system) which used satellite[1]

Every control instruction of ground(wayside) and onboard related train operation defines TCS(train control system). The role of this system is to convey related information to the driver after judgment automatically to the direction of train operation, movement speed, distance between train and train, circumstance surrounding train and safety of railroad. For this purpose, TCS performs automatically visual and audible alarms and vehicle safety action[2]

TCS composes of movement monitoring of train and centralized train control(CTC) which deals with train operation, interlocking for deciding train course, and automatic train control which refers to control and command of train operation speed. CTC and interlocking is mostly given similar forms in the conventional line, speed railroad, metropolitan railroad, while automatic train control is classified of automatic train stop(ATS), automatic train protection(ATP), automatic train control(ATC), automatic train operation(ATO), automatic train supervision(ATS) etc., according to the using environment. These are used for accordance with each line characteristic by sorting the system.  

The common classification of TCS is given like figure 1, on standard of main transformation point. The first generation refers to TCS since 1930’s, it is ground signaling system through looking traffic light installed in the railroad by performing the driver’s operation and stopping. The characteristic
of first generation is that the speed of train is below 130km/h, movement of TCS is performed by electricity element. However, this TCS converts into the second generation added safety devices, TCS as a method of supplementation because of being flexible in responding to collision and crash accident arisen by performing train when driver neglects traffic sign according to train operation speed, increasing numbers of operation train.\[5\]

The development of second generation TCS was induced as a supplementation form of the first generation for preventing human victims and property loss from railway accident which mostly connected great disaster. To minimize train accident caused by vehicle collision and rear-end crash by driver’s mistakes, alarm signal conveys to the driver by safety devices(Beacon or Balise) installed in the tracks in case of excess the maximum operational speed given according to the color of traffic light. If the driver constantly neglects these alarms more than hours, the train will be automatically stopped. The ATS device introduced from Japan in 1960’s is using for this purpose in domestic, it is implementing this function as formal names such as AWS(Automatic Warning System), Indusi, Signum, ASFA in outside country.\[6\]

The new facilities, which means that conventional electricity elements substitutes into electronic elements were also used in the railway owing to the development of electronic technology in 1980’s. In addition, maximum commerce train operational speed is increasing up to 270km/h. Owing to this, an exclusive high speed train line generated and study on high speed train control system has been greatly changed based on rapid of train commerce operation in TGV eastern-southern line(france’s high-speed rail service) in 1987. In high-speed lines, safety by speed is given as the biggest matters of TCS assignment because train possesses characteristic of equal types performs within high speed in long distance line with constant time interval. In high-speed line, ATC device that is the meaning of train automatic control and numerous supplementation devices for safety introduced. The automatic train control device supplies train operation speed accordance with circumstance surrounding trackside to the vehicle through electrical circuit named as track circuit or loop cable. TCS which is provided information by track circuit has the presentative product, TVM used in France’s TGV, TVM430 which is using in Seoul-Busan high speed line is also same as this TVM and representative system using loop cable can be given a name to a system which is using in German ICE.\[1\][4]

The onboard computer of automatic train control device generates real speed suitable for train operation based on the condition of climate and environment surrounding trackside provided from safety device which consists of information provided from the ground, present state of train, and detecting device installed on track and trackside into the vehicle. The driver performs safety action given as displayed speed of only MMI and visual alarm. If these series of movement are uncertain, train performs automatic speed control or emergency control.\[2\]

The future railway classified of the fourth generation can be classified of initiative step which was recently developed and it is performing or testing, intended for finished developing in the immediate future and second step in the process of future train control system in the long term purpose. The characteristic of the fourth generation is that train operation speed(more than 300km/h) and it considered reduction of cost for safety, operation and maintenance by minimizing trackside facilities according to the concept of automatic driving(operation) which makes the most of radio and information technology. When the train passes by the border of nation the concept of transfer was introduced in the special case of high-speed train because the TCS is different between each nation but the operation method changed in order to get through border without needs of transfer by installing all TCSs which uses in each nation with each train(vehicle) in 1990’s. Some safety matters was produced on this operation method due to interference phenomenon which occurred by installing each signal system and lacking of vehicle space caused by various train control Systems which must be installed on the vehicle. TCS according to the passing through each nation and full knowledge of different language from all over the world were played up the biggest matter for the driver. The initial study for these matters have carried forward
on the center of France and Germany since 1985, its result revised Europe regulation related to railway for ERTMS/ETCS of 1998 in order to fulfill high-level safety, prevention monopoly of special company according to the opening market related TCS, competitiveness reinforcement of manufacturing company of railway goods, cost reduction, combination of Europe railroad network by Europe standard, internationalized train operation regulation.

[Figure 2]. An example of a multi-train control system is fitted

[Figure 3]. Commercial operation route of ETCS

2 The development propel case of wireless communication based TCS

The technology development of wireless communication based TCS on high-speed train has common cases such as Europe ETCS, China CTCs. ETCS development of Europe sympathized needs of RBTC by propeling ASTREE project based ATC system (SASEM) which uses in RATP for wireless communication based TCS after collision accident of France train in 1985. At the same time, related project was propelled by initial three nations by recognizing about needs similar with this system in Germany and Italy, these projects propelled ERTMS/ETCS projects for Europe railway unification with UIC, support of EU and products such as Alstom, Ansaldo, Thales, Siemens, Bombardier, Invensys which supplies signal system all over the world. It has spent for 16 years in early days because of the technology exposure of each production company, vested rights of established occupation market due to pursuit of profits and conflicts between each nation for adopting each nation’s technology of production company as a standard until commercialization of ETCS level 1 in 2001. The unification of market based on standard since then was propelled in Europe preferentially. It was investigated that production companies which take part in ETCS in the present are propelling actively into upgrading about the ETCS regulation by spreading all over the world production of ETCS due to be given with various forms the advantage of this system. The commerce operation of ETCS level 1 was gone into effect with Ebicab in Sweden, ZUB in Germany, and KVB in France in the name of ERTMS in order to unify conventional ATP system which used only in the past. Traffic Management Layer for efficiency of management, Global System for Mobile–Railway for unification of radio communication in railway, ETCS which means Europe train control system in accordance with train operation core points.

The development task and study of ETCS selected preferentially standardization about this based on the point that ATP system has the biggest advantage in driving which uses mingled with such as low speed freight train, a passenger train, conventional high speed passenger train etc and most countries in Europe carry out these combined driving. However, the study needs maximize of operation, maintenance and wayside safety by means of establishing on the center of the rolling stocks, minimizing wayside equipment by using wireless communication and IT technology in order to construct future TCS. After this study result, GSM-R project which takes charge in communication of ERTMS project began in the early 1990s in order to construct wireless communication network that uses GSM, mobile telecommunication method of Europe, its standardization specifications of ETCS Level 2 based on wireless communication began with propelling R&D such as EIRENE, MORANE etc, in 1995. The commerce operation started at the first time in Swiss in 2004. ETCS level 3 has established its concept since 2007, it is planning to propel commerce operation from 2017. It is same as CBTC in the field of function but utilization is targeted on conventional line train, high speed line train by means of setting another TCS functions which was not conducted in ETCS level 2 concept for construction of wireless.
a) ETCS level 1 configuration and characteristics

b) ETCS level 2 configuration and characteristics

c) RBTC System configuration and characteristics

The Europe operation of ETCS technology standard approved of much influence with construction similar types unification TCS, not only Europe but also all over the world that uses railway. In the case of Asia, these system is rapidly accordance with China which introduced early Europe railroad communication system GSM. In china, CTCS system was established by analyzing of domestic railway network and reviewing of those things, this system was classified as Level 0, Level 1, Level 2, Level 3, Level 4 according to each application target technology and it was prescribed. CTCS Level 0 and Level 1 are similar with ETCS Level 0, CTCS Level 2 is similar with ETCS Level 1, CTCS Level 3 is similar with ETCS Level 2, and CTCS Level 4 is similar with ETCS Level 3 in the case of types. All these mentioned above levels are accordance with concept of communication network and wireless communication. CTCS is classified by Level 0 and Level 1 while only ETCS Level 0 simplifies into line which is not installed with ETCS facilities. In contrary to Europe, the train is operated with most various on-board signal system, in the case of china, ground signal system and on-board signal system are coexisted with traffic light according to the line and it is operated by them. The ground signal system is classified with Level 0 (the lowest level) on-board signal system is classified with Level 1 in order to sort of both system. Also in the case of ETCS Level 2, track circuit conducted train detection. While balise is mainly used for train operation, CTCS Level 3 in china uses track circuit for information transfer and train detection, only balise has some difference by transferring trackside environment information but it is analyzed in the aspect of concept. CTCS Level 4 is analyzed that it is setting up the concept like ETCS Level 3, comparison between ETCS and CTCS is generally like below figure.

<table>
<thead>
<tr>
<th>Table 1. Level Comparison of CTCS and ETCS</th>
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<tbody>
<tr>
<td><strong>CTCS</strong></td>
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<tr>
<td>Level 0</td>
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<tr>
<td>Track circuits (Train detection) + Wayside signal</td>
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<tr>
<td>Level 1</td>
</tr>
<tr>
<td>Existing Track circuits + Train signal</td>
</tr>
<tr>
<td>Level 2</td>
</tr>
<tr>
<td>Track circuits (Train Operation Information Transmission) + Balise (Train Information) + Fixed block</td>
</tr>
<tr>
<td>Level 3</td>
</tr>
<tr>
<td>Track circuits (Train detection) + Balise (Train Information) + GSM-R (Train movement authority) + Fixed block</td>
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<tr>
<td>Level 4</td>
</tr>
<tr>
<td>Balise (Train Information) + GSM-R + Moving block</td>
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</tbody>
</table>

3 The technology development method of Korean RBTC

The review was pushed ahead based on conventional ETCS, CTCS, and current occupied various signal system and basic conception, which refers to step-by-step classification for establishment of KRTCS. The initial TCS was operated as a single system without division of conventional line, high-speed line and metropolitan rapid transit through signal, by mean of dividing TCS suited on each line characteristic by adding something such as safety facilities suited on high-speed railway, safety facilities suited on general railway and ATS & ATO function which is needed for automatic driving of metropolitan rapid transit to fit each operation environment and its development.
is propelled. However domain of conventional line and high-speed line has unified as same TCS by means of standard conception and speed up of conventional railways since 1980 and then they are operating. For instance, application domain was classified and approached in the step of initial development as application domain of ETCS Level 1 is conventional line and application domain of ETCS Level 2 is high-speed line. However, the eastern Europe where they are having difficulty in economy and most countries except for some countries among Europe which didn’t review about application of speed for speed-up. The single TCS utilization which combines conventional line and high-speed line was reviewed in priority by means of using ETCS Level 2 with improvement of speed on conventional line.

4 Conclusion
It has been more than 100 years since the demand for the development of train control system that is independent of the train speed has been raised and the ETCS system applicable for both conventional and high-speed rail is currently under development. In addition, when the wireless communication method is adopted, a number of advantages can be achieved and they include high density operation, train localization with high accuracy, continuous both-way data communication between vehicle and wayside, reduced Life Cycle Cost (LCC), reduced maintenance manpower and cost, and the automatic operation with higher safety, reliability, availability and maintainability.

The implementation of KRTCS enables not only the data transfer of non-vital information such as passenger information and surveillance, but also the delivery of vital information required in train operation. Therefore, it is one of the essential elements required for the development of optimal train control system independent of train operation speed. The use of wireless communication technology in KRTCS, where the main purpose is to be utilized in the train control system, enhances the compatibility and availability of the railway transportation with the surrounding environments. Moreover, in order to acquire the full advantages from such systems, it is important to make continuous effort for establishment of integrated railway wireless network and securement of radio frequency for the railway use only.

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