

CTCS—Chinese Train Control System

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Abstract

There are very similar features between Chinese Railways and European Railways in terms of train operation mode and train control. ETCS (European Train Control System), supported by the European Union and the European Industrials, has been finalized as the technical standard of train control systems in Europe after more than ten years effort. There is more than 71,500 kilometers of railway operation line in China, which includes conventional lines with a speed of 120 kilometers per hour, a dedicated passenger line with a speed of 250 kilometers per hour and the speed-raising lines with a speed of 160 kilometers per hour. A high speed line from Beijing to Shanghai with a speed of more than 300 kilometers per hour will be constructed in the next few years. Due to historical and technical reasons, there exist more than six kinds of railway signal systems for Chinese Railways. At present, there is no technical standard for Chinese train control systems. In order to ensure the safety and efficiency of train operation and to meet the requirements of modern technical development in railways, the concept of CTCS (Chinese Train Control System) was put forward in 2002 as the technical standard of Chinese train control systems by the Chinese Railway Ministry. In the paper, CTCS is introduced. Based on the present situation of Chinese train control systems and their development requirements, both in technical and management aspects, the frame of CTCS is described. The comparison between ETCS and CTCS is also made.

Keywords: train control system, automation, Chinese railway, European railway, railway signaling.

1 Introduction

At present, Chinese Railways are facing the great challenge. In the next twenty years, the Chinese Railway Network will be through the special periods of the



quick development and extension. There are 71,500 kilometers of line in operation in Chinese railways. With the development of the Chinese Economy, it is estimated that at least another 20,000 kilometers railway line is needed and will be constructed. In addition, the dedicated passenger lines and a high speed railway line will be constructed in the next few years. However, there are more than six kinds of signaling systems and they are not interoperable in the Chinese Railways due to the reasons of historical and technical development. Up to now, there is no standard for railway signaling on Chinese Railways. The existing signaling systems can not be interoperable, and the direction of the new signaling systems is not clear. The situation is very similar with that in Europe before the ETCS (European Train Control System) project began in 1992. There is urgent requirement for the signaling standard of the Chinese Railway. Under the standard, the future signaling systems and the existing signaling systems can be interoperable. The concept of CTCS (Chinese Train Control System) was put forward in 2002 for the Chinese railways by the Ministry of Railway. The working program for CTCS has been started since last year. The event is the milestone in the signaling history of the Chinese railways. It will be playing a very important role in ensuring the Chinese railway network construction and perfection, train operation safety and efficiency, and guiding the future development of the Chinese railway signaling.

CTCS is based on the situation of the Chinese Railways. It is different with ETCS, but it can learn from ETCS. There are very similar features between CTCS and ETCS since there are a lot of similarities in Chinese Railways and European Railways in terms of operation modes and signaling systems.

2 ETCS

ETCS is a subsystem of ERTMS (the European Rail Traffic Management System). Sometimes, it is described as ERTMS/ETCS. ERTMS includes ETCS (Euro-cab), GSM-R (Euro-radio), Euro-balise, Euro-interlocking and so on.

The background of ETCS is the requirements of the European railway network development. With development of European high speed railway network, apart from the different languages, there exists the strong barrier to cross-European borders since there are at least 15 different ATP systems in operation in Europe. Moreover, the ATP systems are incompatible and produced by their own suppliers. In order to make the systems be compatible and break the monopolies, the idea of ETCS was put forward. Supported by the European Union, the European researchers and the six main European railway signaling suppliers called as UNISIG, began to work for ETCS ten years ago.

The goals of ETCS can be described as the following seven aspects. The first one is interoperability which means that trains can be interoperable across borders and able to read signaling in different countries in Europe. It also requires the “operator interoperability” and “supplier interoperability”. The second one is safety. ETCS applications, even with level 0, will improve the safety of train operation by providing ATP or cab signaling. The third one is capacity. The simulation figures indicate that the line capacity can be increased

by from 10% to 30% after ETCS application in comparison with the existing line without ETCS. ETCS can especially improve the line capacity in busy areas since the ETCS can provide smoother train operation. The fourth one is availability. Under the ETCS standardization, there is no need for a train to be installed more kinds of on-board systems. It means less equipment, fewer interfaces and less connection. Moreover, tele-diagnosis and maintenance help dramatically increase the reliability and maintenance of the system. The fifth one is cost-effectiveness. ETCS means fewer products. In this way, its manufacturing cost and maintenance cost could be decreased dramatically. The sixth one is less on-board equipment. It means there is only one on-board system where a single and standardized Man-Machine Interface (MMI) is provided. The last one is open market. It means that monopolies for railway signaling in Europe will be broken. It is also the strong wish of the European Community from the start of the ETCS project.

The applications of ETCS are divided into several levels. They are Level 0, level STM, level 1, level 2 and level 3. Level 0 means that ETCS on-board system (ATP) is installed in locomotives running on the existing line without ETCS or national system or with ETCS system in commissioning. Level STM means that train is equipped with ETCS operating on a line equipped with a national system to which it interfaces by use of a STM. In the application of ETCS Level 1, apart from on-board system, balises or Euro-loops are added to the wayside system, and in-fill information transmission is implemented. With level 2, radio system (GSM-R) is applied between trains and wayside system, and the fixed block system is implemented. With Level 3, based on radio system, a moving block system is implemented.

Now, ETCS is now becoming a reality [4]. It is a very successful solution to railway signaling system in Europe and in the world. Most of ETCS test activities in France, Italy and the Netherlands have been concluded in 2002 or early 2003. ETCS commercial projects are rapidly coming all over Europe. During CTCS specification work, more experience concerning ETCS is expected.

3 CTCS

Like Europe, Chinese Railway is facing to remove the incompatible obstacle of the different signaling systems on the network. The European Railway needs ETCS, and the Chinese Railway needs CTCS. It is needed that signaling systems for high speed lines and conventional lines, passenger lines and freight lines are unified as a standardization, i.e. CTCS.

The purpose of CTCS is to define the signaling systems for Chinese Railways. CTCS will become the standard of the signaling systems in Chinese Railways. The existing signaling systems will be interoperable with the new signaling systems. In the future, all signaling systems, imported systems or home-made systems, wayside systems or onboard systems must be in line with the CTCS standardization. Apart from interoperability, the interface standard between the signaling systems, migration from existing signaling to CTCS, data



transmission format between the subsystems, safety and reliability, capacity increase, easy maintenance, lower investment and open market etc. are considered during CTCS working..

Based on the present situation of signaling system on Chinese Railway Network, CTCS will be divided into the several levels, referring to ETCS. CTCS is planned to be divided into the following five levels [1].

CTCS level 0. It consists of the existing track circuits, universal cab signaling (the digital, microprocessors-based cab signaling that be compatible with the six kinds of track circuits on Chinese Railway Network, designed by the research team of Northern Jiaotong University ten years ago) and train operation supervision system. With level 0, wayside signals are the main signals and cab signals are the auxiliary signals. It is the most basic mode for CTCS. It is no necessary to upgrade the wayside systems for CTCS level 0. The only way to realize the level 0 is to equip with the on-board system. CTCS level 0 is only for the trains with the speed less than 120km/h.

CTCS level 1. It consists of the existing track circuits, transponders (or balises) and ATP system. It is for the train with the speed between 120km/h and 160km/h. For this level, the block signals could be removed and train operation is based on the on-board system, ATP which is called as the main signals. Transponders (balises) must be installed on the line. The requirements for track circuit in blocks and at stations are higher than that in the level 0. The control mode for ATP could be the distance to go or speed steps.

CTCS level 2. It consists of digital track circuits (or analog track circuits with multi-information), transponders (balise) and ATP system. It is used for the trains with the speed higher than 160 km/h. There is no wayside signaling in block for the level 2 any more. The control mode for ATP is the distance to go. The digital track circuit can transmit more information than analog track circuit. ATP system can get all the necessary information for train control. With this level, fixed block mode is still applied. The system indicates the special feature of Chinese railway signaling. It is also called “a points and continuous system”.

CTCS level 3. It consists of track circuits, transponders (balises) and ATP with GSM-R. In the level 3, the function of the track circuit is only for train occupation and train integrity checking. Track circuits no longer transmit information concerning train operation. All the data concerning train operation information is transmitted by GSM-R. GSM-R is the core of the level. At this level, the philosophy of fixed block system is still applied.

CTCS level 4. It is the highest level for CTCS. Moving block system function can be realized by the level 4. The information transmission between trains and wayside devices is made by GSM-R. GPS or transponders (balises) are used for train position. Train integrity checking is carried out by on-board system. Track circuits are only used at stations. The amount of wayside system is reduced to the minimum in order to reduce the maintenance cost of the system. Train dispatching can be made to be very flexible for the different density of train operation on the same line.

The division of CTCS is only preliminary. It could be changed a little bit during CTCS working. However, the frame, the goals and the outline of CTCS

has been made out and described. According to the above definitions, the function requirements specification (FRS) and the system requirements specification (SRS) have been started by the Chinese colleagues.

4 Comparison of ETCS and CTCS

Before the comparison is made between ETCS and CTCS, the configuration of railway signaling system is defined. All the working concerning ETCS and CTCS are based on the configuration. As a matter of fact, the configuration of railway signaling system could be classified as the four parts. (1) Onboard system. (2) Wayside system. (3) Control center system. (4) Communication network including mobile communication [3]. It is also shown in the figure 1. As control center system, by the telecommunication network including mobile transmission, it has all the data for the system to calculate and control. For wayside system, it consists of sensors, actuators (signals and point machines) and RBC (Radio Block Center) etc. The communication network connects reliably and safely the control center with on-board system in trains, sensors and actuators installed along the line and at stations.

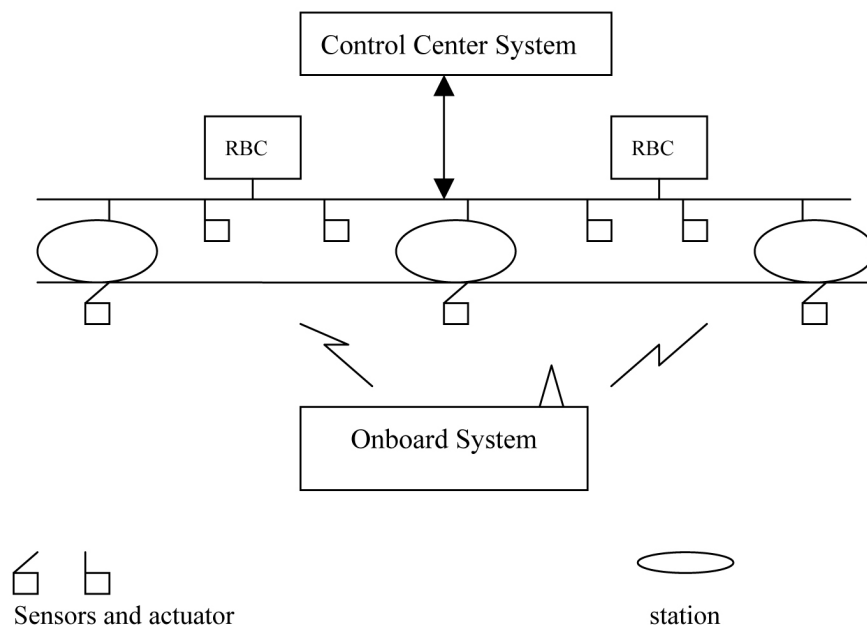


Figure 1.

The architecture of an on-board system is shown in the figure 2. It consists of on-board vital computer units, MMI, train speed measurements unit, train position unit, train integrity checking unit, radio receiver, train data recorder unit, train speed control interface etc.

The two figures give the overview of a railway signaling system as a whole. Both ETCS and CTCS are a universal, future oriented concept, based on the whole system. Their specifications ensure the interoperability of onboard device and wayside equipment in the different lines, in the existing lines and the new lines, produced by the different suppliers.

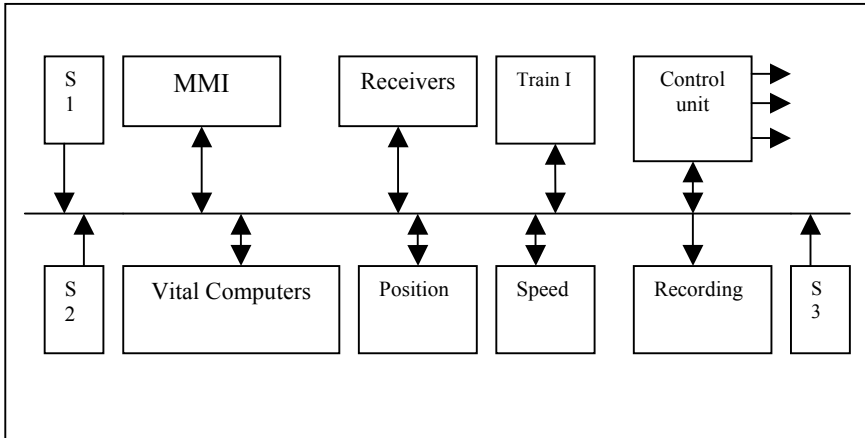


Figure 2.

Background and goals for ETCS and CTCS are very similar. They are respectively the development requirements of the European railway network and Chinese railway network. The key technical issues, such as interoperability, safety, reliability, vital computers for onboard system and control center, easy and less cost investment and maintenance, are the same in ETCS and CTCS.

It is decided by the Chinese Railway that GSM-R will be used as standard of radio system for CTCS.

Both ETCS and CTCS have put moving block systems as its highest level and the final target. This is the result of modern mobile communication development. Based on reliable and fail-safe communication, train control system (moving block system or train control system based on communication) become a close loop safety control system to ensure train operation safety and efficiency.

In CTCS, track circuits still play a very important role. On Chinese Railway Network, track circuit is mostly used and the basis of train control systems. It is not possible to construct CTCS without track circuit. This is the reality of Chinese Railway. The so called “ a point and continuous mode ” will be the special feature of CTCS. Moreover, MMI with Chinese characters is different with the MMI in ETCS. Research on MMI for onboard system have been done in Chinese railways.

In ETCS, balise is a very important device. The communication between onboard train system and wayside systems, positioning can be realized by balise. In CTCS, it is not decided what is used for position after track circuit is removed. We have our own transponder which has not been accepted as standard. Last

year, Euro-balises, produced by Siemens Signaling Company, have been applied in the dedicated passenger line from Qinhuang Dao to Shenyang.

In a word, there are a lot of common points between ETCS and CTCS. However, they are different. CTCS is a standardization of railway signaling system for Chinese Railway. Anyhow, it is true that CTCS could learn from ETCS during its construction process. It is hard and too early to say that ETCS and CTCS would come as a standard for railway signaling system in the world in the future.

5 Conclusion

It can be seen that CTCS is required urgently by Chinese Railway. The first step for CTCS is to finalize the FRS and the SRS according to the situation of Chinese Railway [5]. It is estimated that the project needs at least 3 or 5 years. Moreover, the government officials from the Ministry of Railway, the experts from railway industries and researchers from universities and research institutes must be involved in the projects. It is also recommended that some experts on ETCS from the European participate in CTCS project. To speed up the process of the project, the simulation center of CTCS should be built at the beginning of the project. After the finalization of the FRS and the SRS for CTCS, the center will become the test and verification center of CTCS systems and its products.

After 5 or 10 years, all the wayside signaling systems and onboard signaling systems on Chinese Railway will be in line with the standard of CTCS. It could be the domestic making products or imported products. The systems must be in series with the transport requirements of the line and interoperable.

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