Research and Analysis on the Top Design of Smart Railway

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Abstract. Deepening the informatization and intelligent construction of railways has become an inevitable choice to promote the innovation and development of railways and enhance their core competitiveness. At present, China has in-depth research in smart cities, smart transportation and other fields, but the research on smart railways is still in its infancy, and it is urgent to make plans for the development of smart railways to provide guiding suggestions for the development of railway informationization. Based on the research results of smart cities and smart transportation in related fields at home and abroad, combined with the application trends of internet technology and big data technology in railway informatization, this paper attempts to give a clear definition of smart railway from the perspective of smart city development. It also proposes the overall structure of the top-level design of the smart railway, and the application of the smart railway in combination with the development needs of the construction of the Jing-Zhang high-speed railway.

1. Introduction
The smart railway is a new stage of the development of intelligent transportation informationization, and it is the total integration and comprehensive embodiment of the railway informationization public service system. In 2010, the leadership of the Ministry of Railways, in conjunction with the need to change the way of railway development, proposed the development direction for the smart railway. It is expected to improve the overall capacity of the railway through the intelligent development of the railway, accelerated the transformation of the railway development mode, and realized the sustainable development of the railway. In recent years, China has been working hard in the direction of railway informationization. However, as of now, there is still no standardized norm in the field of smart railways. People's understanding of smart railways is rather vague. In the research of top-level design of smart railways, it is necessary to establish a conceptual model of smart railways, clearly define the connotation and characteristics of smart railways, and build a model of a smart railway architecture system, which will not only help deepen the understanding of the smart railway, but also play a guiding role in the development planning and construction of the smart railway.

2. Research and development of intelligent railways at home and abroad
Japan RTRI introduced the railroad system for the 21st century in 2000 - Cyber Rail (Digital Network Interconnected Railway). In 2005-2010, the EU invested in supporting the Inte GRail project to meet the development needs of the European railway system integration. In 2014, the EU proposed the Shift2Rail program, which is the first large-scale railway research and innovation project in the history of the European Union. In 2007, British rail operator Network Rail proposed the Intelligent
Infrastructure strategy, which changed the strategy of detecting faults in the infrastructure maintenance process to predictive avoidance, and finally avoided by design. In 2009, IBM proposed the Smarter Rail development concept based on the wisdom of the Earth strategy. It outlines the needs of the development of smart railways and the three key intelligent features that smart railways should have: more thorough perception, more comprehensive interconnection, and deeper intelligence. In 2017, China Railway Corporation set up a smart station forum at China Railway International Equipment Exhibition to discuss the application and development of smart stations at home and abroad. In summary, the smart railway is the development direction of railway informationization, the basis for realizing the sustainable development of green railways, and the overall embodiment of the railway modernization level. Therefore, the development of a clear intelligent railway architecture model is an effective way to solve the problems faced by China's railway informatization process, and will have a great significance for scientifically guiding the development and planning of smart railways.

3. Smart Railway Concept and Model

3.1. The concept of smart railway
Under the background of accelerating the construction of smart cities in China, railways are an important transportation channel between cities, and their information construction should also rely on emerging technologies. It should move from the traditional concept of “railway” to the “smart railway”. According to the current research status of railway intellectualization, the definition of smart railway is proposed in this paper:

Smart Railway refers to a railway transportation subsystem of intelligent traffic system in smart cities. It mainly uses new generation information technology such as Internet of Things, cloud computing, big data, satellite positioning and navigation, geospatial information, and artificial intelligence. It is a new system and new ecology that fully integrates with railway transportation planning to support, promote and guide the intelligent development of railway transportation. At the same time, it is also a comprehensive service platform and mobile information physics space on the railroad for mobile leisure, office, learning and consumption.

3.2. The overall architecture model of the top design of the smart railway
Smart Railway integrates new generations of information technology such as cloud computing and big data with railway management to build an intelligent information railway, and realize various services such as accessing various intelligent terminals online at anytime and anywhere in the railway operation. The main features are network ubiquitous interconnection, intelligent sensing, data sharing, business collaboration, and intelligent services.

The overall structure model of the smart railway is shown in Figure 1. It mainly includes the intelligent sensing layer, intelligent transmission layer, information resource layer, application support layer, application platform layer, standard specification management system and information security system.
4. The idea of building a smart railway

4.1. general idea
The construction of smart railways must adhere to the development concept of "innovation, coordination, green, openness, and sharing", adhere to the people-centered development thinking[^10], implement the development requirements of the "Thirteenth Five-Year Development Plan for Railways", and focus on the three core functions of smart railway transportation, operation services, and promoting industrial development, closely linked to the construction of smart railways, vehicles, stations, people "one main line". At the same time, it is necessary to work hard to promote the construction of a new generation of information infrastructure, enhance the smart development capability of the railway, and improve the railway service system to enhance the passenger service experience and strengthen security measures. In addition, it also need to complete the “five major tasks” of improving the information management and security support capabilities of smart railways, promoting the sustainable development of railway, promoting the construction of high-end cultural brands, and enhancing international influence.

4.2. Construction principles

4.2.1. Improve basic and safe development. It is necessary to adhere to the use of independent innovation technologies, products and services, accelerate the construction of railway safety and controllable information infrastructure, strive to improve the intelligent railway information governance and security support capabilities, improve the safety service guarantees of railway operation processes and emergency response capabilities of major events to promote the safe development of the railway.
4.2.2. **Green low carbon, energy saving and environmental protection.** In the process of railway planning and construction, Firstly, we must save resources such as land, line, passage, and promote the comprehensive development and utilization of railway stations and surrounding land. Secondly, it is necessary to strengthen railway environmental protection management, establish and improve railway environmental protection technical standards, assessment and evaluation systems and product certification systems. In addition, we should actively promote the application of new environmental technologies, new materials and new technologies, increase investment in environmental protection and the renovation and renovation of existing environmental protection facilities. Finally, comprehensive measures should be taken to effectively prevent noise and vibration along the railway.

4.2.3. **People-oriented, service-oriented.** It should adapt to the needs of integrated and high-quality travel services, revise and improve the railway passenger transport service quality standard system, strengthen the coordination of various transport modes, and actively carry out passenger transport services. At the same time, it is necessary to optimize the ticketing organization and services, further improve the 12306 network ticket sales, actively adopt Internet ticketing and mobile APP to purchase tickets, etc. Thereby improving the passenger train punctuality rate, improving the service quality of motor trains, improving the service level of ordinary passenger trains, and providing passengers with more good travel experience.

4.2.4. **Transforming and upgrading, improving quality and efficiency.** It is necessary to speed up the transformation of the railway development mode, accurately match the changes in transportation demand, and comprehensively improve service quality and operational efficiency. It will strengthen the integration with other modes of transportation and modern logistics, extend the service chain, tap the resources for revitalization, and enhance the capacity for sustainable development of the railway.

4.3. **The goal of building**
Through in-depth study and implementation of the spirit of the 19th Party Congress and the implementation of the "Thirteenth Five-Year Development Plan for Railways", this paper aims to improve the level of passenger transport services, firmly establish the awareness of safe production red lines, improve the level of rule of law in railway safety management, and save intensive use of resources. It is the construction goal to ensure the maximum energy saving and consumption reduction.

4.4. **Main task**

4.4.1. **Building a new generation of information infrastructure to enhance the ability of railway intelligence development.** It is necessary to build high-speed rail network, speed up railway fiber optic network coverage, with expansion capability gigabit access, to achieve a minimum bandwidth of 50 megabytes user subscription, the popularity of 100 megabytes. There will provide free broadband wireless access to users throughout the railway through the government's purchase of services, and gradually improve the IOT facilities for intelligent operation of railways. In addition, it will strengthen the integrated management of the object management object and the sensing device, and promote the sharing and integration of the IOT data.

4.4.2. **Strengthen security measures to improve smart railway governance and security capabilities.** It is necessary to strictly implement relevant standards and acceptance requirements to ensure the quality and safety of high-speed railway construction and comprehensively improve the safety management level of high-speed railways. In addition, it will establish a safety production situation analysis and early warning and emergency response plan mechanism to improve the ability to detect and prevent safety accidents, strengthen safety measures, and enhance the wisdom of railway management and safety.
4.4.3. **Improve the service system and enhance the passenger service experience.** It should give full play to the advantages of efficient, fast access and wide coverage of the railway transportation network, optimize organization and dispatch, deepen the potential of passenger transportation, and improve the network passenger transportation capacity. In order to meet the needs of integrated and high-quality travel services, it will revise and improve the railway passenger transport service quality standard system, strengthen the transport mode and cooperation of various modes of transport, and actively carry out passenger transport services to improve the passenger service level.

4.4.4. **Promote the sustainable development of railway green.** In the process of building a smart railway, it should give play to the comparative advantages of railways, advocate green travel modes, give full play to the role of railway backbone transportation, and accelerate the construction of a composite logistics channel and an energy-saving comprehensive transportation system with green railways as the backbone. In order to strengthen railway environmental protection management, it is necessary to establish and improve railway environmental protection technical standards, assessment and evaluation systems and product certification systems. Moreover, it will strengthen energy management, promote intelligent energy conservation control, and improve energy comprehensive utilization. Optimize transportation organization, improve transportation efficiency, and further reduce railway transportation energy consumption.

4.4.5. **Promote the construction of high-end cultural brands and enhance international influence.** It should make full use of domestic and foreign resources, and actively promote all-round external cooperation in China's technical consultation, construction, equipment manufacturing, transportation management, personnel training and technical standards, and promote the development of railway "going out" to the high-end direction of the industrial chain and value chain. We should actively follow the development trend of international railway standards, carry out comparative analysis of Chinese and foreign standards research, actively transform international standards suitable for China's national conditions, to build China's smart railway cultural brand and enhance international influence.

5. **Application demonstration in Jing-Zhang high-speed railway**

In order to build a smart Jing-zhang high-speed rail, the railway department actively adopts advanced technologies such as cloud computing, big data, Internet of Things, mobile Internet, artificial intelligence, BIM, etc., carefully designing, organizing and constructing, focusing on building quality projects to break through intelligence. Key technologies such as construction, intelligent equipment and intelligent operation will further improve the modernization level of railway safety production, operation management and passenger transportation services. The above design concept is consistent with the design idea of the smart railway in this paper. Therefore, the conceptual model designed in this paper is demonstrated in the Jing-Zhang high-speed railway, which has the meaning of reality and operability.

5.1. **Application scenario design**

5.1.1. **Smart train.** Smart trains refer to the intelligentization of railway mobile transport equipment and trains. Through the data transmission and communication platform, the smart train realizes the real-time information transmission between the on-board sensors and the reliable mass information transmission between the vehicle and the ground-to-vehicle. The train status information is perceived and monitored through the real-time dynamic digital platform and the operating environment digital platform. The model is to realize the modern detection of high-speed trains and the operation control of trains, and then to connect digitalization of power supply, line engineering and digitalization of geographical environment, and to establish a smart train customer service platform to achieve high-quality services during passenger travel.
5.1.2. **Smart infrastructure.** Smart infrastructure is the intelligentization of railway fixed infrastructure, including road networks, signal equipment and traction power supply equipment. It has automatic equipment such as station interlocking, line blocking control, signal control, traction power transmission control. It can more accurately and reliably support the realization of automatic identification of vehicle number, disaster prevention safety monitoring, traffic safety monitoring, emergency command and rescue, transportation resource management and other systems.

5.1.3. **Smart transportation guarantee.** Smart transportation security is the intelligentization of the railway transportation guarantee process, assisting in the automation of information processing and safety inspection and monitoring of railway equipment maintenance and repair operations, ensuring the reliable provision of transportation production resources and ensuring quality, and ensuring the efficiency and safety of the transportation production process. This article will make full use of communication technology, information technology, decision-making technology, geographic information and virtual reality technology to establish an intelligent emergency platform, timely and accurately grasp the situation, scientifically deploy various types of rescue resources, and create a multi-party collaborative meeting model to achieve complete, unified, efficient emergency information management and command coordination, effectively implement emergency rescue and disposal, and improve the ability of the railway to respond to emergencies.

5.1.4. **Smart management.** Smart management is data-centric, and comprehensively acquires information on transportation production, transportation market demand changes, and business management business process status through various components of smart railways. Among them, various decision support systems can predict the demand for passenger and freight transportation, analyze the current transportation plan's ability to adapt to transportation needs, infrastructure resources, operational efficiency of transportation resources, and completion of business plans, so as to adjust transportation production plans in a timely manner, and continue to optimize the line plan, adjust the allocation of capacity resources.

5.1.5. **Smart passenger service.** Smart passenger service supports a full range of passenger travel services, providing convenient ticket purchase methods, digitizing passenger identity information, providing passengers with information navigation, personalized information services and cross-modal passenger services. The intelligent user navigation service provides passengers with information on train schedules, travel and consignment, and assistance decision support. The smart passenger transport service timely releases railway transportation product information and various service contents, station and agent point distribution through the Internet. At the same time, the intelligent passenger transport service takes the passenger's demand as the optimization goal, and takes the train time, fare and train grade as the constraints, and provides the auxiliary optimization decision for the passenger travel planning through the intelligent optimization technology.

5.2. **Safety measures**

5.2.1. **Strengthen organizational leadership.** The national railway bureau should give full play to the organizational leadership and overall coordination role of industry standards work, and strengthen planning guidance. At the same time, the relevant departments and units will be guided to put the standard work in the strategic position of priority development, and will be included in the relevant department and unit work plan for key deployment and arrangement.

5.2.2. **Improve organizational management mechanism.** The construction and operation of smart railways adhere to the methods of politics, production, learning, research and media alliance. In light of the current situation of the railway, relevant departments set up operational entities with government, industry and academic research as the core, and promoted the construction and operation
activities of different modes with industrial funds as the guarantee. At the same time, government agencies should establish an efficient operation organization, continuously improve the standard operation mechanism and set up a special organization or committee to support the overall planning and design team and key project construction management team to carry out corresponding work.

5.2.3. Strengthen the construction of professional talents. It is necessary to give full play to the resource advantages of scientific research institutes in universities, encourage joint research and development of production, education and research, strengthen the discipline construction and talent cultivation in the field of smart railways, and focus on strengthening the cultivation of complex talents such as cloud computing and big data. The development of smart railway application demonstration and publicity can improve the information literacy, knowledge learning ability and information consumption level of the whole people. It is also necessary to improve the high-end informationized talent service system and introduce talents from key technologies and industries in the domestic and international smart railways and related fields.

6. Conclusion
This paper takes the application of Jing-Zhang high-speed railway as the research object, analyzes and studies the top-level design of the smart railway, clarifies the connotation and definition of the smart railway, deepens people's understanding and understanding of the smart railway, and proposes the overall design architecture model. It has a certain guiding role for the development of railway informationization in China. However, this paper stands in the perspective of the overall development of the smart railway. There are still many shortcomings in the preliminary exploration and research of the Smart Railway. The top-level design is a macro-plan that affects the subsequent development of the smart railway. In the future, it should be updated and improved in real time according to the development of the smart railway, providing powerful guidance for the information development of the railway.

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