Analysis and Research on the Railway Digital Engineering Certification System Establishment

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Abstract—Based on fully studying the current situation of digital certification at home and abroad, this paper analyzes the working basis of railway digital engineering certification from four aspects of technical conditions, organization, standards and qualification conditions, and puts forward the categories and fields of railway digital engineering certification. Finally, it puts forward the ideas and suggestions of railway digital engineering certification from four aspects of top-level design, standard system, personnel training and credit extension, analyzes and studies the pioneering work of railway digital engineering certification in an all-round way.

Keywords-Railway, digital engineering, digital certification, certification, system establishment

1 INTRODUCTION

Digital engineering refers to the digital, online, and intelligent management of whole process construction project involving all stakeholders by taking advantage of the building information model, cloud computing, big data, Internet, artificial intelligence and other new-generation information technologies combining advanced lean construction theoretical methods. Digital engineering certification is a third-party certification for the service level and achievements of digital engineering providers as per the requirements of relevant standards, to evaluate the service performance of the digital engineering, improve the collaborationefficiency among the parties concerned and improvethe engineering quality[1]. Digital engineering certification will help to improvethe standardization and accuracy of digital asset, guarantee the quality and safety of digital assets, improve the overall service level of the industry, enhance mutual trust and demonstrate the digital delivery and service capabilities of digital engineering suppliers to international owners in the international engineering contracting market. Digital engineering certification will be the core competitiveness of and a key driverfor the future industry development.

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From 2015 to 2020, the State Council, the Ministry of Housing and Urban-Rural Development, and the Cyberspace Administration of China have successively issued the documents on digital transformation and mutual recognition of certification, stating that an assessment mechanism should be established. Digital certification has been highly concerned by relevant national authorities and supported by relevant policies.

2 Current Situation of Domestic and International Digital Engineering Certification

2.1 Current Situation of Digital Engineering Certification in China

Digital engineering certification as something new involves a series of procedures such as standard preparation, inspection and testing, recognition and acceptance. Therefore, it is mostly promoted by industry associations or alliances together with other organizations on the basis of relevant international standards and local institutional guidelines. In China, the certification in domestic market is mainly conducted by China Digital Engineering Certification Alliance and China Construction Testing and Certification Union. The main progress is shown in Table 1.

TABLE 1. List of Relevant Domestic Digital Certification Authorities

Organization	Secretariat	Date of Establishment	Digital Certification Related Directory	Typical Cases
China Digital Engineering Certification Alliance	Beijing ZhongJianXie Certification Centre Co., Ltd	2019	It includes digital engineering software information environment evaluation, hardware information evaluation, digital engineering project service certification, enterprise BIM center star service certification, and enterprise digital engineering management system certification	More than 40 projects and units including Shanghai Tower, Tianjin Chow Tai Fook Financial Center, BCEG No.3 Construction Engineering Co., Ltd. and CRRC Information Technology Co., Ltd.
China Construction Testing and Certification Union	China Institute of Building Standard Design & Research	2015	Construction enterprise prefabricated building quality management system certification, construction enterprise excellent quality management system certification, BIM technical service certification, BIM personnel professional skills evaluation, and BIM project certification	China Railway First Group Co., Ltd. (CRFG), China Railway No. 2 Engineering Group Co., Ltd. (CREGC), China Railway Electrification Engineering Group Co., Ltd., China Railway No.8 Engineering Group Co., Ltd., The Second Construction Co., Ltd. of China Construction Third Engineering Bureau

2.2 Current Situation of Digital Engineering Certification at Abroad

International digital engineering certification is mainly based on ISO 19650 series standards, without unified certification system. Diversified digital engineering certification services are provided by organizations according to their own characteristics and business requirements. The international digital engineering certification activities are also at an early stage asthose in China. The number of organizations currently active is relatively small, and most of them are British organizations, which is mainly because of the British government's policy support for BIM Level 2. At present, BSI, BRE and Lloyd's Register are the most influential organizations to carry out digital engineering certification business in the world.List of Relevant International Digital Certification Organizations in Table 2.

TABLE 2. LIST OF RELEVANT INTERNATIONAL DIGITAL CERTIFICATION ORGANIZATIONS

Certification Organizations	**Certification Scope**	**Applicable Standards**	**Certification Performance**
British Standards Institution (BSI)	Enterprise-level Kitemark certification, project-level Kitemark certification and verification, BIM digital product Kitemark certification and verification.	ISO 19650-1，-2，-3；PAS 1192-5；BS 8541-1,-3,-4	Dubai Roads and Transport Authority, Wanda Group, CCCC Second Harbor Engineering Company Ltd., China Construction First Group Corporation Limited, China Construction First Group Construction & Development Co., Ltd., China Construction Second Engineering Bureau Ltd., China Construction Fourth Engineering Division Corp. Ltd., China Construction Eighth Engineering Division Corp. Ltd. , China Shanghai Architectural Design & Research Institute Co., Ltd., Chongqing Architectural Design Institute, etc.
British Research Establishment Group (BRE)	Certification of personnel and enterprises. Personnel certification includes ISO 19650 task information management personnel evaluation, project information management personnel evaluation and BIM professional evaluation, and is applicable to managers, consultants, trainers and professionals of BIM projects. Enterprise certification includes BIM Level 2 pre-assessment	ISO 19650 series standard	There are a total of 68 organizations subjected to BIM Level 2 business system certification, and 4 organizations subjected to pre-evaluation.

	and BIM Level 2 business system certification.		
Lloyd's Register of Shipping (LR)	Own LR BIM certification system	Based on ISO 19650 standard, while introducing the principle of business best practice into the evaluation scope, and absorbing the useful parts of other relevant certification systems.	It has developed into one of the world-leading professional service providers in engineering and technology, helping customers in more than 75 countries around the world to improve the safety of critical infrastructure and improve their performance.

3 BASIC ANALYSIS OF RAILWAY DIGITAL ENGINEERING CERTIFICATION

With the rapid development of digital technology, all the industries are actively seeking for digital transformation. As a main part of national infrastructure investment and the backbone for macroeconomic development, railway construction has been maintaining a strong momentumfor years. In the meanwhile, the railway construction projects are becoming more and more "digital", with more BIM solutions and digital applications for engineering design and simulation, factory processing, precise measurement and control, automatic installation, virtual construction, collaborative management, dynamic monitoring applied. However, at present, there is not a complete railway digital certification standard system in place in China to evaluate whether the data deliverables meet the requirements, and there is no evaluation system for the safety, applicability and standardization of digital engineering. It is necessary to establish a digital engineering certification system to standardize the quality of digital engineering

3.1 Current Technologies

At present, intelligent high-speed rail technology ssytem 1.0 has been established for China railways, including packaged technical solutions for related core key technologies, locomotive & rolling stock, standards and specifications, big data applications, etc. A large number of railway digital engineering solutions have been developed with BIM as the core, which are also widely used in railway projects. A lot of valuable experience has been accumulated. For future intelligent high-speed rail, version 2.0 covering the whole industrial chain from railway design, construction to operation, and version 3.0 supporting full ATO will be established, with railway digital technology system taking shape. The integration of BIM with other digitaltechnologies will serve as the backbone for railway digital transformation.

3.2 Organizational Structure

In 2013, initiated by China Railway Corporation, China Railway BIM Alliance was established by 8 organizations including China Academy of Railway Sciences and China Railway Design Corporation, with more than 90 members nowadays, covering the top level design, research, construction and R&D organizations in the railway sector of China, and has the capabilities to undertake digital engineering certification inspection and testing. Since the establishment of the Alliance, the strategy of "standards first" has been defined. The Alliance has developed and released 15 railway BIM group standards, and carried out the standards verification and improvement in different disciplines at differentlevels, constructing a series of railway projects supported by BIM technologies with theIntelligent Beijing-Zhangjiakou Railway as a typical project[2]. China Railway BIM Alliance actively promotes the Chinise BIM standards to go global. As a strategic member of buildingSmart, it leads the development of railway IFC standardsand has a considerable voice in the international BIM standards. China Railway BIM Alliance plays an important role in promoting the application and development of railway BIM Technology at both home and abroad.

In 2019, "China Digital Certification Alliance" was established and officially started the work of digital engineering certification. China Railway BIM Alliance was invited to join the organization as the vice-chairman organization to closely capture the development trend of national digital certification and actively organize members to shape up the railway digital certification system.

As the only BIM-focusing organization in the industry, China Railway BIM Alliance has a good basis and abundant resources to lead the railway digital engineering certification work and in the meanwhile, it can also assure the authoritativeness and fairness of the certification to the greatest extent.

3.3 Current Standards

At present, the international digital certification is based on the series standards of international standard ISO 19650

- ISO 19650-1:2018 ORGANIZATION AND DIGITIZATION OF INFORMATION ABOUT BUILDINGS AND CIVIL ENGINEERING WORKS, INCLUDING BUILDING INFORMATION MODELLING (BIM) — INFORMATION MANAGEMENT USING BUILDING INFORMATION MODELLING — PART 1: CONCEPTS AND PRINCIPLES
- ISO 19650-2:2018 ORGANIZATION AND DIGITIZATION OF INFORMATION ABOUT BUILDINGS AND CIVIL ENGINEERING WORKS, INCLUDING BUILDING INFORMATION MODELLING (BIM) — INFORMATION MANAGEMENT USING BUILDING INFORMATION MODELLING — PART 2: DELIVERY PHASE OF THE ASSETS
- ISO 19650-3:2020 ORGANIZATION AND DIGITIZATION OF INFORMATION ABOUT BUILDINGS AND CIVIL ENGINEERING WORKS, INCLUDING BUILDING INFORMATION MODELLING (BIM) — INFORMATION MANAGEMENT USING BUILDING INFORMATION MODELLING — PART 3: OPERATIONAL PHASE OF THE ASSETS

- ISO/CD 19650-4 ORGANIZATION AND DIGITIZATION OF INFORMATION ABOUT BUILDINGS AND CIVIL ENGINEERING WORKS, INCLUDING BUILDING INFORMATION MODELLING (BIM) — INFORMATION MANAGEMENT USING BUILDING INFORMATION MODELLING — PART 4: INFORMATION EXCHANGE
- ISO 19650-5:2020 ORGANIZATION AND DIGITIZATION OF INFORMATION ABOUT BUILDINGS AND CIVIL ENGINEERING WORKS, INCLUDING BUILDING INFORMATION MODELLING (BIM) — INFORMATION MANAGEMENT USING BUILDING INFORMATION MODELLING — PART 5: SECURITY-MINDED APPROACH TO INFORMATION MANAGEMENT

Since 2017, China has successively released the Unified Standard for Application of Building Information Models (GB/T51212-2016) and the Application Standard for Construction of Building Information Models (GB/T51235-2017), while these standards cannot be used as certification standards. In 2020, China Digital Engineering Certification Alliance released four standards which can be used as digital certification standards.

- DNQI-003-2020 Certification of Building Information Model (BIM) in Information Technology Environment: Computer Software
- DNQI-002-2020 Certification of Building Information Model (BIM) in Information Technology Environment: Computer Hardware and Software
- DNQI-001-2020 Certification of Project Information Model (BIM): Project
- DNQI-004-2020 Star Rating Standard for Enterprise BIM Center

The 15 standards released by China Railway BIM Alliance have jointly established the railway BIM standard system, which laid a solid foundation for railway BIM development as well as the basis for railway digital engineering certification. However, there is lack of standards at the implementation level of different railway subsystems[3]. See Table 3 for the list for the standards of China Railway BIM Alliance.

TABLE 3. LIST FOR BIM STANDARDS OF CHINA RAILWAY BIM ALLIANCE

S/N	Description	Organization Standard No.	Release Date
1	Railway Engineering Entity Structural Decomposition Guide (Version 1.0)	T/CRBIM 001-2014	2014/12/30
2	Classification and Coding Standards for Railway Engineering Information Model (Version 1.0)	T/CRBIM 002-2014	2014/12/30
3	Data Storage Standards for Railway Engineering Information Model (Version 1.0)	T/CRBIM 003-2015	2015/12/29
4	Data Storage Standards for Information Model of Railway Communication, Signal, Power and Electrification (Version 1.0)	T/CRBIM 004-2016	2016/7/7
5	Expression Standards for Railway Engineering Information Model (Version 1.0)	T/CRBIM 005-2017	2017/9/5

6	Preparation Methods for Railway Engineering Construction Drawing Design Documents Based on Information Model (Version 1.0)	T/CRBIM 006-2017	2017/9/5
7	Delivery Accuracy Standards for Railway Engineering Information Model (Version 1.0)	T/CRBIM 007-2017	2017/9/5
8	Delivery Standards for Geographic Information for Railway Engineering Information Model Application (Version 1.0)	T/CRBIM 008-2017	2017/9/5
9	Guidelines for WBS Work Item Decomposition of Railway Engineering (Version 1.0)	T/CRBIM 009-2017	2017/9/5
10	Guidelines for Preparation of Railway Engineering Quantity Standard Format (Trial)	T/CRBIM 010-2017	2017/9/5
11	Guidelines for Preparation of Railway Engineering Information Exchange Template (Trial)	T/CRBIM 011-2017	2017/9/5
12	Implementation Standards for Railway Engineering Information Model in Design Stage (Version 1.0)	T/CRBIM 012-2018	2018/12/6
13	Implementation Standards for Railway Engineering Information Model in Construction Stage (Version 1.0)	T/CRBIM 013-2018	2018/12/6
14	Standards for Metadata of Railway Infrastructure (Version 1.0)	T/CRBIM 014-2019	2019/11/18
15	Management Specifications for Metadata of Railway Infrastructure (Trial)	T/CRBIM 015-2019	2019/11/18

3.4 Qualifications

According to the Regulations of the People's Republic of China on Certification and Accreditation, the organizations to carry out a third-party certification must has a registered capital of not less than RMB 3 million, more than 10 full-time professional certification staff, and shall be accredited by China National Accreditation Service for Conformity Assessment (CNAS) after being approved by Certification and Accreditation Administration of the People's Republic of China (CNCA). In the process of product certification, CMA testing qualification recognized by the state is also required. At present, China Railway BIM Alliance does not possess the qualifications mentioned above. As a non-profit organization, the Alliance fails to meet the application requirements of registered capital and personnel qualification, so it cannot apply for certification qualifications, nor have CMA testing qualification. Thus, it cannot carry out certification work independently. China Digital Engineering Certification Alliance is an organization with digital certification qualification, but it does not have CMA testing qualification. A member of China Railway BIM Alliance China Academy of Railway Sciences has the qualification of railway product certification, as well as the inspection organization and laboratory accreditation issued by CNAS and CMA qualification certificate issued by Certification and Accreditation Administration of the People's Republic of China (CNCA), but it does not have the qualification of digital engineering certification and needs to be submit additional application on the existing basis. China Railway BIM Alliance can integrate the existing qualification resources of external organizations and members by means of cooperation to carry out digital certification and testing.

4 DIGITAL ENGINEERING CERTIFICATION AREAS

Targeting the current situation of railway digital engineering business and considering the certification areas of China Railway Digital Engineering Certification Alliance, railway digital engineering certification can be divided into three categories: product certification, service certification and management system certification, and each category can be expanded according to the specific business development in Table 4

TABLE 4. DIGITAL ENGINEERING CERTIFICATION

Product certification	Engineering digital software information environment
	Engineering digital hardware information environment
	Survey and mapping engineering
	Alignment engineering
	Subgrade engineering
	Bridge and culvert engineering
	Tunnel engineering
	Track engineering
	Station and yard engineering
	House building engineering
	HVAC engineering (including indoor water supply and drainage and environmental control)
	Communication engineering
	Signalling engineering
	Information engineering
	Power engineering
	Traction substation engineering
	OCS engineering
	Off-site water supply and drainage
	Geology
	Engineering economy
	Environmental protection
	Locomotive, rolling stock and machinery
	Rolling stock
	Engineering machinery
	…….
Service certification	Service certification
	Digital engineering project service certification for owners
	Digital engineering project service certification for general contractors
	Digital engineering project service certification for survey and design contractors
	Digital engineering project service certification for construction contractors
	Service certification for digital centers (big data centers)
	Service certification for equipment manufacturers
	……
Enterprise management system and	Digital engineering information management system certification based on ISO 19650
	Information security management system certification

personnel capability	Information technology service management system certification
	Quality management system
	Environmental management system
	Occupational health and safety management system
	Supply chain system
	Energy management system
	Business continuity management system certification
	Innovation management system certification
	Asset management system certification
	Enterprise credit management system certification
	Green data center certification
	Grass-roots technical personnel of digital engineering
	Project management personnel of digital engineering
	System development personnel and senior management personnel of digital engineering
	……

Railway digital engineering product certification mainly tests and certifies the deliverables of digital assets and the overall digital delivery assets of engineering projects. It mainly includes engineering digital software information environment, hardware information environment and railway professional products such as surveying and mapping, line engineering, subgrade engineering and bridge and culvert engineering.

The service certification mainly certifies digital service processes such as the creation and use of digital assets, which mainly targets digital engineering owners, general contractors, survey and design contractors, construction contractors, digital centers (big data centers) and equipment manufacturers.

The management system certification is aimed at enterprise management system and personnel certification, including digital engineering information management system certification, green data center certification, digital engineering project management personnel certification, which is the enterprise management system certification and digital engineering personnel certification.

5 SUGGESTIONS ON RAILWAY DIGITAL ENGINEERING CERTIFICATION

The railway digital engineering certification shall start from the top-level design, standard system, talent training, acceptance and promotion, etc.As shown in the figure1.

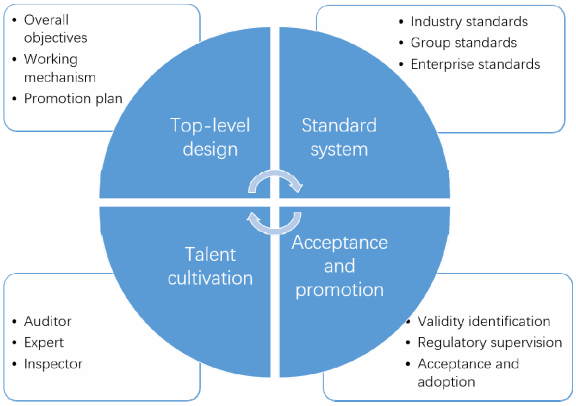

Figure 1 Railway Digital Engineering Certification

5.1 Improving Top-level Design

The top-level design includes the overall objective, working mechanism and promotion plan of digital certification. The overall objective of railway digital engineering certification is to establish a certification system of the Alliance that conforms to the characteristics of the railway industry and guarantees the benefits and interests of railway undertakings,so as to promote the cooperation among railway design, construction, operation and maintenance parties and form a unified closed-loop certification system. Establish a set of orderly and efficientworking mechanisms characterized by open sharing, coordinated development and enhance strategic cooperation with "China Digital Engineering Certification Alliance" to realize experience and knowledge sharing, integrate internal certification, inspection and testing qualification resources of members and mobilize the strength of members, to jointly promote the establishment of railway industry certification system framework, and realize domestic mutual recognition of certification results. By taking advantage of China Railway BIM Alliance's buildingSMART international strategic membership, work together with buildingSMART China branch to jointly promote international cooperation and mutual recognition of certification system.

Two-year, five-year and ten-year plans are formulated for the overall promotion for different stages. Within two years, the working mechanism of railway digital engineering certification is determined; the certification system framework is formed; disciplines, projects and organizations with certain capabilities in terms of capabilities, levels and qualifications of railway digital products are selected as certification pilots; corresponding certification standards and detailed rules are prepared to form a good demonstration effect. Within five years, pilot projects are selected for all disciplines of railway digital engineering certification; the certification standards and detailed rules of each discipline are basically complete; the digital certification system certification and testing system are basically in place; the acceptance and mutual recognition of digital certification results are generally recognized. Within ten years, the railway digital engineering certification system is proven and fully integrated with international standards.

5.2 Continuous Improvement of Standard System

Railway digital engineering certification standards are divided into six parts: BIM related standards in international ISO based on, national BIM related standard based on, BIM related standards in other industries, railway BIM standards, standards and specifications for railway digital engineering testing and certification that need to be expanded, and standards and specifications for railway digital engineering testing and certification that need to be re-developed. The railway industry can be provided with a digital engineering certification standard system established based on the five-dimensional combination of international, national, industry, group and enterprise. Guided by international, national and industry standards, focusing on Alliance's group standards, according to the digital certification work plan and the principle of classification and batch, relying on alliance members, a unified, open and shared standard development order is formed, and finally a complete railway BIM standard system with points, planes, networks and bodies is formed.

The 15 railway BIM standards currently issued by the Alliance are railway BIM technology and basic standards for implementation. For specific certification categories, it is necessary to prepare certification standards, guidelines and detailed rules at the practical level in combination with specific businesses [3]. China Railway BIM Alliance has issued the Management Measures for Group Standards of China Railway BIM Alliance, which has become a strong support for the preparation of digital certification standards. If there is no applicable standard for the certification area to be carried out, standard preparation shall be organized according to the relevant provisions of the group standards of the Alliance. The Alliance can take appropriate incentive measures to encourage its members and other organizations to participate in the preparation of standards. The certification organizations prepare certification rules according to the certification areas issued by the Alliance, and report them to the Certification and Accreditation Administration of the People's Republic of China (CNCA) and the Alliance prior to certification activities.

5.3 Talent Training

Talents are the foundation of digital engineering certification. It is necessary to build a high-quality railway digital engineering certification talent team, covering certification, testing, standards, BIM technology and other dimensions, so as to form a digital certification talent team with reasonable structure including internal auditors, external auditors, experts and inspectors. It is required to develop a scientific and reasonable personnel training system and form a systematic training plan for railway digital certification. Universities, Research Institute of China Academy of Railway Sciences, external certification organizations and the like can be allied for proper organization of strength of BIM Alliance members, and cultivate talents through training, dispatching and exchange, project practice and other ways. Active efforts shall be made to be in agreement with international organizations such as the international BIM alliance, and explore digital certification synchronized with the international community.

5.4 Certification Acceptance and Promotion

It has become a common practice in developed countries to provide fair and impartial third-party certification results to administrative organs for adoption. Acceptance of a third-party

certification is a win-win creative measure, which not only makes full use of third-party certification resources, but also further expands the third-party certification market, promotes the legality and standardization of certification behavior, and provides favorable support for the decision-making of government agencies. The development of railway digital engineering certification needs to vigorously promote the acceptance of railway industry authorities and improve the operational guarantee mechanism for the acceptance of certification results, to realize the parallel acceptance and regulatory supervision, and effectively improve the effectiveness of certification, which is related to the healthy development of certification, the reputation and value of certification work, and the needs of users and the interests of enterprises[4]. Improvement of the effectiveness of certification depends on the practical publicity and strict audit of certification organizations, the correct needs of certification organizations and the improvement of the quality of certification practitioners, as well as the joint efforts of certification regulatory departments and relevant parties[5].

6 PROSPECTS AND OUTLOOK

At present, the industry digital development is an important strategic deployment at the current stage in China. The CPC Central Committee and various ministries and commissions have issued many documents to promote the application of digital technology. Today, rapid progress has been made in technology, including in many industries such as manufacturing industry and construction industry, which have been trying for many years and have made great achievements. From the international front, developed countries in particular, great importance are also attached to digitalization, and certification activities related to digital engineering have been carried out. The digital development of China's railway sector is in a spiral upward trend, with varied level of digitalization services. There is a lack of standard system and conformity assessment technology to standardize the digital service capability and service achievements of the industry. Therefore, the establishment of railway digital engineering certification system will promote the effective implementation of national policies in the railway sector, improve the digital technology application and service quality of the whole industry, and lead the development of the industry. Taking advantage of the influence of BIM Alliance in the international BIM field, active efforts shall be made to contact bSI and other internationally well-known organizations, which will help seize the opportunities in the international digital certification areas.

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