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Digital Railway System

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1. Introduction

1.1 General framework of digital railway system

1.1.1 Construction background of digital railway system

Digital Earth ^[1] refers to the concept proposed by former US vice president Al Gore in 1998, which is described as a virtual representation of the Earth that is spatially referenced and interconnected with the world's digital knowledge archives. Digital Earth promises to make the unified representative and recognition about the real earth and related phenomenon. Specifically it based on computing technology, multimedia technology and large-scale storage technology, interconnected with broadband network, the use of vast amount geo-referenced information to present earth in three-dimensional description of multi-resolution, multi-scale, multi-dimensional and multi-species, the use of information technology to process the entire planet's natural and social activities of various aspects, maximize the use of geo-information resources, and take it as a tool to transform nature and society, to promote the development of human civilization. Digital Earth is considered to be the best way of integrated use of shared data and information resources available, and the main and core body in the process of sustainable development with information resource. Digital Earth will play important role in social development, economic construction, and national security.

Digital Earth has raised the attention of governments, around support for "Digital Earth" concept and the development of key technologies, and set off a new round of information technology infrastructure and applications development boom on a global scale. Increasingly it has formed a lot of strategic directions, such as Digital China, Digital Government, Digital City, Digital Transportation, Digital Agriculture, Digital Meteorology, etc. National information infrastructure, national spatial data infrastructure and a large number of high-tech project started, and Digital Earth related computing science, large-scale storage, high-resolution satellite images, broadband network, spatial information technology, interoperability and metadata, visualization, and virtual reality, etc. technologies achieved breakthrough progress, and shown great potential for innovation.

With the concept of Digital Earth and Digital China in-depth development and popularization, continue to promote the theory and technology, accelerating the pace of project construction, the concept of Digital Railway gradually formed in the railway

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industry. Digital Railway should be the strategic objective of China railway modernization in the 21st century.

1.1.2 Connotation and essential characteristics of digital railway system

1.1.2.1 Definition

Digital railway is new railway information system, which researches digitization of the railway infrastructure (lines, bridges and tunnels, stations, signal system, etc.), mobile equipment (locomotives, cars, EMUs (Electrical Motor Units), etc.) and railway environment (dynamic and static information, multi-resolution and 3D information) based on geographical information system (GIS), Global position system (GPS), Remote system (RS), information system, Internet of Things, virtualization, information integration, etc. to realize overall management and vivid indications of the railway transportation capacity resources and service resources. It internally supports Railway Transport Organization, Passenger & Freight Transport Marketing Services, Enterprise Business Operation Management needs, externally supports visual display of the whole process of passenger travels, freight transportation and query, and synthesizes internal and external information to provide visualization integrated decision support for managers at all levels. It is based on the improvement and transformation of existing railway information system, and has an important role in enhancing the railway management, the level of service and images, and ensuring transport safety [2].

1.1.2.2 Connotation

The concept of Digital Railway has two levels of connotations: the meaning of the first level corresponded with the Digital Earth, is a multi-resolution, three-dimensional representation of China Railway locomotive, car, permanent way, communication & signal, traffic management, etc. related information, and integrated with geographic coordinates, then embedded with large-scale railway associate geographic data and management information; and at the second level, through proper storage management and process with all kinds of data, to make digitalized management for railway transportation industry. Digital dynamic information referenced with static, with a high degree of immersion and presence, in order to facilitate interaction and understanding of the expression to show to the user, makes huge railway system across the country to reproduce the true decision-makers at all levels, to provide a basis for supporting decision-making and production command. Digital Railway will be powerful information infrastructure and resource to support railway modernization construction and operation, and give the decision making organization of railway system the capabilities of meaningful operation, planning and strategy capabilities, and finally realize the idea of "railway in hand". The ultimate goal of the construction of Digital Railway is for servicing with digitalized management to different departments of railway.

In summary, Digital Railway included three aspects of connotation: (1) Digital Railway is a strategic thinking about 21 century China railway modernization development, that will propose integration needs for railway planning, specification, technology, especially information. (2) Digital Railway is a dynamic information mega-system, which provide open, distributed computing capability and full range of services; (3) Digital Railway is virtualized railway, as a digital understanding and reproduction of real railway and its operation [3].

1.1.2.3 The necessity of construction

With the trend of intelligent, green and sustainable development in today, construction and development of Digital Railway still has significance. Digital Railway is the foundation to

realize Intelligent Railway development [13], as well as the content of basic building during railway informatization, and the needs of railway modernization for now and the objective of the future.

Government attaches great importance to the development of national railway, invested heavily in rail infrastructure, especially large-scale passenger line construction. In 2010, China railway mileage will reach 110,000 kilometers, among others, above 200 kilometers per hour and intercity passenger rail line will reach 13,000 km, achieve separating from passengers and freights on busy main line, and a large number of modern integrated transport hub in operation. At the period of great construction and development, various kinds of new business applications are emerging, and made strong demand for railway information. At the same time, for the upcoming large-scale railroad network system, existing decentralized information processing methods of information management systems cannot meet the needs of rapid development of railway operations. That makes urgent needs for modern information technology to carry out in depth research and comprehensive application of railway information resources, integrated utilizing geographical information technology, global positioning technology, remote sensing technology, multimedia messaging technology, intelligent image processing technology, virtualization reality technology and network communication technology, etc., and based on information technology promote Digital Railway construction, use of railway information resource, serving railway business operation, to enhance the level of railway operation and management to provide technical support.

1.1.2.4 Essential characteristics

Digital Railway is a comprehensive, large and integrated, complex and arduous mega-systems engineering, and it is a development strategy. Instead, the rail transport system will depend on the digitalized and network-enabled information infrastructure. In the railway transport system, production and management of internal operations and external marketing and passenger services are all part of the effective interaction based on the "digital flow". It develops the railway information system in an innovative way, that achieve digitalize railway management, to make a virtual reproduction of the "real world" railway through the computer and information network. By Digital Railway research and development, archive digitalized railway survey and design, digitalized railway engineering construction, digitalized railway equipment manufacturing, digitalized railway traffic command and control, digitalized railway safety inspection and monitor, and digitalized maintenance and repair, etc., then archive Digital Railway business process reengineering, digital management decision-making, and promote organizational process reengineering. The research and development of Digital Railway will promote management innovation through technology innovation, reduce operating costs, improve efficiency and level of management, facility the connection between the railway and highways, waterways, civil aviation and other modes of transport, provide digitalized passenger and freight transportation service, promote intelligent and integrated transportation systems development.

1.1.3 Construction objectives and research contents of digital railway systems

The objectives of Digital Railway construction include [2]: on the one hand is the realization of Digitalization and Cyberization of the railway business systems, regulating railway foundation information and the methods of information sharing and exchange for dynamic

business operation; on the other hand is to establish a railway geographic information platform as the core of information services and sharing for railway systems, ultimately to archive the full sharing of information among railway systems, improve resource utilization efficiency and demonstrate the level of service in the railway.

The research contents of Digital Railway include:

1. Research of Digital Railway architecture, study on hierarchy, logical structure, physical structure of Digital Railway system, and proposed the overall framework.
2. Research of Digital Railway standards. The development of digital spatial data content and standards of the railway, data quality control standards, spatial data exchange standards, spatial information sharing service standards.
3. Research of Digital Railway business application for information exchange. According to the unified planning and need of railway information sharing platform, specifications of the railway business information system output and input of information content and interface specifications.
4. Research of railway spatial data model and structure. Propose Digital Railway data structures of spatial models, and demonstrate the content of spatial database system and logical relationship among them.
5. Research of railway spatial information sharing technologies. Research of railway spatial information sharing technologies, including railway foundational spatial information synchronization and spatial information sharing mechanisms, provide a wealth of spatial data sharing and spatial information services, for all railway information systems.
6. Research of technology solution of core applications. Study on application solution with 3S technologies, virtualization technology, Internet of Things, spatial data querying, information integration and comprehensive application, etc. in railway business operation field.
7. Research of Digital Railway application overall program with internal and external user requirement. In-depth analysis of the various digital application contents and presentation requirements of railway business units and outside users, and propose Digital Railway application overall solution.
8. Research of mechanisms on operation, maintenance, safety & security of Digital Railway information system. Propose Digital Railway information operations, maintenance and updates, and safety & security mechanisms, to ensure that Digital Railway information is updated in real time and efficient maintenance.

1.1.4 General framework of digital railway system

From an engineering perspective, Digital Railway is a network centric geographic information systems engineering, related to information resources, technology, organization, standards and rules, etc., and the key task is to achieve the railway business integration applications and services through the sharing of spatial data based on geographic information platform. Therefore, the Digital Railway construction composed with digital foundational information platform, Digital Railway geographic information platform, Digital Railway information systems, technology systems and information standard systems, and several other components, its general framework shown in Figure 1.

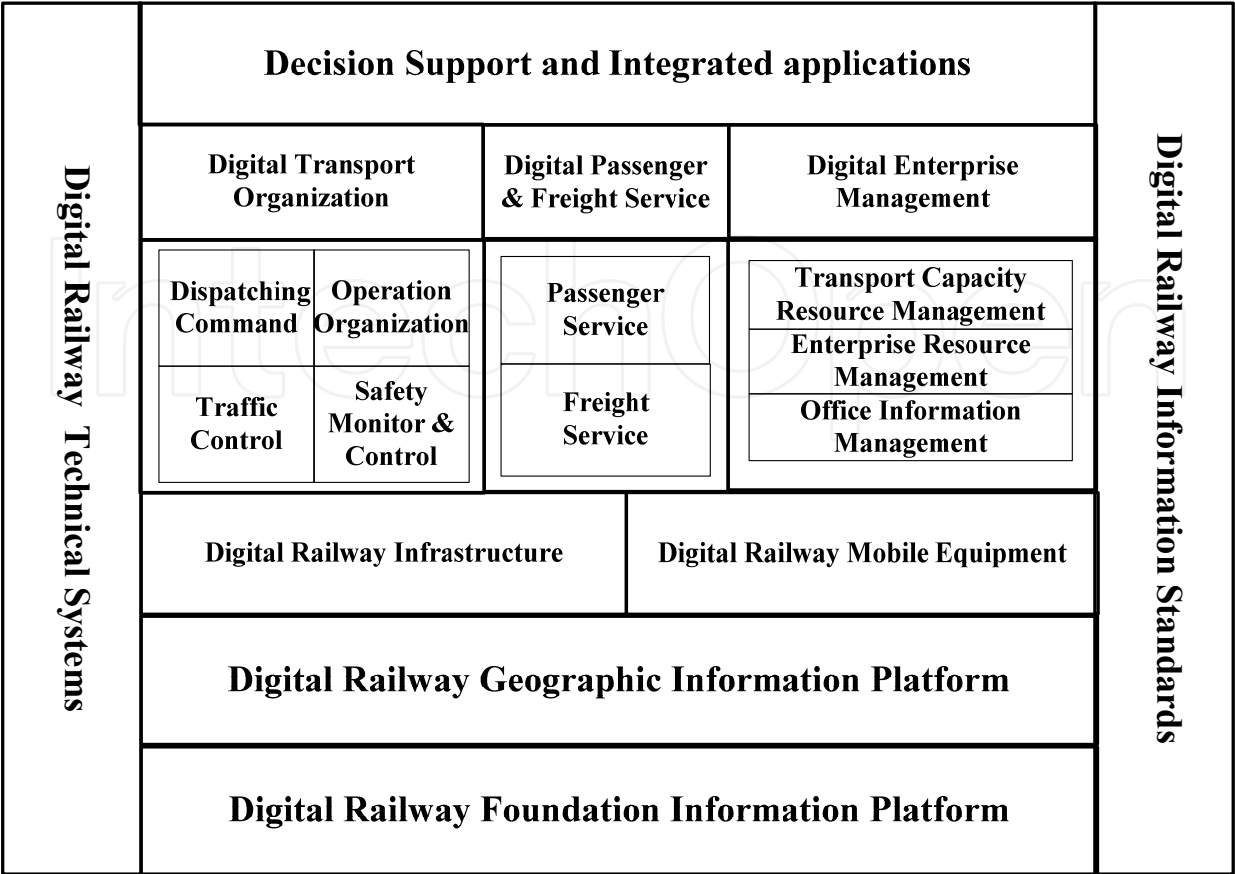


Fig. 1. General Framework of Digital Railway System

Digital Railway foundation information platform

The foundation of Digital Railway is the data in all kinds of railway business operation information systems, and now a large number of railway information system has been put into operation, some systems are under construction. Digitalization for these systems means, according to digital integrated display, publishing, management and decision-making needs, that we should demonstrate information and methods for exchange among these systems(both inside and outside), and we also need construct the railway common information platform and realize dynamic information exchange and sharing of business information. To archive the goal that, on the one hand, to meet the business services and management needs, on the other hand, to satisfy management and decision-making needs at all levels of railway operation.

Digital Railway foundation information platform is an important support for Digital Railway, which includes: network communications platform, information sharing platform, common information platform, information security platform and Digital Railway portal, etc. [4-6]

1. **Network Communication Platform:** Railway network communications platform provide Internet backbone communications infrastructure and intelligent communications management platform for ubiquitous digital network communications environment, including the bearer network (wireless and wired transmission network, switching network, access network), network support

(network management, network synchronization , signaling network) and business-application-centric integrated data network (business network) and other components. Network communication platform provides information network access and digital information transmission services.

2. **Information Sharing Platform:** Information Sharing Platform is the assurance to achieve interoperability among Digital Railway systems. One of the dominated construction principle of Digital Railway Information System is service-oriented. Service-oriented system build method provides support for whole process visualization of Digital Railway operations. Digital Railway information sharing platform uses ESB (Enterprise Service Bus) -based mode to achieve service-based information system interoperability.
3. **Common Information Platform:** Common information platform provides total quality controlled data services for coding data, metadata, and transport common data, geospatial data, and other public base data, including data directory services, security management, quality management, data integration tools for data through the gathering, cleaning and change, and the way the service bus, serving for the Digital Railway information systems information gathering.
4. **Information Security Platform:** Information security platform provides complete roles and authentication system, secure information resources access totally under user access control, security features through network security domain segmentation for Digital Railway, to ensure reliability, availability, confidentiality, integrity, authenticity and controllability.
5. **Digital Railway Portal:** Digital Railway portal is integrated a variety of applications, the unified way that interact with the outside for railway for the access of internet services. It is for passengers, shippers, partners, government and industry authorities to provide interactive information services, e-Commerce, e-Government, e-Collaboration applications such as shared information platform, and to optimize business model, expand market channels, improve customer service and enhance the image of the railway.

Digital railway geographic information platform

The core of Digital Railway is railway geographic information platform. Digital geographic information platform provide a unified national railway map, a unified digital geographic information service for railway information systems, support to achieve the train locating, materials positioning, network planning and other services, and all kinds of information related to railway operations, in a unified interface in the virtual space and time display, achieving convergence and sharing of information

Digital railway information systems

Digital Railway information systems support Digital Railway planning and design, engineering construction, construction and operation management of the entire process, from the composition of a number of information systems. As Digital Railway connotation and core features, and Digital Railway core business value chain, Digital Railway core information systems comprise of planning and design, engineering construction, transport operation organization, passenger and freight services, and business management information systems, etc. Additionally, these information systems highly depend on ubiquitous information provided by Digital Railway infrastructure and Digital Railway mobile equipment.

Digital Rail infrastructure and mobile equipment is an important components of Digital Railway, they use of RFID, Internet of Things technology, the uniform code with the railway line bridge and tunnel infrastructure, locomotives, vehicles, EMU, and railway equipments of communication , signals, traction, power, information, and large parts of the RFID-based unified identity management and all of its static and dynamic information management, to develop standards for RFID applications and fitting processes, to make all parts of railway facilities achieved real-time tracking and timely maintenance, to meet the management needs of Digital Railway to ensure the safety of railway transport.

Decision support and integrated application is the highest level of Digital Railway applications, through data analysis, virtual simulation and presentation, and cross-business collaboration and other technical means to improve the efficiency of railway operations, operational efficiency, and transport security as the purpose, supporting route selection, service program, passenger and freight marketing decisions, security risk identification and early warning, emergency response and other business applications.

Technologies and information standards

A large number of key technologies and information standards support the realization of the concept of Digital Railway development. Key technologies of Digital Railway include, such as 3S (GIS, GPS, RS), virtualization, railway spatial data modeling, mass data storing, spatial information sharing, Internet of Things related, cloud computing, etc. technologies Digital Railway information standards include common railway information coding rules based standards, spatial data content and standards, geospatial data exchange standards, GIS shared services standards, geographic information service based on OGC (Open Geospatial Consortium) standards, SOA (Service oriented Architecture) related standards, etc.

1.2 Geographic information platform of digital railway system

1.2.1 The definition of digital railway geographic information platform

Geographic Information Platform of Digital Railway System is a foundation platform which takes railway spatial information database as the carrier, GIS technologies as the core, achieving railway spatial information and services sharing as the goal. It is responsible for collecting, storing, maintaining and managing of spatial information, which including railway public fundamental spatial information, sharable valuable professional spatial information and related spatial attributed data which gathering from business information systems. Geographic Information Platform also provides spatial information and related services which can be shared to business information systems.

China's railway information systems applied the concept of GIS in varying degrees, and some had already established the GIS subsystem [7], such as information system of permanent way works department (PWMIS), railway land management systems. Ministry of Railways also organize related units to study the overall framework and the programs of railway geographic information systems [8,9]. However, part of the railway business information system uses the different platforms for geographical information, and spatial information sources are not uniform, resulting in spatial information is inconsistent, maintenance workload continued substantial growth, and these are difficult to play overall

effectiveness. To this end, an urgent need to tidy plan the construction of Digital Railway from an unified, standardized aspect, and study an advanced application of scientific and rational, safe and reliable railway geographic information platform for railway infrastructure management and maintenance of spatial information, to provide specifications of the railway geospatial data and spatial information services for business information systems of the railway.

1.2.2 The functions of digital railway geographic information platform

Digital Railway geographic information platform railway main functions are as follows:

1. **Railway Spatial Data Management.** Collection, storage, maintenance and management of the national rail spatial information, including common rail base national railway spatial information, and extracted from the business system, there are valuable for sharing of the professional spatial information, metadata and related attribute data. To achieve spatial data of GIS database synchronization and integration between different departments.
2. **Railway Spatial Information Services Management.** Publish spatial information and analysis model, which managed by geographic information, in a standard GIS service delivery style, including spatial data visualization services, GIS data services, GIS function service, GIS directory services. In addition, GIS services can be based on the basic types, custom professional business space in different applications such as passenger and freight space-time statistical analysis of marketing services, and emergency evacuation paths used in service to meet business services for GIS analysis needs.
3. **Railway Geographic Information Service Release.** Provide query, search and locate services on railway spatial information. When the other systems user develop a rail service system, or need to use a GIS data, services, they could through service inquiries, to obtain a specific service path, and call the service and complete implementation of the entire business flow.

1.2.3 The architecture of digital railway geographic information platform

Railway geographic information platform based on the latest Geographic Information shared services model [11]. Geographic information platform is composed by railway spatial data layer, spatial information services layer, rail service interface layer of geographic information, while the necessary network information infrastructure, standards and normative system, security system, so as to ensure the railway geographic information platform running smoothly. Railway systems and other space-related business applications can be built on the basis of geographic information platform, and through the service interface, invoke the railroad railway geographic information platform provided spatial information services. The overall structure is as follows:

1.2.3.1 Data layer

GIS data layer of the railway geographic information platform, responsible for the collection, storage, maintenance and management of the railway spatial information, including railway unified common railway spatial information, and extracted from the business system, there are shared values of the professional spatial information, metadata and related attribute data.

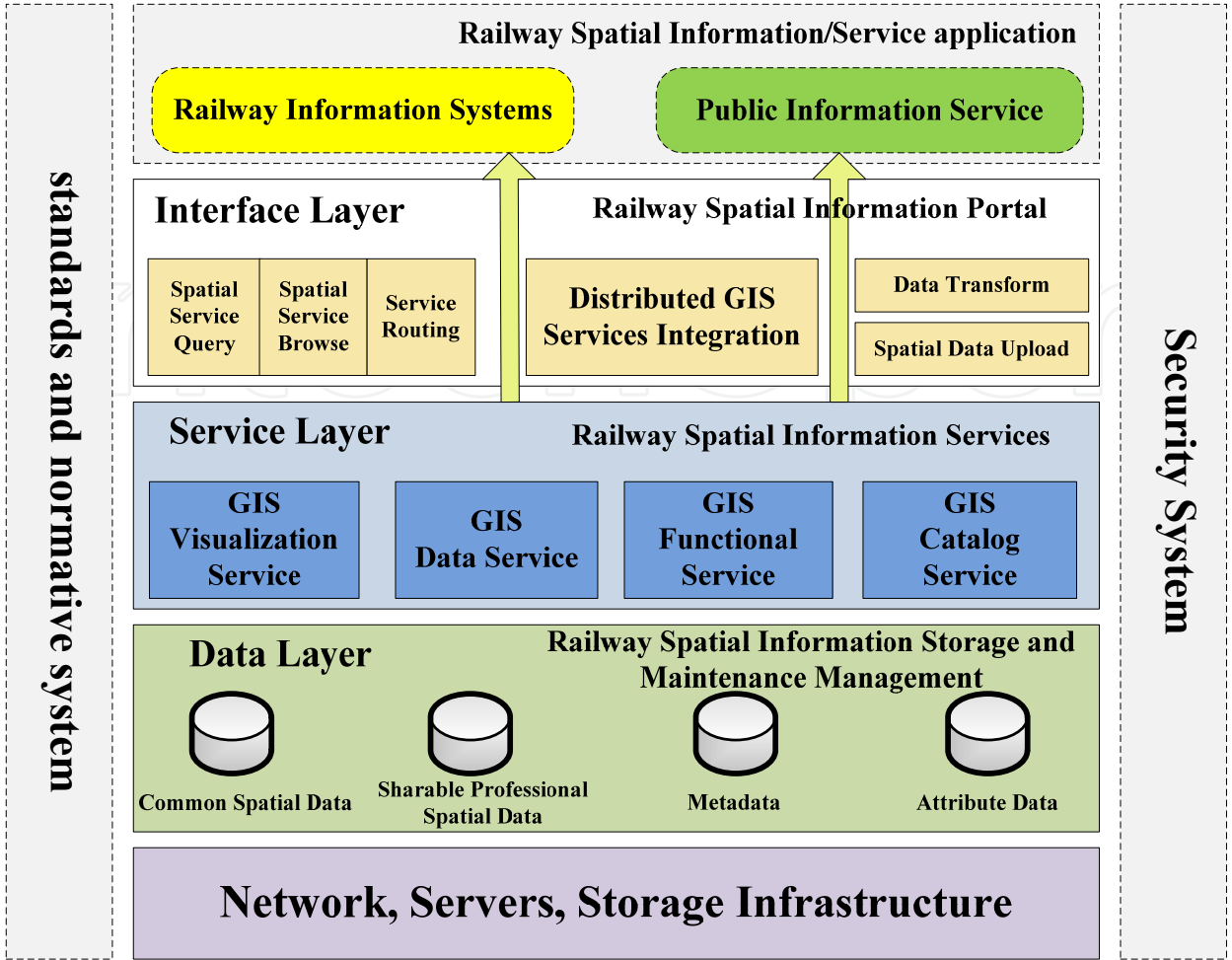


Fig. 2. The Architecture of Digital Railway Geographic Information Platform

1.2.3.2 Service layer

The services layer of railway geographic information platform is the critical part to achieve GIS services. The spatial information services layer serves the system and public, who have the needs for the entire railway geographic information and services, and build a unified, distributed, loosely coupled, space GIS services platform for the railway business functions and information services. Geographic information services layer is responsible for publishing the standard GIS services and GIS spatial analysis models managed by geographic information sharing platform, including spatial data visualization services, GIS data services, GIS functional service, GIS catalog services. In addition, GIS services can be based on the basic types, custom professional business space in different applications such as passenger and freight space-time statistical analysis of marketing services, and emergency evacuation paths used in service to meet business services for GIS analysis needs. It will provide different services for outside and inside users.

1.2.3.3 Interface layer

Railway geographic information platform interface layer is also the railway geographic information services portal, which provides geographic information services portal railway spatial information services available to search and locate. When the other system users develop a rail service system, or need to use a GIS data, services, he can log in railway

geographic information services portal for service inquiries. Service portal will call the GIS service management module to access a specific service path. So users can directly call the service and complete implementation of the entire business flow.

1.2.4 Spatial database

According to the railway GIS platform design, the data layer is composed of the maintenance of spatial databases and spatial data management subsystem^[10].

Railway spatial database is composed by the railway common spatial data, and spatial data can be shared professional and metadata.

1. Railway common spatial data mainly include different scale vector, raster, and three-dimensional and other types of data (such as multimedia data), specific data content is divided into two areas: the national base railway map, railway lines vertical section diagram. The railway map based spatial information to provide a national basis, the distribution of the railway line, railway bureaus and the main station spatial information; railway line longitudinal vertical section of the line graph is to describe the base railway spatial information, survey and design drawings by the railway line through the vector data formats obtained after conversion and data processing.
2. Shared professional spatial data refers to the professional spatial information that stored in the certain railway information systems, and has the demand to share, and this part of the information can be copied to the railway geographic information platform for the sharing of other business information systems. The professional spatial information is superimposed on the common spatial information can be used to generate the relevant professional expertise layer.
3. Railway metadata is mainly contains the metadata of railway spatial data.

Digital Railway spatial database can be divided into three parts by their contents, which are the national common geographic information data, the railway geographic information data and the sharable railway professional GIS data.

The spatial data maintenance and management sub-system is responsible for the management of the spatial data and metadata, which are stored in geographic information platform, including geographic information platform model and spatial data management, spatial data (vector and raster data) to import, export, convert, copy, append; spatial data quality control, network topology and relationship maintenance; incremental replication and exchange of spatial data; spatial data metadata management, including meta-data collection, management, publishing and navigation.

1.2.5 The application patterns of digital railway geographic information platform

The Application Patterns of Digital Railway geographic information platform includes internal and external service, and they are respectively reflected by Digital Railway Information Sharing Platform service layer and Digital Railway spatial information services portal.

1.2.5.1 The service layer of digital railway information sharing platform

The service layer is a key part of railway geographic platform to realize GIS services, and its core function is to provide GIS services. GIS services in Railway geographic information platform include GIS visualization services, GIS data services, GIS services and directory

services functions. The GIS services can be divided into two levels: the first layer for GIS visualization services (map services and OGC services) and GIS data services (data transform service and spatial data upload service), and the second layer for the GIS functional service (map query service, map locate service, map edit service, spatial information service). Which GIS data visualization and GIS services are the basic types of services, GIS capabilities that can achieve some of the major service-specific features and analysis of GIS services, to achieve GIS functional services need to rely on GIS visualization or data services, and when GIS functions called services, they often need to call the GIS visualization or data services.

In addition to providing features of a variety of GIS services at the spatial information services layer, but also must have created publishing services, service interfaces, service management and security management functions, and provide a variety of standard access interfaces such as SOAP (Simple Object Access Protocol), REST (Representational State Transfer), OGC standard services with web services, for the spatial application of business systems.

The railway geographic information platform services layer design shown in figure 3:

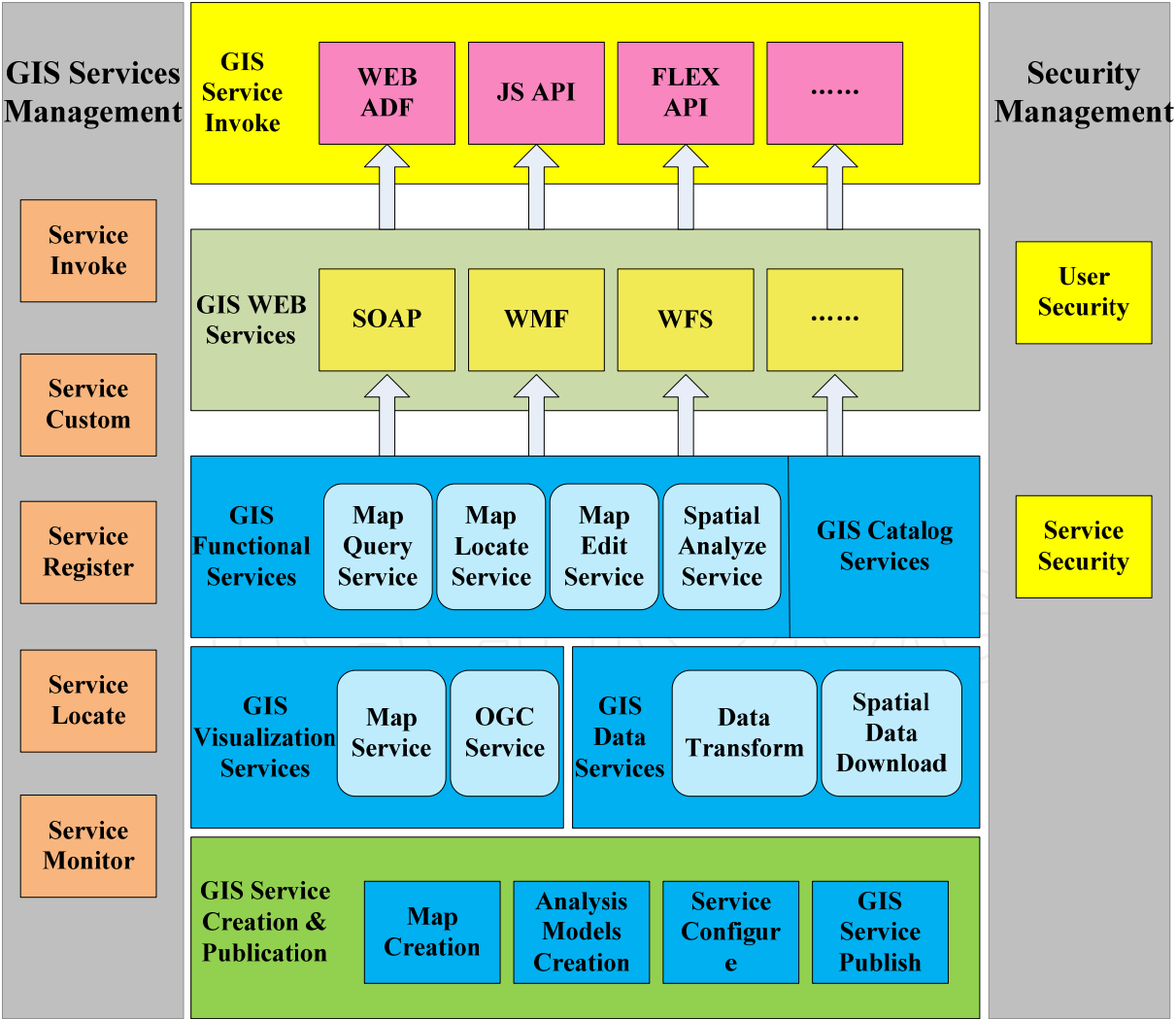


Fig. 3. The Service Layer of Railway Geographic Information Platform

1.2.5.2 Digital railway spatial information service portal

Digital Railway spatial information service portal mainly realize searching and location of railway spatial information services. Through logging spatial information service portal to query, services portal will call the GIS portal service management module to access a specific service path. Service management system called Enterprise Service Bus or GIS services management module, to obtain a specific service path. So users can directly call the service flow path and complete the implementation of the entire business.

Railway spatial information services portal designed the main functions are as follows:

- Distributed GIS Services Integration: integration of data services provide a unified, integrated spatial information services, data services platform is released service.
- Spatial Services Query: allows users to search the spatial information, which published by spatial information service platform through a certain keyword.
- GIS Data Services Browse: enables users to browse the map spatial information service platform for publishing a variety of data services
- Service Routing: after user retrieved service, the service call through the feedback information directly to the user's service call request is forwarded to the service providers.
- Service registration: In addition, the railway geographic information platform provides spatial information services, information sharing through the railway system (platform) in the service registration, the business information system can use Information Sharing Platform for shared services functions, call the railway geographic information platform provide a range of spatial information services.

1.3 Digital railway information systems

Digital Railway information systems are formed by the large number of information systems to support planning, construction and business operation of Digital Railway. Based on the connotation and key characteristics of Digital Railway, and the core business value chain of Digital Railway, Digital Railway information Systems mainly include information systems of planning and design, engineering construction, railway transport organization, passenger & freight transportation services and business management. At the same time, the information systems depend on the Digital Railway infrastructure and Digital Railway mobile equipment. Digital railway information system components, as shown in Figure 4.

1.3.1 Digital railway infrastructure

Digital Railway infrastructure is the digitalization of fixed infrastructure, including road network (lines, bridges, tunnels, and a variety of stations), signal equipment and traction power supply equipment, etc.

The variety of technical equipments of Digital Railway infrastructure should be configured with electronic tags, and layout of the railway lines and stations operate all types of sensors to form a pan in the perception of railway infrastructure environment. Perception of information include various types of railway infrastructure, safety and quality service state, the operation of mobile equipment identification capacity, location and service status, driving environment, wind, rain, snow, earthquake, etc. affect the normal driving state of the weather and the natural environment, goods and passenger service station related information.

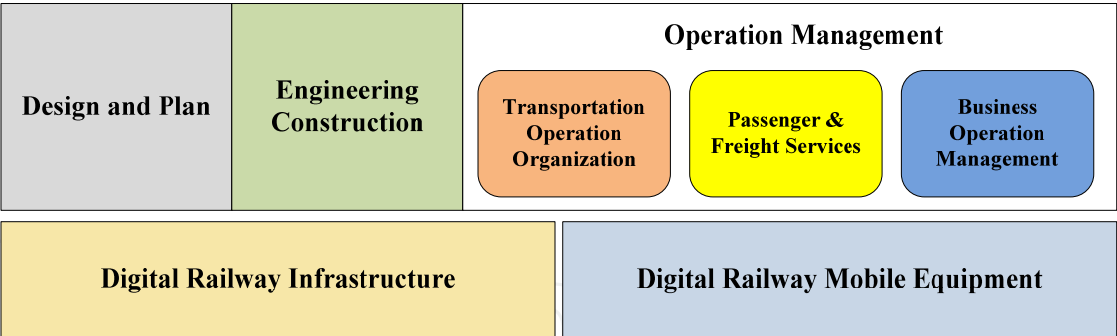


Fig. 4. Digital Railway Information Systems

Various types of sensors of Digital Railway Infrastructure communicate with each other by wireless, cable transmission networks, and rolling stock by means of radio frequency transmission protocol to exchange information. Digital Railway infrastructure contains the station interlocking, line occlusion control, signal control, traction control and power transmission, etc. automatic equipment. Digital Railway infrastructure are more accurate and reliable supporting of ATIS (Automatic Train Number Identification System), disaster prevention and safety monitoring, traffic surveillance, emergency command rescue, transport resource management system implementation.

1.3.2 Digital railway mobile equipment

Digital Railway mobile equipment generally refers to railway mobile transport capacity equipments (including locomotives, vehicles, EMU, etc.) and the digitalization of trains.

Digital Railway mobile equipment percept all kinds of state information of train operation, including their location, speed, power, air resistance, energy consumption, emissions, load and test monitoring equipment state information; position information about itself and the adjacent train; the infrastructure state inspection information around train running alongside; information of natural and meteorological along the train running; automatic access to scheduling and driving instruction program information; locomotives, vehicles and all kinds of EMU state information; state information of cargo and passengers in carriages, and so on.

Digital Railway mobile equipment, through the assembled digital data transmission and communications equipment, realize real-time information communication between the vehicle-based sensors and reliable mass information transmission between train and infrastructure, or between trains. Through real-time dynamic digital platforms, and combine with the digital platforms of operating environment, the model of train status information sensing and monitoring is built, it can realize modern detection for high-speed train, train operation control, digitalization of traction power supply, line public affairs, and digitalization of geographical environment. By data processing integration and intelligent decision-making platform, it can realize the data integration between train and infrastructure, and calculation of self-adaptive, self-test, self-repairing and mandatory safety protection based on knowledge database and intelligent decision. It can provide quality travel services to passengers at journey by building a digital train customer service platform.

Digital Railway mobile equipment has carried a large number of digital train control equipment, including train control, power control, over speed protection control, brake control, automatic control of vehicle equipment, control of the train services, and train

monitoring which is interactive with centralized scheduling system, marshalling yard automation systems and road safety monitoring system interaction, it execute the train control. To ensure the reliability and safety of these devices, different types of monitoring systems and various forms of detection equipment must be equipped.

1.3.3 Digital railway network planning and design

1.3.3.1 Digital railway network planning decision support system

According to the railroad network development needs, based on the Digital Railway geographic information platform to provide spatial information services, based on digital model of topography, surface features, geological conditions, and other constraints of line environment, in a different alignment objectives, generate a set of optimal line selection program. For station planning, it will adjacent with the full consideration to stations around the city planning and municipal facilities, combined passenger and cargo location monitoring data, supporting integrated transport and modern logistics system analysis, optimization and smooth convergence of internal and external traffic, the smooth convergence of urban space and the station, and the organization of station function space, etc.

1.3.3.2 Digital aided line design and survey & reconnaissance analysis system

Using of remote sensing, geophysics, in-situ testing, geological exploration, integrated exploration, based on the structure, coupling and system dynamics model survey and calculation methods, auxiliary rolling stock, track, roadbed, bridge and tunnel, the natural environment and other aspects of digital survey data collection, analysis and design, combined with a comprehensive survey and test data management tools to improve the accuracy of the railway survey and design, optimize design, reduce construction costs.

1.3.3.3 Digital railway integrated simulation design system for the design of digital hub station

Modeling and simulation with the design artifact of the marshalling yard, and large or medium-sized terminal station and hub of the total figure, container and rail logistics center, etc., and integrated transport system operating conditions, optimize the real transport operation scenario of the railway station hub of traffic, people, goods, and station equipment, to enable the effectiveness of the design results and reasonable verification. On this basis, to simulate the existing lines in operation, and evaluation of the current operating results, the formulation of emergency response plans to provide effective support for the theory and simulation.

1.3.4 Digital railway construction

1.3.4.1 Digital railway construction project management system

Supporting Digital Railway construction management, including project risk management, project schedule management, project contract management, procurement management, construction management, engineering estimates of integrated management and other digital services, and with the data of operating assets management consistency.

1.3.4.2 Digital railway construction precision apperception and measurement system

Using the track inspection train, digital integrated experimental train, as well as the digital sensors and measurement equipment of the bridge, the tunnels and stations, cable

infrastructure and meteorological, geological, hydrological etc.. combined with data processing and testing simulation system to support Digital Railway construction, comprehensive experiment, project acceptance, engineering maintenance.

1.3.5 Digital railway transport operation organization

1.3.5.1 Digital transport command and dispatch system

Includes the Centralized Traffic Control system (CTC), the operation planning management systems, the traffic projections and adjust system, the marshalling yard automation system, etc., and combining with Digital Railway geographic information platform, to digitalize the whole process of the transportation command and dispatch.

1.3.5.2 Digital transport operation organization system

Includes the opening line of program planning system, O-D assisted analysis systems, freight management, passenger transport management, professional transportation management, and automatic train identification system (ATIS) system, etc.

1.3.5.3 Digital transport safety safeguard system

Includes train operation safety monitoring system, emergency rescue command system, hazardous materials safety inspection system, station passenger flow of real-time analysis and early warning systems, security information management system, with simulation of a natural disaster situations, production of railway operations and emergency response and recovery simulation and training capabilities.

1.3.5.4 Digital transportation operations simulation system

Achieve train operation, station operations, transportation security and other aspects of transportation operations virtualization symbiotic simulation, decision support for transport operation organization.

1.3.6 Digital railway passenger & freight transport service

1.3.6.1 Digital passenger service system

Includes ticket sale and reservation system, passenger service system, passenger marketing decision support systems, automatic ticket amount optimize the allocation and pricing adjustments, and provide travel the whole process easy digital navigation services and electronic commerce services.

1.3.6.2 Digital freight services system

Includes freight marketing and capacity allocation system, freight service system, freight marketing decision support systems, to provide cargo tracking, integrated transport and other logistics services.

1.3.7 Digital railway transport capacity and business management

1.3.7.1 Digital transport capacity resource management and maintenance system

For the maintenance, tracking, procurement and operations of the lines, bridge and tunnel, crossing, embankment, repair equipment, communications signals, locomotives, vehicles and

other types of capacity resources, provide full life-cycle asset management and effectiveness of accounting services, complement the railway norms, optimizing asset management system, enhance asset management efficiency. Based on the failure mechanism and mode of the capacity resources, and reliability requirements, combined with the economic cost of such repair and maintenance data, forming the maintenance and repair schedule predictive models library and knowledge base, to achieve a reliable forecast maintenance and repair system, the maximum degree of safety, and reduce operating costs and risks.

1.3.7.2 Digital business decision support system

To provide digital-based integrated business information display, statistical analysis and other functions, auxiliary open line programs, asset utilization, operational efficiency and optimize energy efficiency and emissions of other aspects of decision making.

1.4 Digital railway key technologies and information standards

1.4.1 Digital railway key technologies

1.4.1.1 3S Technology and application

3S technology is composition of RS, GIS, and GPS, and it is a modern information technology which is a combination of spatial technology, sensor technology, satellite positioning and navigation technology and computer technology, and highly integrated multi-disciplinary to collect, process, manage, analyze, express, disseminate and apply spatial information. 3S technology is the basis of the construction of Digital Railway. We can use RS technology to get the required railway exploration data, and use GPS technology to solve positioning problem of railway mobile equipment, and GIS technology is the basic displaying platform for development and application of Digital Railway.

1.4.1.2 Railway spatial data modeling Technologies

Data model is an abstraction of real world phenomenon, which describes the basic structure, relationship and the various operations of data. Data model is the formal representation of content and logical organization of relationship of data in database system and it describes and reflects the business activities and information flow in a department or system using abstract form. Railway Geographic Information System requires an efficient data organization mode, which not only can include comprehensive information (including information potentially useful for the future) as possible, but also can be easily and quickly selected.

1.4.1.3 Mass Spatial Data Storage and Access Technologies

Because of the ever mass span geographical spaces of China Railway, the enormous of electronic map, equipment spatial vector image, aerial and satellite photograph, videos along with the rail line, required to study the mass spatial data storage and process technologies, to make railway spatial data management efficient and effective.

1.4.1.4 Railway spatial information sharing technology

The essence of Digital Railway is to establish service and sharing system of railway information which core is railway spatial information. The core of railway geographic information platform is to provide basic spatial information and sharing professional spatial

information. Railway spatial information sharing technology, including synchronization mechanism of railway basic spatial information and service mechanism of railway spatial information, can provide sharing spatial data and rich spatial information services to improve resource comprehensive utilization efficiency. Constantly perfected standards of Digital Railway spatial information is an important means to railway spatial information technology management, and we must make the standards of railway basic spatial information, quality control of railway geographic data, railway geospatial data exchange and sharing services of railway GIS according to the principle that "authoritative data from authoritative department, resources Co-establishing and sharing", to achieve the target that "one base map in railway"

1.4.1.5 Railway spatial information security technology

Sector of Surveying and Mapping have strict regulations in spatial information management, because spatial information interrelates to the national security. Furthermore, digital geographic information is easier to replicate and spread, we must study railway spatial information security technology, and on national spatial data security level, to realize the unified convergence case management of railway spatial information, and take different effective measures to secret-related and public railway spatial information, on the premise of ensuring data or information safety, furthest to realize sharing of railway spatial data.

1.4.1.6 Virtualization technology

Virtualization is a process that to express computer resources using a way which user and applications can easily benefit from. It provides a logical view for data, computing power, storage and other resources, and it is a logical representation of resources which is not subject to physical limitations. Virtualization technology, include network virtualization, system virtualization, computer hardware virtualization, language virtual machine and distributed system simulation technology etc.

Through application of virtualization technology, all the resources of Digital Railway will run transparently on a variety of physical platforms, and it changes logical resource into logical resource, to realize automated allocation of resources. Therefore, we can build Digital Railway under existing applications and platforms using virtualization technology instead of rebuilding a new system.

1.4.1.7 Internet of things related technologies

Under the foundation of computer internet, Internet of Things based on the use of RFID, wireless data communications technology, to construct "Internet of Things" that covered everything in the world. Automatic Train Identification System (ATIS) Implemented by Ministry of Railway is realized using RFID technology. Using technology of Internet of Things, by embedding and equipping sensors into railway lines, bridges, tunnels, culverts, traffic signals and other rail infrastructure, locomotives, vehicles, train-sets and other mobile devices, informatization facility and large fittings, and integrating with the existing information network, can realize overall real-time management of manpower equipment and infrastructure of railway, that is to realize digitalization of railway equipment management, to improve resource utilization and productivity level of railway, and to promote construction of Digital Railway.

1.4.1.8 Cloud computing technology

Digital Railway was supported by a mass of information applications and information processing services, and it needs IT infrastructure and services basis that support the

development of the railway business. The traditional construction mode that deploy IT infrastructure according to business information system leads to that information and information technology resources merged into some existing rules and regulations by specialty division. Cloud computing technology provides technical capability and management scheme for construction, maintenance and management of information services and upgrade of information technology infrastructure of Digital Railway and this will improve the ability of information technology of Digital Railway. Cloud computing comes from that business change to virtualization and diversification, and those need information technology to provide business agility, resulting in needs of IT infrastructure integration, data processing tasks and services quality assurance. Cloud computing is a concept and technology system to build a dynamic IT infrastructure, information technology services and information systems architecture. Cloud computing technology offers a way of IT resources development, making information systems to support business to the changing and have dynamic capabilities. Service-oriented hierarchical information services technology, virtualization technology, massive data processing and building mode of centralized data centers in Cloud computing areas provide opportunity to realize alignment of business and IT of Digital Railway.

1.4.1.8 Hybrid system modeling and validation technology

Each system in Digital Railway collects all the physical resources and the environment status information and takes all control decisions according to state changes. State change in physical world is based on continuous model, but control decision is based on discrete model of information space. Predictive maintenance of all kinds of digital equipment in Digital Railway needs continuous and discrete mixed modeling and validation analysis technology - hybrid system modeling and verification techniques. Hybrid systems are a class of widely used computer-based systems, such as embedded systems, information physical integration systems can be considered a typical example of hybrid systems. Currently hybrid automata are the main design modeling language, and reachability test of it is an important way to improve the quality of the system.

At present, the study of hybrid system in the railway has just started, and hybrid systems analysis, hybrid control system design will provide more reliable, more accurate techniques for the analysis, design and verification of massive information physical integration system.

1.4.2 Digital railway core information standards

Precondition of Digital Railway construction is to establish perfect Digital Railway information standards system. Core information standards in Digital Railway standards system include data content (including metadata) standards, data quality control standards, data exchange standards, spatial information sharing service standards, OGC (Open GIS Consortium) standard and SOA (Service Oriented Architecture) standard.

1.4.2.1 Railway common spatial data content and standards

Railway basic spatial data content and standards is a major part of spatial data management standard, including standards of railway basic spatial information, sharing professional spatial information and metadata content.

Digital Railway should establish on the base of international standards, at the same time can achieve expansion and compatibility of state metadata standards. Main reference of

international metadata standards in metadata standard construction of Digital Railway list as follows: ISO 19115 metadata standard, ISO 19139 metadata XML Schema implementation standard, ISO 15836 Dublin Core standard.

1.4.2.2 Railway spatial data quality control standards

At present spatial data in each business system of Ministry of Railway independently purchase and make. Because different systems have different requirements of spatial data, in addition to the implementation time of each business systems are not same, leading to spatial data quality irregularity of each department. In construction of Digital Railway, must accord with corresponding national standards and industry standards of spatial data, while take strictly control for spatial data quality to ensure the validity and public of spatial data in storage.

1.4.2.3 Railway spatial data exchange standards

The core figure of Digital Railway is share, so data exchange format standardization of GIS spatial data is also a very important part.

Digital Railway should achieve data exchange between data providers and data users in different GIS platform through data exchange format. Therefore, it should be able to: support the commonly used data formats such as DXF, DWG, TIF, IMG, etc.; support the de facto standard exchange formats such as SHP, E00, etc.; support the national standard exchange formats, such as VCT and so on.

1.4.2.4 Railway GIS shared services standards

The shared services provided by Digital Railway Geographic Information platform should be able to support heterogeneous GIS system even non-GIS system to read and call, to reach the purposes of data integration and function sharing of system. To achieve this purpose, Digital Railway geographic information platform use service-oriented architecture, involves a lot of interoperability standards.

1.4.2.5 OGC standards

For GIS application services of Digital Railway, it is essential to provide standard OGC services. The OGC standard services include WMS (Web Map Service), WFS (Web Feature Service), WCS (Web Coverage Service).

1.4.2.6 SOA architecture standards

In Railway Geographic Information platform, in addition to providing spatial data share using OGC service, should also provide a variety of more advanced GIS map services and geographic analysis services for external which are OGC standards cannot be achieved. We should provide standard Web Services through SOA architecture to provide a variety of GIS mapping services and geographical analysis services. Therefore, Digital Railway construction will also need to follow some of the SOA architecture standards, including WSDL (Web Services Description Language), UDDI (Universal Description, Discovery and Integration), and SOAP protocol (Simple Object Access Protocol).

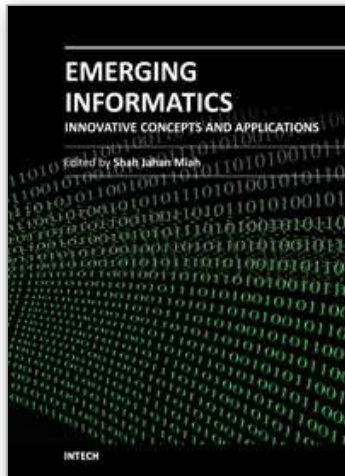
1.5 Conclusion

Digital Railway is the direction of railway system development and construction, which based on the transformation and improvement of existing railway information system, and

it plays an important role to enhance the level of railway management, service and images, and to ensure transport safety. This chapter first discussed the background, content and characteristics of Digital Railway construction, and established a general framework for Digital Railway and analyzed its main study content and basic information platform. Carry out depth research on Digital Railway geographic information platform important part of Digital Railway, analyze its location, function and present the overall structure and application mode. It combined with material carrier and core business of Digital Railway, put forward system composition of Digital Railway information system, including Digital Railway infrastructure and mobile, planning and design, engineering construction, transport organization, passenger and freight services and management applications. Finally, analyze and give key technologies and core information standards of Digital Railway. By the construction of Digital Railway, it will realize the digital upgrade and transform of existing railway system to achieve digital railway operation. The development and construction is a continuing process, and it will lay a foundation for intelligent, green, and sustainable development of the modern railway.

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