Study on the Construction of the Standard System for Highway Abnormal Indivisible Load Transport

Jian Xiao[1], Shuangliang Dai[1], Daiyue Wang[2,3], Wangtao Liu[1], Jianbo Wang[1], Pengfei Li[2,3]

1 China Electric Power International Forwarding Agency Co.,Ltd., Beijing 100080, China

2 Beijing Xinqiao Technology Development Co., Ltd., Beijing 100088, China

3 Research and Development Center of Transport Industry of Automated Construction Technology, Beijing 100088, China

Abstract: Addressing the prominent issues in China's current standard system for highway abnormal indivisible load transport—including fragmentation, inadequate regulations in key links, and insufficient inter-regional coordination—this study conducts a systematic exploration of the system's construction. Guided by policy orientations and practical demands, and structured around pre-event, in-event, and post-event management phases, the research delves into the standardization pain points and core requirements of four key stakeholder groups: abnormal indivisible load manufacturing enterprises, transportation enterprises, construction units, and supervision authorities. A comprehensive standard system framework is established, encompassing seven major modules: basic commonality, enterprise management, permission management, traffic management, operation management, post-event supervision, and service management. The functional positioning and standard components of each module are clearly defined. This research contributes to advancing the full-chain standardized management of highway abnormal indivisible load transport, laying a solid standardization foundation for resolving the industry's dilemmas of "low efficiency, high risks, and poor coordination." It further enhances transportation safety and efficiency, providing robust support for the development of national major projects.

Keywords: Traffic engineering; Highway abnormal indivisible load transport; Standard system; system construction; Standardized management

1. Introduction

Highway abnormal indivisible load transport refers to specialized logistics activities involving the transportation of large, heavy goods via highway networks. Characterized by their large volume, significant weight, and non-disassemblable nature, the transported items serve as critical logistics support for national major engineering projects [1]. The level of standardization in this field directly impacts industry efficiency, operational safety, and sustainable development.

In recent years, with the advancement of national key projects such as wind power, nuclear power, and petrochemical engineering, coupled with the rapid growth of the high-end equipment manufacturing industry, the demand for highway abnormal indivisible load transport has maintained a steady upward trajectory [2]. To regulate industrial development, government departments

including the Ministry of Transport have successively issued policy documents such as the "Provisions on the Administration of Abnormal Indivisible Load Transport Vehicles Traveling on Highways" and the "Notice on Further Strengthening the Management and Service of Abnormal Indivisible Load Transport." These documents explicitly call for improving the management system and technical standard system for abnormal indivisible load transport, while enhancing transportation efficiency and safety assurance capabilities [3, 4]. Nevertheless, the current landscape of highway abnormal indivisible load transport still faces several systemic challenges: Firstly, inconsistencies exist in the definition of core concepts and scope. For instance, unified evaluation standards and specifications for abnormal indivisible loads—particularly those classified as Class III and above—are lacking, making it difficult for relevant enterprises and institutions to conduct rapid and accurate assessments during transportation route selection and review [5]. Secondly, approval processes and technical specifications are not unified. Cross-provincial abnormal indivisible load transport requires endorsements from multiple provincial authorities and departments, resulting in phenomena such as "regional policy variations" and "repeated evaluations." This leads to prolonged average approval cycles that fail to meet the timeliness requirements of engineering construction [6]. Thirdly, coordination mechanisms and standard systems are inadequate. Supervision standards across departments including public security, transportation, and housing and urban-rural development are poorly aligned, giving rise to prominent potential safety hazards during transportation [7, 8].

Overall, existing research and practices related to highway abnormal indivisible load transport in China primarily focus on individual links. The standard system exhibits a fragmented structure, with regulatory gaps in key stages and insufficient inter-regional coordination. These issues result in significant disconnects in transportation processes, approval procedures, and safety risk control [9]. Faced with the urgent demand for safe and efficient abnormal indivisible load transport driven by national strategic engineering construction, the development of a scientific and comprehensive standard system has become imperative to achieve full-chain standardized management in this field.

Based on the policy orientations and practical needs of highway abnormal indivisible load transport, and following the logic of pre-event, in-event, and post-event management, this study systematically organizes the standard system framework and proposes strategies for its construction. The research aims to address regulatory gaps, resolve the industry's "low efficiency, high risks, and poor coordination" predicament, and provide strong support for the standardized development of the sector. It holds great significance for improving the systematic and standardized level of abnormal indivisible load transport while laying a solid foundation for subsequent legislative and policy formulation efforts.

2. Research status of standardization for highways Abnormal Indivisible Load Transport

Several developed countries have achieved remarkable outcomes in constructing standard systems for highway abnormal indivisible load transport. For example, the United States has formulated comprehensive policies, laws, regulations, and standards governing vehicle dimensions, weight limits, and transportation route planning, ensuring the safety and efficiency of abnormal indivisible load transport [10]. The European Union has enhanced the convenience of cross-border abnormal indivisible load transport among member states by unifying and standardizing measures such as approval processes, vehicle technical requirements, and transportation safety management [11]. Japan regards logistics information exchange standards as the core pillar for realizing in-depth

logistics informatization and electronic data integration systems [12]. Canada has established a gradient transformation framework of "international standards - national standards - industry standards," achieving the integration and transformation of multi-level standards and promoting the unification of the standard system through a hierarchical coordination mechanism [13].

In recent years, China has carried out a series of standard formulation and research initiatives in the field of highway abnormal indivisible load transport. The Ministry of Transport and other relevant departments have issued a series of normative documents on the management of abnormal indivisible load transport, clearly defining the basic requirements, approval processes, and safety assurance measures for such operations [14]. Meanwhile, industry associations, research institutions, and universities have actively participated in the development of abnormal indivisible load transport standards, achieving significant phased results. Through literature retrieval and research, it is found that there are over 40 existing standards related to highway abnormal indivisible load transport in China, covering industry standards, local standards, and group standards across multiple fields including transportation, electric power, and automotive manufacturing. In terms of content, existing standards primarily focus on transport vehicle size and weight limits, highway safe traffic capacity evaluation, and abnormal indivisible load transport approval processes. However, regulatory gaps or inadequacies persist in key links such as transport equipment technical requirements, abnormal indivisible load transport route planning, and in-transit safety management [15].

In summary, compared with advanced international standard systems, China's highway abnormal indivisible load transport standard system still has room for improvement. These include the need to enhance technical standards in key links, strengthen standard implementation and supervision mechanisms, and improve the systematic coordination of standards. Specific issues are as follows:

(1) Imperfect standard system: Existing standards related to highway abnormal indivisible load transport lack systematicness and completeness. Coordination and unification among various standards are insufficient, leading to overlaps, redundancies, and even contradictions.

(2) Lack of technical standards: Significant technical standard gaps exist in key links and core technical fields of highway abnormal indivisible load transport. Examples include specialized abnormal indivisible load transport route planning methods and real-time transport monitoring and safety early warning technologies, which fail to meet the practical needs of industrial development.

(3) Inadequate standard implementation and supervision: Currently, effective supervision and service management standards are lacking in the field of abnormal indivisible load transport, limiting their regulatory and guiding role in practical operations. Driven by economic interests, some abnormal indivisible load transport enterprises engage in illegal activities that seriously threaten transportation safety, such as over-limit transport and deviation from approved routes.

The standardization of highway abnormal indivisible load transport in China has steadily advanced from the initial stage of "establishing basic standards" to the deep-water zone of "collaborative implementation." In the future, efforts should focus on cross-provincial mutual recognition as a breakthrough point, digital empowerment as a leverage, and green safety as a bottom line to construct a standard governance ecosystem with Chinese characteristics [16]. This not only represents a key pathway to fundamentally resolve the "efficiency bottlenecks" in highway abnormal indivisible load transport but also an inevitable choice to support the construction of an engineering power.

3. Analysis of standard requirements for highway abnormal indivisible load transport

Highway abnormal indivisible load transport involves the collaborative efforts of multiple stakeholders, including abnormal indivisible load manufacturing enterprises, transportation enterprises, construction units, and supervision authorities [17]. However, in practical operations, these entities generally face prominent issues such as low efficiency, high safety risks, and ambiguous responsibility boundaries due to inadequate standardization. Based on field visits and investigations of these stakeholders, this section systematically analyzes their practical needs and existing problems in the highway abnormal indivisible load transport process. Starting from the core responsibilities and current pain points of each entity, targeted suggestions for standard system construction are proposed.

3.1 Abnormal Indivisible Load Manufacturing Enterprises

As the primary "source entities" of highway abnormal indivisible load transport, manufacturing enterprises are responsible for the R&D, production, and factory inspection of abnormal indivisible load goods. The quality of their delivery directly impacts the safety and feasibility of subsequent transportation plans.

Currently, abnormal indivisible load manufacturing enterprises face two major standardization challenges: Firstly, the prominent issue of source compliance for goods, which imposes high normative requirements on the factory inspection of bulk goods. Secondly, the lack of coordination standards in the transportation link. Delays in synchronizing goods delivery schedules and temporarily adjusted parameters result in additional scheduling costs for transport providers. Moreover, unified information transmission interfaces and timeliness standards between manufacturing and transportation enterprises are lacking [18].

Based on the above pain points, the standard requirements of abnormal indivisible load manufacturing enterprises focus on "source information standardization," as shown in Table 1.

Table 1: Standard Requirements for Abnormal Indivisible Load Manufacturing Enterprises.

Serial Number	Problem Focus	Scope/Content of Standards
1	Goods Supervision	Standards related to parameters, packaging and protection, and factory compliance of abnormal indivisible load goods
2	Collaboration between Production and Transportation	Standards related to handover and collaborative operations between abnormal indivisible load manufacturing enterprises and transportation enterprises

3.2 Abnormal Indivisible Load Transportation Enterprises

As the "executing entities," abnormal indivisible load transportation enterprises are responsible for the full-process control of abnormal indivisible load transport. Their responsibilities include transportation route survey, vehicle equipment configuration, loading and reinforcement operations, escort services, and emergency disposal. These enterprises directly influence the safety and efficiency of abnormal indivisible load transport.

Currently, the standardization pain points faced by abnormal indivisible load transportation

enterprises in industrial practice are mainly concentrated in five areas: Firstly, the lack of unified standards for the survey, planning, and evaluation of abnormal indivisible load transportation routes, leading to increased transportation costs. Secondly, the absence of clear regulations on vehicle equipment, elevating transportation risks. Thirdly, non-standard loading and reinforcement technologies. Different enterprises adopt inconsistent guidelines in the selection of reinforcement materials and determination of reinforcement points, increasing the risk of goods displacement. Fourthly, the lack of unified regulations on escort plans, such as unclear requirements regarding the type and quantity of escort personnel, resulting in high potential risks. Fifthly, inadequate emergency disposal processes. When encountering emergencies such as vehicle failures, road blockages, or extreme weather, enterprises lack unified emergency response procedures, which may lead to secondary risks [19].

In response to the aforementioned problems, the standard requirements of abnormal indivisible load transportation enterprises primarily focus on "full-process transportation standardization," as shown in Table 2.

Table 2: Standard Requirements for Abnormal Indivisible Load Transportation Enterprises.

Serial Number	Problem Focus	Scope/Content of Standards
1	Transportation Routes	Standards related to the planning, survey, design, and evaluation of abnormal indivisible load transportation routes
2	Equipment Management	Standards related to technical requirements, marking and identification, and documents and licenses of abnormal indivisible load transportation equipment
3	Loading Management	Standards for the loading and reinforcement of abnormal indivisible load goods, including reinforcement methods, effects, and inspection processes
4	Escort Plans	Standards related to escort vehicles, personnel configuration, and plan selection
5	Emergency Disposal	Emergency disposal standards, clarifying the classification and grading of emergencies, response processes, temporary disposal measures, and backup plans

3.3 Construction Units

As the "receiving entities" of highway abnormal indivisible load transport, construction units are responsible for on-site acceptance, unloading management, on-site coordination of abnormal indivisible load products, and collaborative connection with transportation enterprises. Their operational efficiency directly affects project progress.

Currently, construction units face three major standardization pain points: Firstly, the lack of unified on-site acceptance standards, leaving construction units without consistent measurement criteria for evaluating delivered abnormal indivisible load goods. Secondly, non-standard unloading management processes. At present, there are no clear standards for the selection of hoisting machinery or specific requirements for safe operation distances. Thirdly, the absence of standards for

collaborative connection links. Construction units and transportation enterprises lack unified specifications for confirming arrival times, coordinating on-site parking positions, and configuring unloading auxiliary personnel, leading to increased transportation costs [20].

Based on the above pain points, the standard requirements of construction units focus on "receiving collaboration standardization," as shown in Table 3.

Table 3: Standard Requirements of Construction Units.

Serial Number	Problem Focus	Scope/Content of Standards
1	Goods Receiving	Standards for the receiving and acceptance of abnormal indivisible load goods, clarifying acceptance items, judgment standards, and dispute resolution processes
2	Unloading Management	Standards for the unloading of abnormal indivisible load goods, specifying crane selection, operation site requirements, safety protection measures, and unloading operation steps
3	Collaborative Operations	Standards for collaborative operation management between abnormal indivisible load transportation enterprises and construction units, clarifying the arrival time confirmation mechanism, on-site parking and site preparation requirements, and the collaborative responsibilities of both parties

3.4 Supervision Units

Supervision units include key authorities such as transportation departments, public security traffic management departments, and emergency management departments. As the "guarantee entities" of highway abnormal indivisible load transport, these departments assume important responsibilities including enterprise qualification review, transportation process monitoring, and illegal activity investigation and punishment. The standardization of their supervision directly impacts industrial order and safety thresholds.

Currently, supervision units face four major standardization pain points: Firstly, regional differences exist in over-limit transport regulations and transportation monitoring frequency requirements. Inconsistent regulatory indicators hinder cross-regional transportation for enterprises. Secondly, some regions adopt different criteria for reviewing the vehicle qualifications and personnel qualifications of transportation enterprises, leading to inconsistent enterprise qualification evaluation standards and unfair competition. Thirdly, non-standard cross-departmental collaborative supervision. While transportation departments are responsible for route approval, public security departments for traffic guidance, and emergency departments for accident rescue, a unified mechanism for data sharing and responsibility connection among these three is lacking, resulting in regulatory blind spots. Fourthly, unclear legal basis for illegal investigation and punishment. The definition standards and penalty ranges for illegal behaviors such as "deviation from approved routes" and "non-standard loading and reinforcement" are not unified, leading to significant arbitrariness in law enforcement [21].

In response to the above problems, the standard requirements of supervision units mainly focus on "supervision system standardization," as shown in Table 4. Since content related to law

enforcement falls under policy and legal documents, it is not included in the table.

Table 4: Standard Requirements of Supervision Units.

Serial Number	Problem Focus	Scope/Content of Standards
1	Traffic Supervision	Standards related to the traffic management of abnormal indivisible load transport, unifying over-limit identification standards, supervision methods, and safety risk assessment indicators
2	Qualification Management	Standards for the qualification and credit management of enterprises related to abnormal indivisible load transport, clarifying vehicle and personnel qualifications, equipment configuration, and credit ratings
3	Information Management	Standards related to the construction of information systems, clarifying the type of information systems, data formats, sharing interfaces, and update frequency

4 Framework of the Standard System for Highway Abnormal Indivisible Load Transport

4.1 Objectives of the Standard System Construction

The construction of the standard system for highway abnormal indivisible load transport aims to ensure the safe and orderly operation of such transport activities and promote the high-quality development of the industry. Focusing on the full-process links and core elements of highway abnormal indivisible load transport, the system is committed to establishing a service-oriented standardization framework that balances safety and efficiency. Specific objectives are as follows:

(1) Standardization of transport entities: The standard system should clarify the qualification conditions, responsibility boundaries, and operational processes of transport entities. This ensures that all types of entities conduct transport activities in accordance with laws and regulations, preventing transport violations, responsibility shirking, and safety accidents caused by inconsistent qualifications, overlapping responsibilities, or ambiguous boundaries.

(2) Precision of transport objects and routes: The standard system should define the classification and grading of highway abnormal indivisible load transport objects, clarifying the scope of abnormal indivisible load transport subject to standard management. Simultaneously, it should standardize transport route requirements and grading standards, ensuring full coverage of transport objects and meeting the needs of safe passage and operational efficiency.

(3) Integration of collaborative institutions and platforms: The standard system should facilitate the interconnection of collaborative institutions and service platforms nationwide. It maintains consistency in standard formulation and service execution processes, eliminating regional and departmental standard differences and information barriers. This enables seamless connection and sharing of information related to traffic approval, dynamic monitoring, and emergency response.

(4) Whole-chain transport management: The standard system needs to fully standardize the entire process of highway abnormal indivisible load transport, covering safety management, risk prevention and control, audit standards, and supervision mechanisms. It constructs a systematic management framework where various links support each other, ensuring full traceability of abnormal indivisible load transport and minimizing safety risks.

4.2 Design of the Standard System

Combining the demand analysis of four core stakeholders—"abnormal indivisible load manufacturing enterprises, abnormal indivisible load transportation enterprises, construction units, and supervision units"—in highway abnormal indivisible load transport, and guided by policy documents such as the "Provisions on the Administration of Abnormal Indivisible Load Transport Vehicles Traveling on Highways," a systematic standard system is constructed. Drawing on the hierarchical logic and collaborative management concepts of standard systems in the transportation field, the standard system for highway abnormal indivisible load transport is divided into four levels: "basic commonality, technical, management, and service." The core positioning and construction path of each level are clearly defined. The design of the standard system for highway abnormal indivisible load transport is shown in Figure 1.

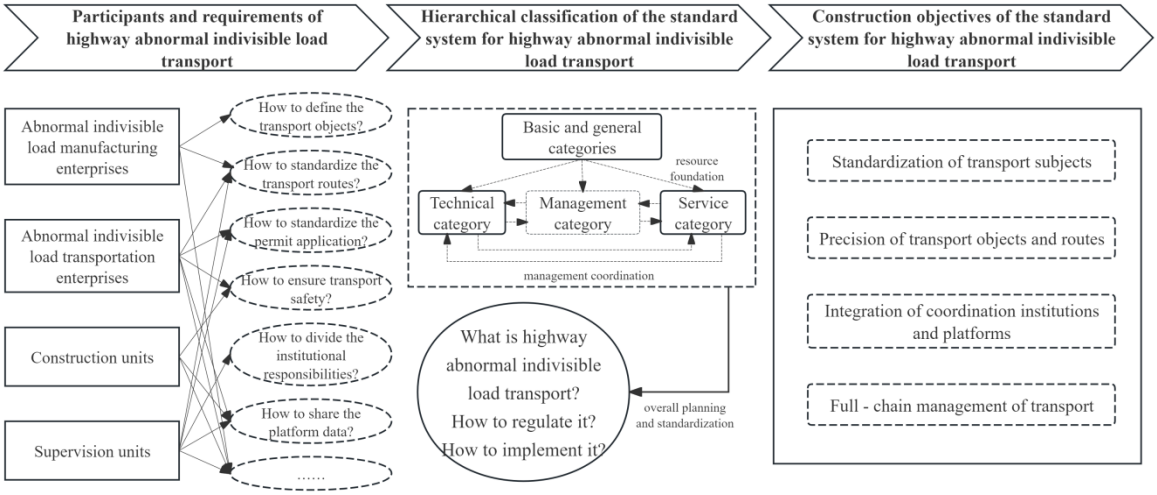

Figure 1: Design of the Standard System for Highway Abnormal Indivisible Load Transport.

4.3 Framework of the Standard System

The framework of the standard system for highway abnormal indivisible load transport comprises four levels: The first level is the module layer, which classifies standards based on the coordinated development needs of highway abnormal indivisible load transport, including basic commonality, enterprise management, permission management, traffic management, operation management, post-event supervision, and service management. The second level is the sub-module layer, which summarizes the sub-categories of existing, required, and planned standards to be formulated or revised within each module. The third level is the detailed sub-module layer, which further refines the specific categories of existing, required, and planned standards to be formulated or revised within each sub-module. The fourth level is the relevant standard layer. The framework of the standard system for highway abnormal indivisible load transport is shown in Figure 2.

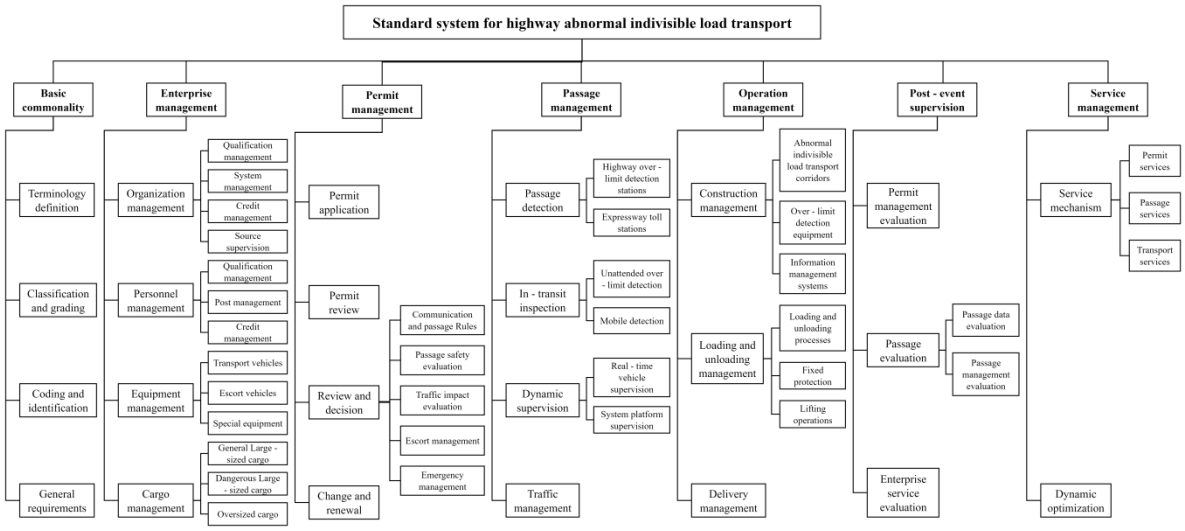

Figure 2: Framework of the Standard System for Highway Abnormal Indivisible Load Transport.

The basic commonality module represents the general foundational requirements for the standard system, standard management, and standard formulation of highway abnormal indivisible load transport. It clarifies the positioning of standards in this field and outlines the regulations and requirements that must be followed in the process of standard management and formulation. The enterprise management module provides technical and management specifications for the management of enterprises, personnel, equipment, and goods related to highway abnormal indivisible load transport. The permission management module specifies the technical and management standards to be followed for the application and review of highway abnormal indivisible load transport permits. The traffic management module establishes the technical and management specifications that must be adhered to during highway abnormal indivisible load transport. The operation management module covers the technical and management specifications for the construction of relevant conditions, goods loading and unloading, and delivery management of highway abnormal indivisible load transport. The post-event supervision module aims to standardize the technical and management requirements for permission management, traffic supervision, and enterprise service evaluation of highway abnormal indivisible load transport. The service management module clarifies the management and service standards for highway abnormal indivisible load transport services and their dynamic optimization mechanisms.

5. Application of the Standard System for Highway Abnormal Indivisible Load Transport

Figure 3 intuitively illustrates the applicable scenarios and service objects of various standards, systematically presenting the core functions of each standard and their specific service values in practical transportation operations. This enhances the transparency of the application of the standard system for highway abnormal indivisible load transport.

Through the clear presentation of the logical division and core components of the standard system, this study provides explicit guidance for the implementation of highway abnormal indivisible load transport standards. It helps relevant entities quickly grasp the standards required at each stage, avoiding confusion and fragmentation in standard application. Establishing the correspondence between stages and standards strengthens the regulatory role of the standard system in the

transportation process. For example, it provides a basis for route and vehicle selection in the planning stage, ensures the safety of loading and unloading operations and road passage in the execution stage, and clarifies responsibilities and assessment indicators in the supervision stage. This promotes the standardized and efficient operation of the entire highway abnormal indivisible load transport process, converting standard advantages into improvements in actual transportation service quality and risk control capabilities.

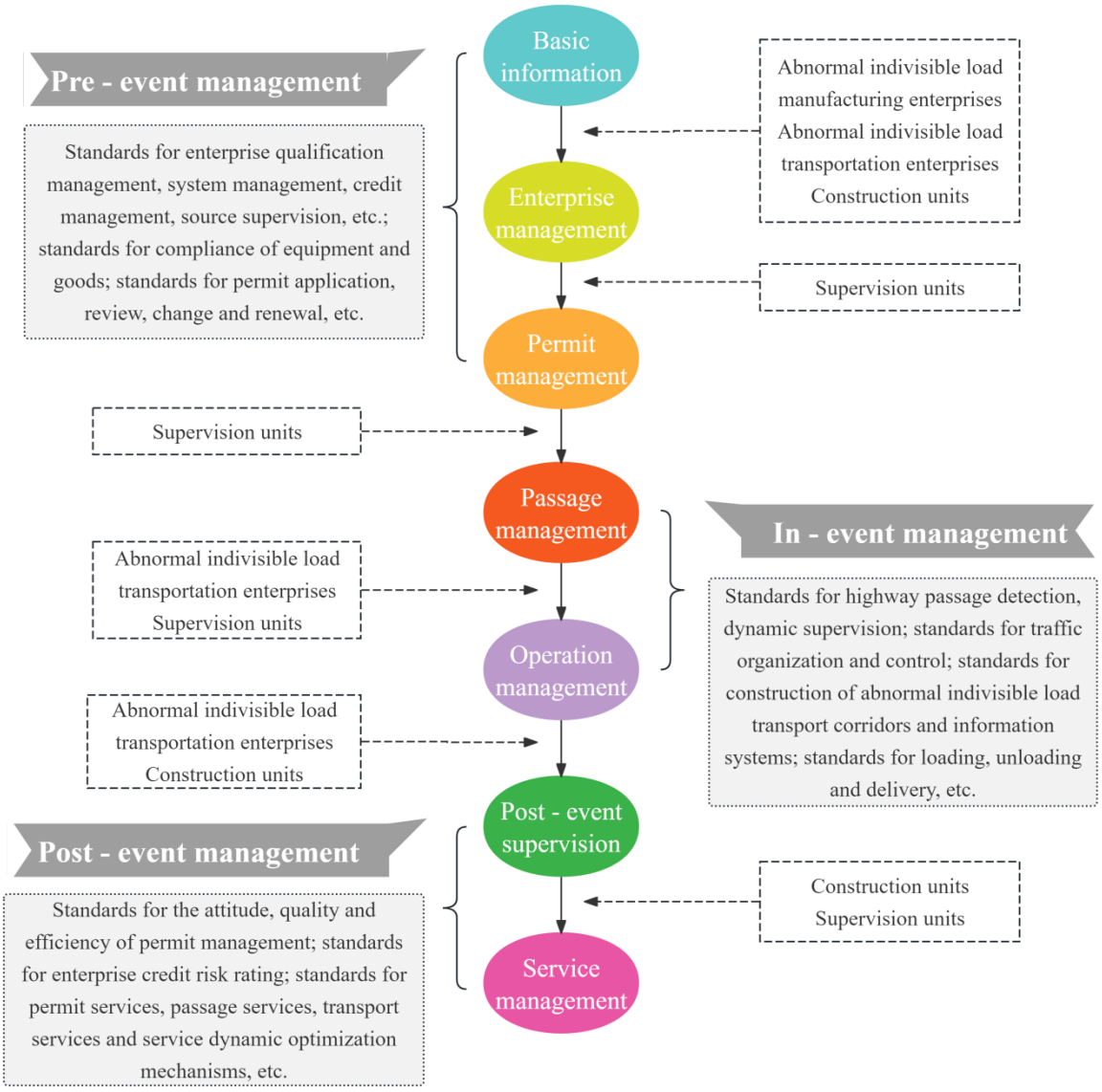

Figure 3: Application of the Standard System Based on the Highway Abnormal Indivisible Load Transport Process.

6. Conclusion

This study systematically constructs a standard system for highway abnormal indivisible load transport, with basic commonality standards as the cornerstone. The system covers six core modules—enterprise management, permission management, traffic management, operation management, post-event supervision, and service management—and is further subdivided into several sub-modules and specific standard categories, achieving full-chain coverage of highway

abnormal indivisible load transport.

The standard system for highway abnormal indivisible load transport regulates the qualifications of transport entities, operational processes, and the definition of responsibility boundaries, effectively curbing illegal behaviors and responsibility shirking. Simultaneously, it realizes the accurate matching of transport objects and routes, facilitating cross-departmental and cross-regional information sharing and significantly improving approval efficiency. Additionally, by standardizing key links such as equipment technology, loading and reinforcement, escort plans, dynamic monitoring, and emergency disposal, transportation risks are systematically reduced. Moreover, the standard system runs through the entire process of production source, transportation execution, construction receiving, and supervision guarantee, ensuring the controllability and traceability of the transportation process.

The implementation of the standard system for highway abnormal indivisible load transport lays a solid foundation for the improvement of subsequent relevant legislation and policies. It represents a key measure to enhance the systematic and standardized level of highway abnormal indivisible load transport in China. Future research should focus on promoting the practical application of cross-provincial mutual recognition, digital empowerment, and green safety within the standard system.

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References

[1] TIAN Zhending, LV Lu, Wang Yuying, et al. Evaluation Method for Space Accessibility of Highway Abnormal Indivisible Load Transport. Journal of Highway and Transportation Research and Development, 2024, 41(03):179-189.

[2] YAN Shengyu, WANG Zhaolong, LI Xingju, et al. Planning and Considerations on the National Highway Transportation Channels for Large Cargo. Highway, 2025, 70(05): 229-233.

[3] SONG Zhigang, ZHANG Qiao, SUN Dawei. Risk Identification and Prevention and Control of Road Heavy Cargo Transportation Based on WSR Methodology. Journal of Beijing Jiaotong University (Social Sciences Edition), 2022, 21(04): 45-53.

[4] Ministry of Transport. Decision of the Ministry of Transport on Amending the Provisions on the Administration of Abnormal Indivisible Load Transport Vehicles Traveling on Highways. Gazette of the State Council of the People's Republic of China, 2021, (29): 87.

[5] DONG Ying. Optimization Research on Multimodal Transportation Path Selection for Large Cargoes. Dalian: Dalian Maritime University, 2024.

[6] REN Xiaohui, SHAO Yongjun, WANG Lianzhu, et al. Research and Development on the Functions of the Oversized Cargo Transportation Management System. Journal of Highway and Transportation Research and Development (Applied Technology Edition), 2015, 11(12): 26-28.

[7] QI Xiangyu, YU Jian, BAI Huishan. Research on Vehicle Selection and Load Standard Based on Large-scale Transportation. Highway, 2020, 65(08): 126-132.

[8] ZHAO Xiaojin, WU Jiajia, WANG Xianan, et al. Study on Rapid Preliminary Screening Algorithm of Safety of Large Cargo Transport on Bridge. Journal of Highway and Transportation Research and Development, 2023, 40(02): 81-88.

[9] GU Yuhong. Enlightenments from the Cooperation between Ririshun and Yadea on the Development of China's Oversized Cargo Logistics. Practice in Foreign Economic Relations and Trade, 2019, (03): 85-87.

[10] Zhou Y M, Zeng C H, Xian F. Study on Highway Transportation Route Selection of Heavy and Oversize Cargo. Applied Mechanics & Materials, 2015, 730: 25-28.

[11] PAN Tingting. On the Routes Decision for Outsize Cargo Road Transportation Considering Traffic Control. Chengdu: Xihua University, 2021.

[12] Moon D S, Kim D J, Lee E K. A Study on Competitiveness of Sea Transport by Comparing International Transport Routes between Korea and EU. Asian Journal of Shipping & Logistics, 2015, 31(1): 1-20.

[13] HE Bin. Research on Improvement of Management Capability of Highway Bulk Transport Enterprises in China—Based on the perspective of institutional change. Chengdu: Xihua University, 2021.

[14] WANG Xiaodan, XIONG Li. Research on the Collaborative Governance System for the Highway Transportation of Bulky Cargo. Logistics Sci-Tech, 2024, 47(22): 86-88+97.

[15] ZHU Ping. Research on the Highway Oversized and Overweight Transportation Permit System. Nanjing: Nanjing University of Information Science and Technology, 2022.

[16] LV Xiaoqian, JIANG Xue,MIN Dan, et al. New Opportunities and Challenges for Oversize and Heavyweight Cargo Logistics with the Goal of Carbon Neutrality and Carbon Peak [J/OL]. Logistics Research, 1-11 [2025-08-21].

[17] ZHAO Luming. Research on the Evolution of the Tripartite Game of Highway Bulky Transport Safety. Chengdu: Xihua University, 2024.

[18] HAN Yong. Study on the Logistic Development Strategic of Railway Large Cargoof China Railway Special Cargo Services Co.,Ltd. Beijing: Beijing Jiaotong University, 2015.

[19] CHENG Bo. Research on Safety Production Key Technology of Oversize/Overweight Transportation Enterprises. Chongqing: Chongqing University, 2012.

[20] MENG Lin. Research on Organization and Security Methods of Abnormal Load Haulage. Jilin: Jilin University, 2013.

[21] LI Tieshun, XIE Haoming. Construction of Blockchain-Based Oversized Cargo Transportation Service and Supervision System. China Highway, 2023, (07): 106-109.