

# *Research on Risk Assessment and Index System Construction of Urban Rapid Rail Transit Operation*

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**Keywords:** Urban rail, Traffic operation, Risk assessment, Construction of index system

**Abstract:** In order to solve urban traffic congestion, environmental pollution and other related problems, major cities across the country have set off a climax of Urban Rapid Rail Transit (URRT) construction. In the URRT industry, the realization of safety risk management, based on the existing safety management, the strengthening of safety awareness, the improvement of safety concept and the optimization of work ideas are conducive to reducing operation risks and improving the level of safety guarantee. On the contrary, if the potential risks in URRT operations are identified and evaluated before the accident occurs, and preventive measures are taken as soon as possible, this proactive “pre-accident prevention” safety management method can truly reduce the risk of accidents. Frequency to achieve the effect of preventing problems before they occur. In view of this, this paper combines the current situation of URRT safety management, starts from the goal of risk assessment, discusses the establishment of risk evaluation index system for different management levels, and establishes an evaluation model based on extension theory, and then provides a new method for URRT risk evaluation. Identifying the risk factors of URRT operation safety through scientific and effective methods, analyzing the safety status of URRT operations, and preventing and controlling operation safety accidents are of great significance to ensuring the safety of URRT operations.

## **1. Introduction**

In recent years, with the rapid development of society and economy, urban traffic congestion has become increasingly serious, and ground transportation has been unable to meet people's growing demand for transportation, and the contradiction between transportation supply and transportation demand has become more acute [1]. The country has set off an upsurge in Urban Rapid Rail Transit (URRT) construction. According to statistics from the National Development and Reform Commission, there are currently 43 cities in my country that have been approved for rail transit planning and construction, with a total planned mileage of about 8,600 kilometers [2]. At the same time, traffic congestion, exhaust emissions, noise pollution, traffic safety and other common problems in the rapid development of cities, in turn, restrict the development of cities. Therefore, it is particularly important to study the relationship between risk factors of URRT. Reading the literature, it is found that there are relatively few studies on risk balancing, and the research on risk balancing of URRT operation in China is still in its infancy [3]. Actively explore and effectively

solve the problem of traffic congestion in major cities all over the world. At present, the more recognized solution is to give priority to the development of public transport. At present, there are many phenomena around the world, such as urban traffic congestion, frequent traffic accidents and atmospheric environmental pollution. In particular, most cities in China have been plagued by “haze” in recent years. In the future, URRT projects will become the main force of urban public transport development [4]. The carrying capacity of ground transportation is limited. In the long run, URRT will strive to promote sustainable development [5].

Beijing Metro Line 1, China's first URRT line, started construction in 1965 and was completed and opened to traffic in 1969. URRT has become an indisputable development in the United States, Europe, China, Japan and other countries and regions because of its outstanding characteristics such as speed, safety, punctuality, comfort, environmental protection and large traffic volume [6]. It has become an important means of transportation to alleviate the problem of traffic supply and demand and improve the traffic structure [7]. By the end of 2016, the national URRT operating mileage reached 4,152.54 kilometers, and it is expected that by 2020, the national operating mileage will reach 6,000 kilometers [8]. In the past ten years, China has experienced a large-scale and rapid development process of railways and URRT. In recent years, China's URRT is developing in the direction of large-scale, networked structure, diversified systems, and intelligent equipment. The URRT system is becoming more and more complex, and the risk sources are also increasing, and the risk factors affecting the operation safety of this complex system of URRT are random, dynamic, uncertain and fuzzy [9]. Coupling and interweaving, the system is highly complex. Through the risk assessment and research on the equipment factors in the operation safety of URRT, it can be instructive for the cities where URRT is initially built, and it is exploratory and forward-looking for cities with rapid URRT development [10]. On this basis, establish an evaluation model that meets the evaluation requirements, so as to improve the rigor and practicability of the evaluation, and put forward feasible suggestions for the improvement of supporting facilities, which is of great significance to safe operation.

## 2. Analysis of Safety Accidents in URRT Operation

### 2.1 URRT Operation Accidents

Within the operation scope of URRT, due to the reasons of rail transit operation unit, passengers, force majeure and other non operation unit reasons. Therefore, through the investigation and analysis of the accident data, this chapter finds out the influencing factors of URRT risk, combs out the coupling relationship between the influencing factors, and paves the way for the construction of a multi-level URRT operation risk evaluation index system later. General accidents are scattered, mainly including signal fault, train fault, traction fault, braking fault, etc. However, creating an efficient and perfect risk assessment index system is not a simple thing. Therefore, we need to identify and deal with the risk elements according to the corresponding principles and methods, so as to deal with the problem efficiently. URRT is a means of passenger transport with large capacity in the city, and its operation safety risk control is particularly urgent. Therefore, once an emergency occurs at a certain subway station or a certain operating line, other related stations or lines will be affected, and if a serious accident occurs, it will even affect the entire operating network. URRT is relatively closed, and the rescue and safety passages are relatively narrow. In the event of an accident, it is difficult for passengers to quickly evacuate the scene, and it is also difficult for rescue personnel to quickly arrive at the scene. It is difficult to use rescue equipment, causing rescue difficulties. A comparative analysis of the advantages and disadvantages of the commonly used risk assessment analysis methods is shown in Table 1.

*Table 1 Advantages and Disadvantages of Commonly Used Risk Assessment Analysis Methods*

Method	Complexity	Interpretability	Fuzzy processing	Risk level	Method category
Expert evaluation method	Simple	Interpretable	Can not	Can not	Directional analysis
Analytic hierarchy process	Commonly	Interpretable	Can not	Can not	Semi directional analysis
Neural network method	Complex	Unexplainable	Can	Can	Quantitative analysis

## 2.2 Classification of Safety Accidents in URRT Operation

Because URRT is a complex and comprehensive transportation system, the safety accidents that occur during its operation are also manifested in various types. Whether in a tunnel or on an elevated train, because the train runs in a fully enclosed environment, once an accident occurs, emergency rescue is extremely difficult, and it will inevitably cause serious casualties and property losses. The severity of these faults leads to different train interruption times, and thus different levels of corresponding general accidents. Generally speaking, most accidents occur within 10 minutes of train interruption, that is, the number of C-type accidents occurs more frequently. According to the business unit and the actual situation, the safety risk problem is divided into monitoring and maintenance, equipment maintenance and other parts. The operation of subway requires coordination and cooperation among multiple disciplines. Combing and analyzing the risk change law among various disciplines can better investigate the risks of various disciplines and lines. Hazard identification refers to the process of identifying the existence of hazard sources and determining their characteristics. It plays a more and more important role in people's travel. It is of great significance to consider the risk factors of rail transit operation safety so as to conduct a good risk assessment. However, its characteristics of centralized personnel, high complexity of equipment and facilities, closed or semi closed operation and systematic management make it difficult to ensure operation safety. Therefore, this section will introduce the national standards and local guidelines for the classification of URRT operation safety accidents respectively.

## 3. Construction of Risk Evaluation Index System for URRT

### 3.1 Construction Objectives and Principles of Evaluation Index System

The construction of URRT operation safety risk evaluation index system should have both evaluation goals and guiding goals. A good safety management model can promote the healthy and orderly development of the URRT system, but inadequate safety management may lead to chaotic organizational management, lack of supervision and management, lax personnel safety awareness, illegal operations, and missed inspections and repairs, which in turn leads to safety accidents in URRT operations. Risk pre-control management includes not only the identification, assessment and monitoring of risk factors, but also the organizational guarantee of risk management, ensuring that the risk management system that has been formulated can be effectively implemented, and promoting the comprehensive development of risk pre-control management in URRT operations. The power of continuous coupling will continue to expand, and the risk of not being able to couple again will tend to disappear. It is precisely because of the complexity of the equipment system that the hidden risk factors have different degrees of impact on the operation safety of URRT. It may only cause the delay of operation and the temporary detention of passengers. It may also cause the fatal accident of vehicle destruction and human death and the paralysis of the main urban

transportation network. The selection of latent and explicit variables of type needs to first determine the risk evaluation index, and the index selection is mainly based on the principles of systematicness, comparison, operability and scientific theory. The traditional principle oriented risk assessment is relatively simple. It relies more on professional experience and pays more attention to form than substance. While the goal oriented risk assessment reaffirms the principle orientation, it is more specific and operable. The following results can be obtained by comparing and analyzing the risk level with the responsible unit, as shown in Table 2.

*Table 2 Comparison between Risk Level and Responsible Unit*

Responsible unit	Risk level		
	Level 1	Level 2	Level 3
Branch 1	6	15	38
Branch 2	8	1	5
Branch 3	2	8	24
Branch 4	1	5	6

### 3.2 Construction Ideas and Basic Process of Evaluation Index System

Based on the investigation of URRT safety risk at home and abroad, this paper uses the risk coupling analysis method to explore the influencing factors of rail transit risk. The URRT operation safety index system should be set scientifically, which should not only conform to the actual situation of URRT operation safety, but also comprehensively and systematically reflect the risk level of various constituent elements of URRT operation safety. Based on the construction principles and objectives of the evaluation index system, according to the structural characteristics of rail transit and considering the needs of different management levels, the safety risk evaluation index system is constructed from the three levels of station, line and line network, so as to realize the micro, meso and macro safety risk evaluation of URRT. The on-board equipment mainly includes on-board wireless units and on-board Ethernet switches. The risk assessment of URRT equipment system is the basis and precondition for the hierarchical management of URRT equipment system. System dynamics mainly relies on the internal connection between all the information fed back and related factors, using these two points to carry out a reasonable analysis, and on the basis of the analysis conclusion, build the structure diagram of the system and simulate the system at the same time. It involves a wide range of knowledge, strong theory, and high accuracy of output results. It is a method with strong practicability. In order to reflect the operational safety level of URRT from all aspects and angles, the construction of the index system should select relevant indicators from the URRT operation system and various subsystems. Each level index system uses the factor analysis method to calculate and screen the indicators to ensure the comprehensiveness and non-repetition of the selected indicators. All selected indicators are clearly defined one by one, and corresponding calculation and measurement methods are given to characterize the impact of URRT safety degree of influence.

### 4. Conclusions

To alleviate the problems caused by the rapid development of cities such as urban traffic congestion and vehicle emissions, many cities are planning and building URRT. With the rapid advancement of networked operation of rail transit in major cities, safety risk assessment plays a role in promoting and connecting the safety planning, design, management, and maintenance of URRT to form a closed-loop effect, which is of great significance for reducing operational risks and

ensuring operational safety. Through on-the-spot investigation and reviewing a large number of documents, the equipment system is divided into vehicle system, power supply system, electromechanical system and communication signal system. Therefore, based on the in-depth analysis of the current situation and risk assessment theory of URRT operation safety at home and abroad, this paper establishes the index system according to the relevant national standards and local guidelines, introduces the interpretive structure model and the fuzzy polymorphic Bayesian network model, and makes relevant research on the risk assessment of URRT operation safety. This paper explores the accident law in the operation of URRT from the dimensions of time, space and specialty, and determines that human factors, equipment and facilities, environmental factors and management factors are the four major factors affecting its safe operation.

## Acknowledgements

Supported by the Science and Technology Research Program of Chongqing Municipal Education Commission (Grant No. KJZD-K201904301).

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