Original Research Article

Research on the Risk Warning and Control of the Project Progress of Beijing Daxing International Airport

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Abstract: Based on the theory of progress control and risk management, this paper systematically sorts out the progress risk of Beijing Daxing International Airport, discusses the general schedule and progress risk identification model and its approach, and constructs multi-level early warning and dynamic monitoring methods for progress risk. Meanwhile, the method for general schedule and progress risk management of large-scale airport projects is also studied. The practice of early warning and control of the general schedule and progress risk of Daxing Airport project has achieved good results, which provides support for the comprehensive progress control of Daxing Airport project, and guarantees the realization of the target completion time of general schedule.

Keywords: Airport project; Schedule risk; Progress deviation; Early warning; Dynamic control.

1. Introduction

As an important infrastructure for civil air transportation and urbanization, the construction of Beijing Daxing International Airport (hereinafter referred to as "Daxing Airport") has effectively alleviated the tension of airspace resources, not only improved the comprehensive transportation system in the Beijing-Tianjin-Hebei region, but also played the role of an aviation hub connecting the world, bringing a wide range of social and economic benefits, and becoming a new power source for the development of the country. A new power source for national development. Daxing Airport, including the main airport project and its many ancillary projects, is a huge airport project group, characterized by large construction scale, complex engineering content, high coordination difficulty and tight schedule, etc. The construction of the airport is full of a high degree of uncertainty, which makes the overall schedule control and the achievement of the overall schedule target of the Daxing Airport project at a certain level of risk.

There have been a number of studies on construction schedule risks and their management. Since engineering projects are usually influenced and constrained by a variety of internal and external factors, Yuan Yongbo et al. concave regarded the construction project as a complex dynamic system, and identified the causes and consequences of schedule risk in the implementation stage. Wang Yujing and others investigated the complex relationship between the construction process subsystem, scope subsystem, resource management subsystem, target subsystem and project performance subsystem, and established an integrated large-scale complex project planning model based on this. In terms of progress monitoring, Chen Dongfang and others proposed a general process of progress early warning and selected schedule progress and investment progress as early warning indicators for tracking and control. Shao Xiaoliang and others implemented hierarchical monitoring and early warning for project progress risk and grasped the project progress status through layer-by-layer feedback linkage. Han Xiaokang and others constructed an early warning and tracking system of progress plan, including node change and resource optimization to achieve effective control. Li Cunbin aand others simulated the different impacts of schedule risk treatment time on project objectives by taking power grid construction projects as an example.

Although existing studies have theoretically analyzed the schedule risk of engineering projects, there is still

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a need for in-depth discussion on how to carry out schedule risk management of large-scale engineering projects, especially the total schedule warning and its target management and control for the characteristics of airport projects and project groups. This paper intends to combine the successful practice of the comprehensive control of the total progress of Daxing Airport, based on the system theory, to build a goal-oriented and data-supported risk management structure for the total progress of airport projects, to respond to the risk factors in a timely manner and to continuously track them, and to study the risk warning and control methods for the total progress of large airport projects on the basis of the analysis of the characteristics of complexity.

2. Risk System Analysis of Total Schedule of Daxing Airport Project

In the comprehensive control of the total progress of the Daxing airport project, in addition to passive control, active control is also carried out, i.e., by analyzing the possibility of progress deviation and sending out signals to remind and warn the potential progress risk before the progress deviation occurs, and implementing progress warning. This is because there are many uncertainties in the process of the construction and operation preparation of Daxing Airport according to the scheduled plan, and by carrying out the risk control of the total progress of the project, it is possible to take precautionary measures in advance according to the progress warning and the risk information, and try to minimize or avoid the risks that may cause the progress deviation.

2.1 Indicator System Construction

Engineering project risk management refers to the identification, analysis and effective control of the factors that may lead to the failure to complete the project objectives or delayed completion during the project life cycle, so as to maximize the value of the economic unit with the lowest risk cost. Analyzed from the perspective of the objectives, engineering project risk management mainly includes four dimensions: schedule risk, cost risk, quality risk and safety risk, and the different dimensions can be transmitted to each other, thus generating a chain effect. Figure 1 reflects the complex relationship between risk factors, interacting with each other under different mechanisms, cost risk brings resource constraints and then affects the schedule, quality risk and safety risk will cause rework or even stoppage, which will ultimately lead to project schedule lag, resulting in failure to complete the target. Therefore, the achievement of progress goals should be promoted by risk management, in addition to the factors that directly constrain the progress, we should also pay attention to the impact of different dimensions of risk, and consider the correlation between risk factors.

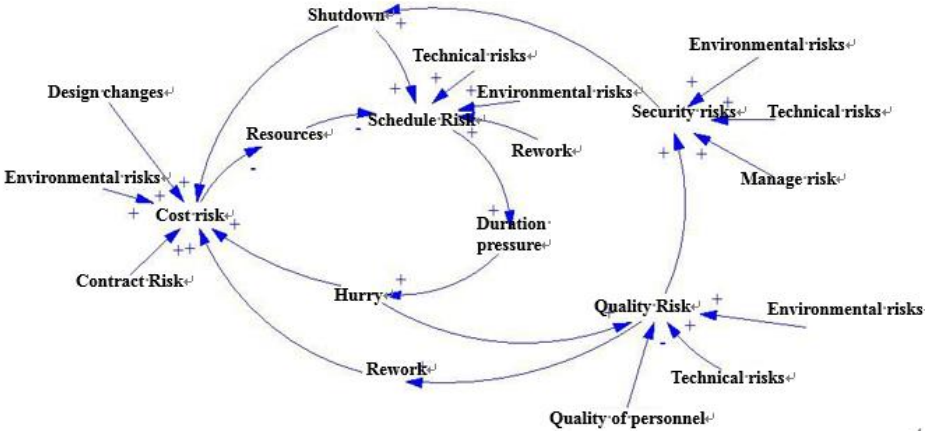

Figure 1 Risk causality diagram of airport project total schedule.

2.2 Scope of Risk Assessment and Analysis of Total Progress of Daxing Airport Project

The total progress risk is the uncertainty events and negative factors affecting the realization of the total progress target of the Daxing airport project, and all possible uncertainties affecting the realization of the total progress target should be included in the scope of the total progress risk assessment. The construction and operation preparation of the Daxing Airport project is a systematic project, which has certain factors, random

factors, fuzzy factors and unknown factors, and the interaction between the system environment and elements poses various threats to the total progress of the project. The source of schedule risk is defined as a multilevel system scope in the total schedule risk assessment, and its conceptual model is shown in Figure 2, including four parts: the core system layer, the intermediate system layer, the sub-peripheral system layer and the peripheral system layer:

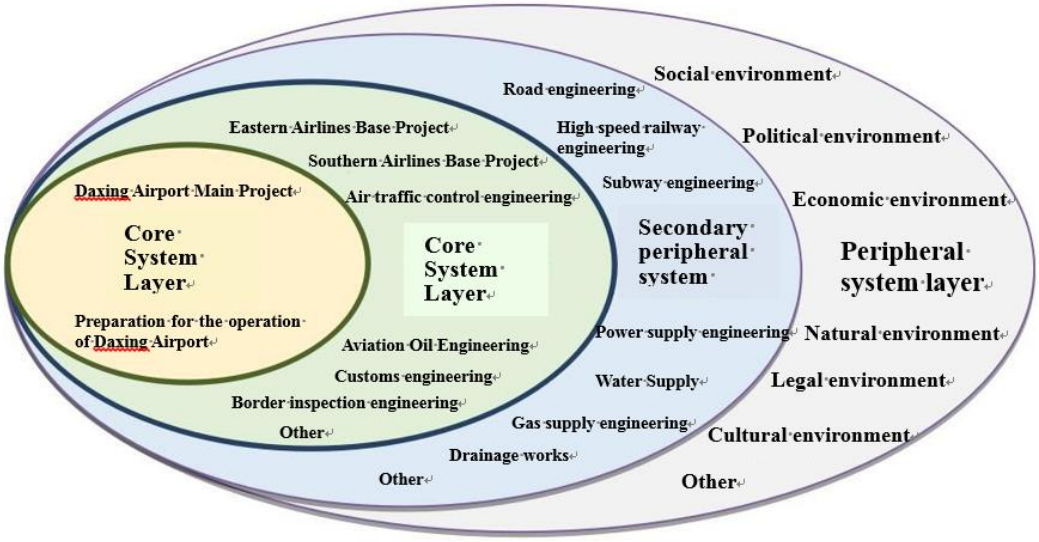

Figure 2 Conceptual model of risk system for construction and operation research of Beijing Daxing Airport.

(1) Core System Layer: the possible schedule risk in the construction and operation preparation of the main project of Daxing Airport is the core of the schedule risk assessment, and the scope of responsibility for the risk mainly includes the responsible units such as the construction unit of the main project of the airport (Daxing Airport Construction Command) and the operation unit (Daxing Airport Management Center);

(2) Intermediate System Layer: the work and works of other construction and operation units in the airport area other than the main project of Daxing Airport may bring about schedule risks, and the scope of risk responsibility mainly includes the responsible units such as airlines (China Eastern Airlines and China Southern Airlines), air traffic control, aviation fuel, customs, border control and public security;

(3) Sub-peripheral system layer: the schedule risks that may be brought about by various off-site municipal ancillary projects outside the Daxing Airport area, such as road systems, rail transportation, power supply, gas supply, water supply and drainage, etc. The scope of risk responsibility mainly includes the Beijing Bureau of China Railway, the Airport North Line Company, the Beijing-Tianjin-Hebei Metropolitan Railway Company, the Beijing Infrastructure Investment Company, and the New Aviation City Holding Company, and other responsible units;

(4) Peripheral system layer: the external environment of the Daxing airport project, including the social environment, political environment, economic environment, legal and regulatory environment, and natural environment. The risk factors of the peripheral system will affect the core system layer project through the intermediate system layer, and may also directly affect the core system layer project.

2.3 Indicator System Construction

The risk of the total progress of the Daxing Airport Project is dynamic due to the influence of changes in various factors, and the corresponding risk control is also a dynamic cycle process, including risk identification, risk assessment, risk control and risk tracking. Among them, risk identification, as the basis, is mainly to find the source of risk, based on historical experience and expert consultation on the one hand, and on the other hand, it is judged by objective information and scenario analysis. Risk assessment is based on a comprehensive analysis of the probability and severity of risk events, and the risk is evaluated through PERT, VERT and Monte Carlo

Simulation. Risk control is mainly based on the PDCA cycle, which proposes risk reduction measures from multiple dimensions such as technology, organization and economy. Risk tracking not only monitors the residual risks in the project cycle and evaluates the effectiveness of risk control, but also identifies new risks to form a closed loop. The risk warning and control process for the total progress of the Daxing airport project is shown in Figure 3.

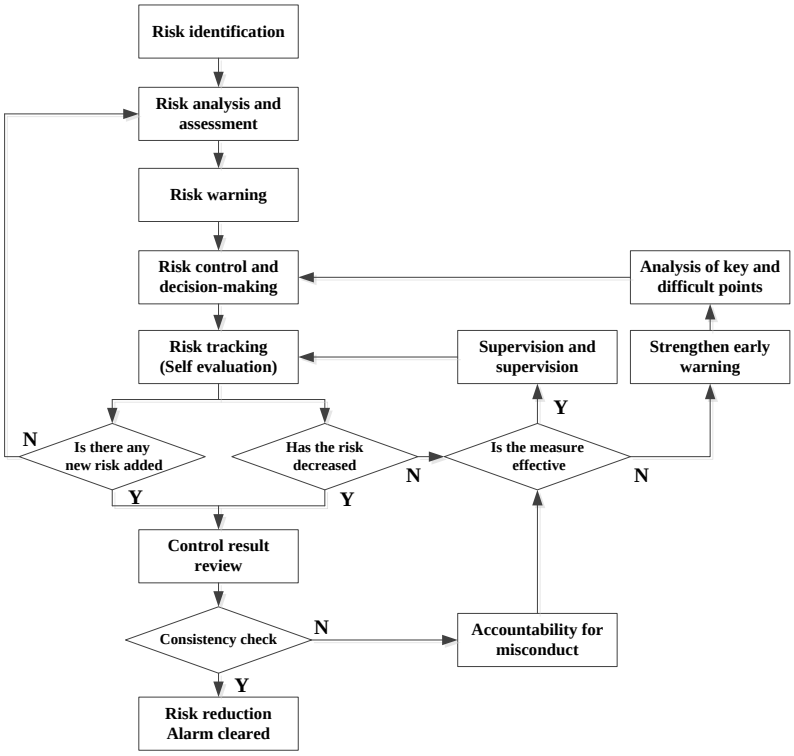

Figure 3 Beijing Daxing airport progress risk early warning and control process.

3. Risk Identification and Evaluation of Total Progress of Daxing Airport Project

3.1 Daxing Airport Project Total Schedule Risk Identification Model

Daxing airport project total schedule risk assessment from the project dimension, process dimension, element dimension three dimensions of the airport project construction and operation preparation schedule risk factors to sort out, build risk identification model:

(1) Project Dimension: according to the composition of the Daxing Airport project, the total schedule risk is identified, analyzed and evaluated by the main airport project, civil aviation supporting project and off-site supporting project, etc. respectively;

(2) Process dimension: according to the construction phase of the Daxing airport project, identify, respectively analyze and evaluate the progress risk of each process phase by the process of pre-construction, construction implementation, completion and acceptance, project handover and operation preparation, etc.

(3) Element dimension: according to the source and nature of various risk factors, the total progress risk identification, analysis and assessment are carried out separately by management organization risk, technology risk, economic risk, legal risk, safety risk and environmental risk.

3.2 Method and approach of total schedule risk identification

The three elements of risk identification for the total progress risk of the Daxing Airport project include risk sources, risk events and risk signs. Risk identification is the foundation and important part of conducting risk management. In order to identify all kinds of risks as comprehensively as possible and prevent omissions, the identification of risks of the total progress of the Daxing airport project is not confined to a certain way, but

is carried out in a variety of forms.

(1) Progress information reporting. For the responsible units or departments included in the Daxing Airport Total Progress Comprehensive Control Plan System, they are required to report the image progress of the project on a regular basis, including the completion of the current month's work, next month's work plan, and influencing factors, etc., covering the two aspects of engineering construction and operation preparation. According to the progress information, it is possible to analyze the lagged nodes, the planned nodes of the current month and the planned nodes of the next month, and identify the risk factors. The information reporting cycle is usually monthly or weekly, and the frequency depends on the progress of the project and the control needs. The "zero report" system was also adopted during the sprint phase of the Daxing airport project, i.e., the data was reported on a daily basis, so as to grasp the progress status in real time.

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(3) On-site inspections. Site inspection, as a more direct way, is an activity led by the Daxing Airport Progress Control Working Group and attended by all construction units to regularly review the progress of each area of the project and at the same time comprehensively identify risk factors. As the on-site environment can fully expose the problems encountered during the construction process, especially the detailed defects that can be easily overlooked, it is of great help in risk identification. In addition, feedback from front-line staff on site is a good way to identify potential risks.

(4) Engineering Analogies. Due to the general similarity of airport construction projects, the method of engineering analogy is also frequently applied to the risk identification of Daxing Airport. Engineering analogies require full knowledge of the Daxing Airport project, familiarity with the project characteristics and progress, as well as a wealth of accumulated experience, so as to accurately locate the risks based on the comparison of specialized knowledge bases, and to prevent the problems that existed in other airports during the same period of construction.

Based on the information collected and the analysis of the total progress risk situation, the total progress risk of the Daxing airport project can be initially identified through direct and indirect symptoms. On this basis, several rounds of communication and interviews will be conducted with relevant units and departments to verify in detail the progress of the Daxing Airport project construction and operation preparation work, discuss and summarize the uncertainties and difficulties in the work, explore the deep-rooted potential risks, and conduct the review, identification and categorization of the total schedule risks.

3.3 Quantitative Assessment of Total Progress Risk of Daxing Airport Project

The basic idea of risk assessment is to measure the severity of the risk based on the probability of occurrence and the degree of loss, however, considering the high complexity of the Daxing Airport, the above elements are difficult to be described quantitatively, and thus the main method of The Prouty Approach, which is relatively simple and effective, is used in conjunction with the PERT technique to make a judgment, and to categorize the total progress risk of the Daxing Airport project into high, medium, and low grades according to the level of the probability of occurrence and the degree of the impact, that is to say:

(1) High risk: there is a high probability of occurrence, which may have an impact on the progress of

construction and operational preparations on a larger scale, and risky accidents can have serious consequences without clear countermeasures;

(2) Medium Risk: the probability of occurrence is high, which will cause a certain range of impact on the progress of engineering construction and operation preparation work, and the consequences are more serious, but measures can be taken or there are corresponding countermeasures;

(3) Low risk: the probability of occurrence is low, the progress of construction and operation preparation will not be greatly affected, or can be effectively controlled under relevant measures, and the consequences of risky accidents can be ignored under certain conditions.

4. Early Warning and Monitoring of Total Progress Risks of Daxing Airport Project

According to the identified risks of the total progress of the Daxing Airport Project, a signal reminder and warning is issued in advance to the potential progress risks before the occurrence of progress deviation, and a progress warning is implemented. According to the progress warning and risk information, the risk control of the total progress of the airport project should be carried out, and preventive measures should be taken in advance to minimize or avoid the occurrence of progress deviation, so as to achieve the purpose of controlling the total progress of the Daxing Airport Project.

4.1 Daxing Airport Project Total Schedule Risk Warning

In the process of comprehensive control of the total progress of the Daxing airport project, a multi-level early warning mechanism is adopted for the progress risk. Analyzing from the task point of view, according to the total progress comprehensive control plan, three levels of project overall target, annual plan and monthly plan can be carried out, and early warning signals can be issued based on the progress deviation. For the monthly plan, the progress deviation mainly selects the node completion ratio and buffer time as the analysis index, and the annual plan also considers the investment deviation. From an organizational perspective, Daxing Airport includes three parts: the main project, the civil aviation supporting project and the off-site supporting project. Early warning signals are first issued at the sub-project level, which are controlled by each investment body, and then escalated to the project-level early warning signals when the risk affects the overall target. The risk assessment of the overall goal is mainly based on the cumulative completion rate of various project nodes and their trends to judge. As shown in Figure 4, reflecting the trend of the node completion rate of various types of investment subjects in Daxing Airport process in July 2019, the slope of the curve indicates the rate of project advancement, showing that the progress is in the state of speeding up or slowing down, in order to serve as an important basis for risk assessment.

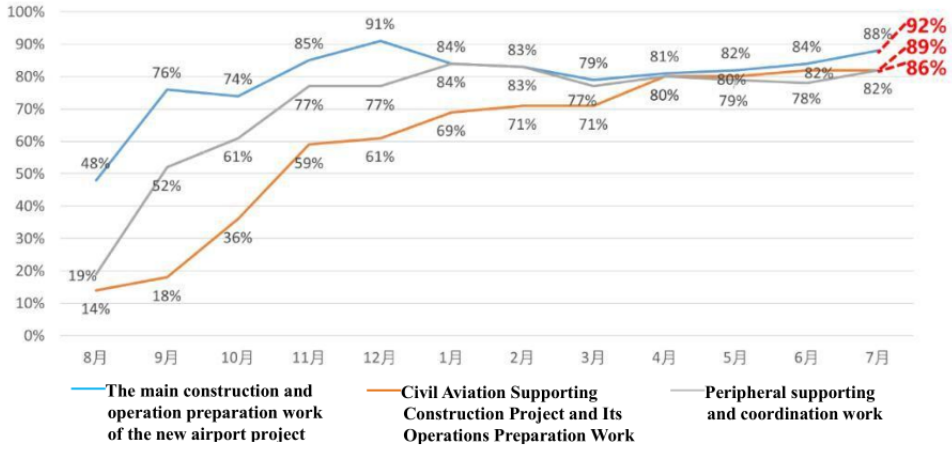

Figure 4 Change trend of completion rate of various investment main nodes in Beijing Daxing Airport.

The identified total schedule risk is the most important result of the total schedule risk assessment of the Daxing Airport project, which is prompted by the total schedule risk list (Table 1). Accordingly, early warning signals are issued to alert relevant units and departments in advance of the execution of the month's nodes to ensure that they are completed as planned. Early warning signals are expressed in green, yellow, orange and red according to the risk level, and Table 2 reflects the correspondence between the warning level, progress status and risk. The green color indicates a normal status that does not require adjustment, the yellow color indicates a mild risk that requires attention, the orange color indicates that the progress has been delayed and risk control should be strengthened, and the red color indicates a serious status at high risk that requires high attention and timely treatment.

Table 1 List of risk alerts for the general progress of the daxing airport project.

Number	Investment Subject	Critical control nodes					warnin	Note
		job category	Node name	Plan time	Node number	execution		
Delayed nodes are expected to be completed within the current month		Delayed nodes are expected to be completed in the current month with high risks			The delayed nodes are expected to not be completed in the current month			

Table 2 Correspondence between warning level, progress status and risk.

Level of risk	Description of the early warning situation	Difficulty of post control	Level of Warning	Warning signal
High risk	Progress is seriously delayed, unable to complete the work on time	Difficult	Severe	Red
Medium risk	Progress delays are manageable and require attention	Harder	Moderate	Orange
Low risk	Slight progress delays with low impact	Easier	Light	Yellow
Risk-free	Progress is normal and can complete the task on time	Easy	Normal	Green

4.2 Daxing Airport Project Total Schedule Risk Warning

The fundamental purpose of risk identification and assessment is to effectively respond to risks, which, in the strict sense, cannot be completely eliminated, but only measures can be taken to minimize them. Based on the practice of comprehensive risk management at home and abroad, the risk response methods adopted in the comprehensive control of the total progress of the Daxing Airport Project include seminars, interviews, thematic analysis and expert consultation, etc., in which the responsible units or departments analyze the deep-rooted causes and then take measures to control them. For risks that are influenced by the interaction of multiple factors, it is necessary for all departments to coordinate and cooperate to solve them.

(1) Implementation of responsibilities and establishment of special control teams. In order to effectively cope with the problem of numerous construction projects at Daxing Airport and the difficulty of organization and coordination, the total progress control organization of Daxing Airport project is optimized, and a special control team and commissioner mechanism is established (Figure 5). Implementing risk responsibility attribution. For the civil aviation supporting projects and off-site supporting projects, each investment body appoints a commissioner to control them, ensuring that each risk has a corresponding responsible unit or department. The control commissioner connects information with the outside world and coordinates relevant issues, gives feedback on professional opinions, and improves the comprehensive control and communication effect of the

overall progress.

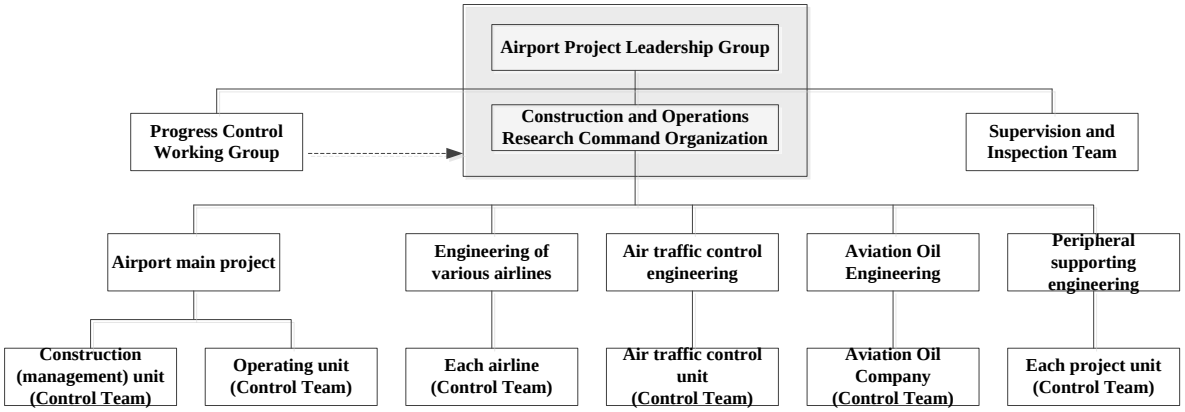

Figure 5 Organizational structure for integrated control of the total progress of the Daxing Airport project.

(2) Finding out the causes and conducting expert consultations. Expert consultation is a supplementary means for the overall progress control of the Daxing Airport Project, in which experts are invited to analyze the root causes of major progress problems and put forward countermeasures. The expert consultation is mostly carried out in the form of seminars, adopting methods such as theoretical analysis and example explanation, analyzing, arguing and summarizing the major risks, and finding scientific and reasonable solutions. The final opinions will be incorporated into the daily control system, playing an important role in resolving conflicts and reducing risks.

(3) Focused tracking and implementation of supervision and accountability. For problems where there is a significant risk to progress that leads to serious delays in progress and where corrective measures have not been taken or where the effect of corrective measures is not obvious, control is increased and focused tracking is carried out. Supervision and inspection team can issue supervisory documents, requiring the responsible unit to reply and rectify within a time limit. At the same time, under the leadership and scheduling of the General Command of the commissioning, all parties coordinate to solve various conflicts and difficulties. Through increased control and integration of resources, comprehensive advantages can be formed so that progress problems can be solved quickly and progress risks can be resolved in time.

(4) Rewards and punishments are given and incentive assessment is strengthened. The appraisal mechanism is used as an incentive for the comprehensive control of the total progress of the Daxing Airport Project, and it guides the improvement of the related work while recognizing the work achievements, and controls the problems at a lower level and solves them. The appraisal program is based on the completion of the total progress comprehensive control plan and nodes, and the implementation of stage-by-stage performance evaluation, which includes:

1) Analysis of information, such as progress plans, control systems, control programs and outcome reports prepared by relevant units and other relevant information, to examine the comprehensiveness, effectiveness and reasonableness;

2) On-site evaluation, such as the implementation of the control plan, the quality of control work, the effect of progress correction and correction of bad behavior, etc., based on the results of the on-site visit scoring.

4.3 Risk Tracking and Monitoring of the Total Progress of the Daxing Airport Project

The environment changes all the time in the process of promoting the total progress of the Daxing airport project, and dynamic tracking of risks can, on the one hand, clarify the stage-specific focus of risk control and provide decision makers with a clear management pulse; on the other hand, it is possible to understand the real-time situation of the risk factors and find out the deep-rooted reasons for the changes. Grasping the trend of risk changes also makes it possible to verify the work carried out by the responsible departments or units and assess the effectiveness of measures. In addition, based on the systemic nature of existing risks, which may lead to new

risks, risk monitoring and tracking can identify new risks as early as possible, so as to prevent them from occurring in the first place.

During the risk tracking process of the total progress of the Daxing airport project, the departments or units under the responsibility report the changes of the existing risks and the effect of the implementation of the control measures, and focus on observing the changes of the risk probability, impact and level, and evaluating whether the overall risk is decreasing or not, and feedback the newly increased risks on this basis; the progress control working group reviews the risk situation, and puts forward the signal of alarm lifting or strengthening after re-assessment.

The total progress risk tracking and monitoring is based on a monthly cycle, which can be varied in terms of approach and rhythm according to the needs of the work, and its main outcomes are the risk tracking and monitoring report and risk list prepared on a rolling basis.

The continuity of the total progress risk monitoring report reflects the changing trend of risks, such as reduction from high risk to medium risk or transformation from low risk to high risk. The tracking and monitoring of the risk of the total progress of the Daxing Airport Project enables the General Commanding Department of the commissioning to have a comprehensive understanding of the progress, a clear grasp of the overall priorities, a clearer understanding of the changes in risk, and provides basic support for its efficient scheduling, coordination of resources and scientific decision-making, so that the overall progress of the project is always in a controllable state.

5. Conclusions

The risk management of the total progress of Daxing airport project is a dynamic and complex process, which brings a lot of uncertainty and difficulty in risk control and prevention due to the coexistence of multiple risk factors and constant changes with the changes of internal and external environments of the project. This paper applies the relevant theories and methods of risk management, and based on the practice of early warning and control of the total progress risk of Daxing Airport project, it studies and explores the methodology system of the total progress risk management of large civil airport project, including the analysis method of the total progress risk system of the airport project, the total progress risk identification model and its way, the total progress risk multi-level early warning and the dynamic monitoring method, etc. It is hoped that this method will help to improve the overall progress risk management of Daxing Airport project. It is expected that the successful practice of risk early warning and control in the process of comprehensive control of the total progress of Daxing Airport will provide a reference for the comprehensive control of the total progress of large civil airport project construction and operation preparation.

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