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THE CIVIL AIRCRAFT DEVELOPMENT PROJECT RISK MANAGEMENT RESEARCH

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Abstract

In Civil Aircraft Development Project, risk management is one of the key project management functions. It manages and controls the project risk by planning, identifying, evaluating, dealing with and monitoring the project risk. After carrying out the first flight test of one type of aircraft, the risk management activities of the major technical risks of the aircraft were planned by making use of the best period of project preparation at the initial stage of the certification phase of the flight test, the use of risk management procedures effectively responds technical risks at the project level. In the project, through the application of specific risk management procedures to solve the technical problems in the project, and effective implementation of the entire project organization the major technical risks are deal with. Through the project risk management, the risks that threaten the civil aircraft development project will be planned, identified, assessed, responded to and monitored, and the project risks that were previously neglected and poorly managed will be effectively identified and responded to. The project risk management has greatly strengthened the risk response of the project and ensured the smooth implementation of the civil aircraft development project. Risk management has become an effective tool for a civil aircraft research and development unit to deal with technical risks.

Keywords: Risk Management, Systems Engineering, Civil Aircraft Development Project, Technical Risk

1. Introduction

Civil Aircraft Development Project is large-scale, high technical difficulty, and very complex development process. Because the project risk may threat the achieving of the project goal, it is necessary to establish project risk management mechanism in the project, and systematically plan, identify, evaluate, respond to and monitor the project risk. On the basis of effective risk management of the project, the objectives of the project are successfully achieved. Risk Management is a very important technology and tool for project management, which is carried out in all development stages, work packages and teams of the project.

From the perspective of systems engineering, project risk tends to be more technical risk [1], and project risk management procedures can effectively deal with technical risks. After one type of civil aircraft project entered the airworthiness certification phase, in order to achieve the goal of obtaining airworthiness certification evidence, a civil aircraft research and development unit systematically investigated the technical risks of the project, and use the risk management mechanism to effectively deal with the major technical risk projects. In airworthiness certification phase, the basic flight test are with the objective material conditions, and are easy to find the potential risk of aircraft. At the same time, in this stage the risks of large-scale, high difficulty, a large amount of design changes need to be deal with. The project team, on the basis of inheriting the previous risk management system of the project, creatively used the systematic method of risk management to control the major technical risks of the project and ensure the smooth implementation of the project, greatly increased the success rate of the project.

The understanding of risk is highly consistent from top to bottom in the civil aircraft development unit. Only by actively identifying and dealing with risk, we can effectively use the time of the project cycle, effectively deal with the risk and improve the technical success rate of the project. In the project, we should actively deal with the project risk, rather than waiting for the risk to occur, and then jeopardize the successful implementation of the project.

2. Overview of the problem

In the initial stage of airworthiness certification after the first flight, it is the best time to carry out the risk identification of one type of civil aircraft project. During this time, the test aircraft has begun flight testing, the project has entered the airworthiness certification phase. In this stage of preparation for airworthiness certification, we can effectively avoid the actual occurrence of the risk by systematically checking the technical risk, identifying the technical risk of the project, and taking the initiative to use the time of the project development cycle to deal with the risk, avoid bringing major technical issues to the production and operational phases of the aircraft model in order to achieve a better posture for project implementation.

At the above time of the project, it is a good time to use the project risk management mechanism to deal with the project risk, which is a clear judgment of the project senior management. After identifying the timing and type of the problem, the project management decided to use a risk management model to track and manage these technical significant risks.

On the basis of identifying the project risk, analyzing the cause of the risk, making a project risk response plan, and let the project team decisively and positively implement the task of risk management response, so as to actively respond to the project risk. Because the civil aircraft development unit applied the risk management system for the first time in the airworthiness certification phase to deal with such a level of project-level risks, the risk management is relatively lack of practical project experience. Therefore, when the project timing and task type, how to organize these technical risk management matters, implement, and then defuse the project risk, has become a major project technical management issue. This paper explores and answers the management question raised by the senior manager of the civil aircraft research and development unit, and answers the management question of the technical risk on the basis of summarizing the practical work. The timing and task of risk identification and response, as well as the organization and implementation of risk management measures, belong to the link of risk planning in the risk management procedure.

The risk management procedures of the civil aircraft development unit include risk planning, risk identification, risk assessment, risk response, risk monitoring and so on, risk management procedures can effectively address these technical risks. The senior management of the civil aircraft research and development unit requested the project management team to take the lead in organizing the sorting out, analysis and formulation of measures and plans to deal with the major technical risks of the project, and put forward to study the management methods of the major technical risks, develop specific and effective management and control measures to strengthen the management and response to technical risks.

In order to solve the problem of how to deal with the technical problems of the project in the early stage of flight test, the project management team of the project analyzed the characteristics of the technical problems of the project are consistent with the characteristics of the project risk, the solution to the technical problems of the project is also compatible with the project risk management procedures. The project team has had a small amount of similar project experience in ground testing at previous stages, to organize and implement technical problem solving by use the procedure of risk management.

According to the high-level requirement of the civil aircraft development unit, the project management team of the civil aircraft project planned the important event of risk management in the initial phase of the flight test. The project team responds to identified technical risks by using risk management program tools. Throughout the project organization, risk identification, risk assessment, risk response and risk monitoring and other risk management matters, and effective management and response to these risks.

For the civil aircraft development project, the relatively important risk is the technical risk, the identification and response of the technical risk reflect the high management level of the project risk management. To deal with the technology risk, we need to find the root cause of the technology risk. Only by investigating the root cause and the transfer mechanism of the technology risk, can the technology risk be solved fundamentally. At the same time, the request unifies the root cause analysis, consummates the corresponding technical specification and the standard,

guides the follow-up model development, avoids the potential technical risk to occur repeatedly.

In principle, the solution to the risk and the optimal design also have the requirement of engineering verification, and need the procedure of engineering verification. During the initial stage of flight test of the civil aircraft project risk response planning, active and full use of the project cycle time, in the project airworthiness certification cycle in parallel design optimization and engineering implementation, referring to the manufacturing nodes of several test aircraft, the engineering changes of risk response are implemented on the following test aircraft, and the optimized engineering design is incorporated into the airworthiness verification process of the project. In this way, the solution of technical risk can be verified by engineering without new technical risk.

The schedule risk and the cost risk in the project risk, their reason has the management factor, also has the technical factor. Schedule risk and cost risk are managed together in the risk management system. Schedule risk and cost risk are often considered unimportant. In order to resolve the project risks in terms of schedule and cost, after verifying and fully understanding the causes of risks, measures such as adjusting task schedule time, arranging work schedule and strengthening on-site scheduling are often adopted in view of schedule risks, and measures such as adjusting project budget are often adopted in view of cost risks.

3. Introduction of key concepts

To facilitate the discussion below, a few important concepts are discussed. These important concepts include risk [1,2] , technical risk, risk management [2] , risk management model and organization.

3.1 Risk and risk management

In a project, there are uncertain negative events and situations such as "risks" . Project risk refers to the events and circumstances that may have adverse impact on the project development objectives under the constraints of technology, cost and schedule. The elements of project risk are in three elements, including uncertain events and circumstances, risk probability and the potential outcome of the risk[1]. Project risk is not a problem that has occurred on the project, but an event that has not actually occurred and has not caused a hazard in fact to the project. The hazardous event of project risk is a hazardous event with the possibility of actual occurrence and negative impact of the project. Often through the application of risk management procedures, such hazardous events can be better deal with.

Risk Management is a continuous, forward-looking process that applies to anticipating and averting risks that may have a negative impact on the project and actively exploring opportunities that may have a positive impact on the project. Risk management is a traditional project management function as well as a systems engineering management function. In the systems engineering, when it comes to risk management, the emphasis is on technical risk.[1]

Project risk management, around the project goal, through the establishment of the project risk management system, in the project and product life cycle, continue to carry out the project risk identification, risk assessment, risk response and risk monitoring of the complete process, reduce the risk of harm and probability, the project risk control within the scope of affordability [1] . Risk management is a typical project management process because risk is unique and time-cycle and all kinds of resources are required to deal with the project risks. Project risk management is a very comprehensive management area. Risk management in all development phases of the project are actively implemented. There will be risk management issues in the teams of engineering design, final assembly manufacturing, flight test and customer service engineering. At the same time, the type of project risk will cover the type of technical risk, schedule risk and cost risk.

The project risk management model is highly recognized and widely used in civil aircraft research and development projects because it can successfully control the technical risks of the projects by risk management.

3.2 Technical risks

The risks in the project generally include schedule risk, cost risk and technical risk. Risk

management is both a project management process and a systems engineering process [1]. Technical risk refers to the risk other than the two factors of project schedule and cost, which is generally caused by technical reasons. The solution to the technical risk needs to be solved from the technical scheme. By formulating and implementing new technical schemes, the technical causes leading to technical risks can be eliminated fundamentally. Due to the complexity of the technical risk causes of the project, the response of technical risk cannot be separated from the efforts and attention of the project engineering team.

Technical risk refers to the events and situations that may have a direct impact on product performance. Even though the technical risk may also lead to the corresponding schedule and cost impact, it still belongs to technical risk from the perspective of its most fundamental cause. Schedule risk refers to the events and circumstances that affect the schedule of a project. Schedule risk generally does not affect performance.Cost risk refers to the events and circumstances that affect the development cost of a product. Cost risk generally does not affect product performance, and is usually caused by technical risk and schedule risk. From the perspective of systems engineering, project risk mainly refers to technical risk [1].

The identification, evaluation, response and monitoring of technical risks cannot be separated from the discrimination and analysis of the root causes of risks. The harmfulness and probability of occurrence of risk events can be gradually reduced through the modification or formulation of subsequent technical solutions. With the progress of the project, plans should be carried out to deal with the root causes of risks, so that the harmfulness of risk events is gradually eliminated and the occurrence probability of risks is gradually reduced. When the harmfulness and occurrence probability of the project are reduced to a considerable extent, the risk can be closed after assessment.

3.3 Mode and organization of risk management

The pattern of risk management is defined by the top-level management requirements of the project that are prepared at the beginning of the project. Risk management, a proactive and structured approach to predicting, understanding and avoiding potential technical, schedule and cost risks [1]. In the development project of civil aircraft, the risk management mode generally includes risk planning, risk identification, risk assessment, risk response and risk monitoring.

Risk planning, including the definition of the various links and steps of risk management, also includes the advanced specification of the working methods and tools. Risk identification includes sorting out project WBS work package item by item and identifying hazardous events that are hazardous to the project and have certain probability of occurrence. Risk identification is the first step of actual risk management. Risk assessment is the analysis and assessment of the potential causes, possible hazards and severity levels of risks. Risk response refers to the formulation of response plans aiming at the potential causes of risks, and the implementation of response plans to resolve and eliminate project risks. Risk monitoring is to track the progress of the risk response plan, evaluate the risk status regularly, and finally eliminate the risk.

The organization of risk management is also planned in the early stage of the project and revised as the project develops and the project organizational form changes. The organization of risk management is built on the basis of project organization, including the establishment of risk managers at all levels, whose main functions are risk monitoring and reporting. The identification, evaluation, response and partial monitoring of risk management shall be completed by the original project executive staff of the project organization.

4. Problem analysis and thinking

The current understanding is that project risk management is an effective means to eliminate project risk. After risk identification, potential technical risks can be identified as technical risks of the project and incorporated into the project risk control system. The use of risk management methods and systems is also able to deal with large technical risks of the project. In the early stage of the project flight test stage, there is a certain confusion on understanding. After experiencing this stage, it is confirmed that the project risk management method is effective, and the project risk management needs to be studied and summarized.

4.1 Time opportunity of raising the question

The first is the timing discriminating of the application of risk management mode to deal with technical risk management. It is the time opportunity to raise the question when is the best time to identify and solve the potential technical risks. This is a task of risk planning in stage.

After this type of civil aircraft has entered the flight test stage, the first verification aircraft participating in the flight test is undergoing engineering adjustment, at the same time, the subsequent verification aircraft are gradually put into production, at the same time, the follow-up flight test plan of the aircraft is also arranged and discussed. With the development of the flight test, some engineering and technical problems in manufacturing, flight and operation were exposed.

The build completion of the prototype test aircraft also brings good conditions for aircraft technology evaluation to operational users and customers. This type of civil aircraft has been carried out the technical evaluation by the planned first batch of users of the aircraft, and the airline company has put forward very good suggestions for the modification of the aircraft from the perspective of use and operation.

With the development of these verification and validation activities, potential technical risks are gradually exposed. The view at the time was that these potential technical risks, if not addressed, would gradually emerge as real technical problems later in the certification process and after the airline's operations. It will be more difficult and costly to change aircraft after potential technical risks become technical problems at a later stage. Rather than this, it is better to identify the potential technical risks and to solve the potential technical risks timely and proactive. After the cause of the problem is clear and the design measures are developed, the decision of design scheme should be made in time. Taking advantage of the adjustment time after the first flight test, the management discriminant on the time to investigate and solve the potential project technical risk is very clear. Considering this project, a large-scale risk investigation was carried out to identify the potential technical risks of the model after it entered the flight test stage.

The whole technology risk investigation, mobilized all participate project teams of this type of civil aircraft development unit. The potential technical risks of the project are identified through technical inspection by each project team. Technical problems exposed during ground tests and flight tests, physical inspections by aircraft customers, inferences and examples drawn parallel of various known problems with this aircraft model, inferences and examples drawn parallel of problems exposed during the development of previous aircraft models, and technical problems exposed in various technical reviews are all possible sources of potential technical risks. After identifying the potential technical risks of the civil aircraft model, the potential technical risks that needs to be solved by the senior management of the development unit and the research and development team can be identified by ranking the severity.

4.2 Determination of management methods and tools for potential technical risks

After the detection of these potential technical risks, what kind of management method to control the removal of these potential technical risks is a actual problem. While these potential technical risks are no actual happened, the project work is still in continuing progress and the market value of the aircraft has not been actually erosion, but the design of the aircraft has been the existence of the real, when the aircraft operating in case of corresponding potential risks for these techniques is very likely to happen, and to become serious technical problems. These technical hazards have a high probability of occurrence and may harm the project at the same time.

The potential technical risks here is the risk of technology. However, since in the initial stage of the project flight test, the potential technical risks are not identified as technical risks, and it is not determined whether these potential technical risks should be managed by the management procedures of technical risks. Therefore, they are temporarily referred to as potential technical risks in this paper instead of directly refer to technical risks. Corresponding to the actual project procedure, when the potential technical risk is determined to be technical risk through risk identification and risk assessment, and determine the management mode of technical risk, it is called technical risk in the paper.

The removal of these potential technical risks is a result of using the typical technical risk management measures. After the potential technical risks are found in the flight test or inspection,

it is necessary to investigate the root causes of the potential risks. What causes and mechanisms lead to these potential risks of the aircraft should be clearly identified. After the preliminary determination of the causes, the root causes should be determined through simulation or flight test. After the investigation of the causes of these potential technical risks, the design modification schemes should be formed, which require the decision-making of the senior management of the civil aircraft development unit. These changes influence is very big, need to re-design parts of the aircraft, the implementation of the change scheme resources demand is big, change often involves more professional, more teams and units of collaboration, these changes also need to carry out the ground test and flight test for engineering verification, ultimately affect the certification configuration and production, therefore, the design change need high-level technical decisions.

At the same time, the causes and mechanisms of potential technical risks are implicit and unclear, so it is necessary for the technical professional of the project to conduct parallel systematic investigation according to the directions of multiple potential technical risks in the design. Use the fault tree to troubleshoot the potential technical risk. After finding the possible technical reasons, it is necessary to arrange the test to reproduce the technical fault and determine the cause of the potential technical risk.

After finding out the potential technical risk, the design optimization of multiple schemes should be carried out. The effective design optimization scheme needs to be select from several design optimization schemes, through technical analysis, design implementation, ground test and flight test. After engineering verification and design trade-off, the final decision is made which design scheme to implement. After the design scheme is determined, the manufacturing implementation and certification flight tests are needed. After the design optimization scheme is determined, the design configuration should be implemented and applied to the manufacturing configuration of the flight test prototype. The manufacturing cycle of the flight test prototype is the schedule constraint of the design optimization. Some minor design modifications can be implemented onboard during the flight test period.

In addition to the work of design, verification, manufacturing, flight test and airworthiness certification , the solution of potential technical risks also requires the engineering implementation of suppliers. The cost of these works is very high, but the cost of solving the potential technical risk is far less than the cost of letting the technical harm happen, and it is very economical to find the potential technical risk and correct it in time.

The characteristics of these matters are that the potential technical risk is an accidental event with a high probability of occurrence and a high potential harm event.The solutions to potential technical risks are obscure and require the collaboration of multiple departments and specialties. The solutions will cost a lot in terms of time and money.

After analysis, the management requirements of these potential technical risks are consistent with the management characteristics of project technical risks.The technical risk of a project is the event with high probability and potential harmfulness. To deal with the technical risk of a project is to find out the root cause of the risk, formulate the response plan and resolve the technical risk through the implementation of the response plan. Therefore, on the basis of forethought and discussion, it is decided to use the management tools of risk management to manage the potential technical risks and organize the solution of the potential technical risks.

After deciding that the management mode for these potential technical risks is risk management mode, the team uses risk management procedures to control these potential technical risks. After each potential technical risk passes the risk identification link, it is determined as the project risk in the project and incorporated into the risk management system.

4.3 Integrated management of risk planning, identification, assessment, response and monitoring

After identifying the opportunity to solve the potential technical risks of the project, and identifying and deciding the management method to solve the potential technical risks, it is necessary to start and carry out the solution of potential technical risks. Since the management mode of technology risk management and control is identified and adopted, the risk management tools and means of technology risk can be used to resolve and remove the technology risk. It can be considered that

technical risks are objective and realistic. In the development stage of the project, the technical risks can be effectively resolved as early as possible before the occurrence of risks and hazards by utilizing the procedures and methods of technical risk management and making effective use of the limited time period of the project.

Risk management procedures include the measures and steps of risk planning, risk identification, risk assessment, risk response, risk monitoring. In the development project of civil aircraft, the project risk is mainly technical risk. Project risk management procedures are consistent with the approach to solving potential technical risks. The test of practice confirms the judgment of this management mode, and the risk management procedure can effectively solve the potential technical risks. Thus, from the implementation way and effect, also confirmed that the potential technical risk is the technical risk, the technical risk management procedures and measures can effectively solve the the potential technical risk.

The technical management of technical risks requires the senior managers to carry out the project technical decisions in real time and actively. In the process of risk planning and response, the design, manufacturing, flight test, customer service and other functions should be fully involved, and the project executives in charge of each function should make timely decisions. The reason of technical risk of civil aircraft is obscure, and its mechanism is not clear. When the problem or the potential risk is identified, the technical path to solve the technical risk also has multiple paths and multiple solutions. The engineering effect of each technical path and the results of engineering verification are also uncertain in the process of technical risk resolution. At the same time, the response to the technical risks of civil aircraft is highly integrated and comprehensive, and it is cross-professional, cross-unit and cross-project life cycle. With the progress of technical risk and project, the decision points of technical risk management are gradually expanded. The whole technical risk management must have a large range of coordination, and the senior management of the civil aircraft development unit must have real-time and active management supervision and technical management decision-making.

In the comprehensive risk control procedure of civil aircraft project technical risks, the defined procedure steps are integrated and comprehensive. Risk identification includes the initial identification of risk status and causes, as well as the display and change tracking identification of risk causes and risk measures after the imposition of risk response and control. Risk assessment is also a highly comprehensive tool here. The identification of risks is changing, and a follow-up risk assessment mechanism is needed after the implementation of risk response, so as to assess the risk status in real time and make the judgment of risk response. Technical risk response is a highly comprehensive means, the workload of risk mechanism analysis and failure recurrence is large, and with the actual situation of risk response to adjust the plan of risk response. The risk response plan here is a packaged work plan that includes the preparation, evaluation, implementation and supervision of the response plan. One of the key elements is the timing of the risks reporting and management decisions.

In the response to and implementation of technical risks, close management tracking, reporting and decision-making of senior management are typical characteristics of civil aircraft project and of technical risks in the early stage of aircraft flight test. These risks are dealt with in a tight cycle, involving a wide range of areas, and the scale of the measures to deal with the risks is huge. The response to the exposed technical risks after the flight test involves the manufacturing of the installed parts of the supplier, the manufacturing installation and the flight test verification. At the same time, the time period of optimized technical design scheme and the implementation cycle is tight, so it is necessary to catch up with the airworthiness verification and not delay the progress of the airworthiness certification of the project. Thus, the management of technical risk emphasizes high-level project management involvement and real-time decision-making. For such a big issue, the timely decision of the senior management of the civil aircraft development unit ensures the real-time and follow-up risk management, and ensures that the management decision is not missing.

Technical risk management supervision link, through risk management personnel of each product team and project management team , collect risk information and prepare project risk report, systematically collect the risk response, and assess the risk status, and then evaluate whether the

need to close the risk. According to the project risk report and their own understanding of the project, management personnel at all levels impose management measures on the project risks under their management through the project team to deal with and close the risks.

In short, the technical risk management of civil aircraft has these highly integrated and comprehensive characteristics, and the risk management procedure designed on this basis can effectively manage the potential technical risks exposed after the flight test, and solve the technical risks of the project through the technical risk management procedure. The risk management procedures include risk planning, risk identification, risk assessment, risk response and risk monitoring.

The working procedure for project risk is integrated and clear. In the risk identification link, identify the project risk. In the risk assessment link, the cause, description and impact of the project risk are analyzed, the probability level and consequence impact level of the project risk are evaluated, and then the severity of the risk is evaluated. In the risk response link, after the risk response plan is formulated, the risk response should be carried out continuously until the project risk is closed. At the same time, in the risk monitoring link, the senior management of the civil aircraft development unit frequently listens to reports and makes timely technical and management decisions, which effectively promotes the risk response and ultimately effectively eliminates the technical risks of the project.

After the root causes of major technical risks are identified, they should be implemented and reflected in the corresponding technical specifications and standards. In this way, the same problems and risks can be avoided repeating in different projects. This is the special requirements of the civil aircraft technology risk management of the high level management of the civil aircraft development unit. According to this requirement, the technical specifications and standards of the civil aircraft development unit will be updated and changed according to the plan as the technical risk response is completed.

5. Results and discussion

Civil aircraft development project risk management, controls project risks from the perspective of technology, schedule and cost. The majority of project risks are technical risks, and the progress and cost of proactively solving technical risks are far less than the losses after technical risks become hazards. The benefit of actively dealing with the risk is higher than the cost of dealing with the technical risk.

In the early stage of the civil aircraft in flight test, application of project risk management procedures to effectively copes with the technical risk exposed in the user evaluation of test process. Technology risk management in the implementation of the project had a great deal of actual benefits, and solve or relieve the almost all of the technical risk. The few technical risks that have not been fully resolved are also highly supervised by the project. It can be said that the technical risks of this type of civil aircraft have been effectively dealt with and managed after it entered the initial stage of flight test, and the risk management of this type of civil aircraft is effective and successful.

The reasons that technical risks can be effectively handled are for several main reasons. First of all, whether a potential technical risk is a technical risk and whether it can be controlled by the risk management process is demonstrated and discriminated. The characteristics of the potential technical risk are consistent with the technical risk, and the corresponding procedures and risk management procedures for the potential technical risk are also consistent. It can be seen that in the initial stage of the flight test, the project managers carried out a risk planning and identified that the risks in the initial stage of the flight test were obscure and the root cause of the risks needed to be clarified. The risks response process at this stage, which also identifies, is one that requires large-scale project coordinated and timely project decisions. It was with this risk planning step that the subsequent risk response was very successful.

Secondly, through risk identification, the potential technical risks are clearly identified and the risk list is formed. For each risk, identify the person responsible, check and report regularly. In this way, the potential technical risks will be turned into project risks, to carry out the response work. Through risk identification, the unclear potential technical risks is turned into a relatively clear

project risk. In this way, the project team formally commits staff and resources to addressing the potential project risks that would otherwise be left unattended. Moreover, the person responsible for the risk is usually the expert or technical backbone in the field. After being incorporated into the project risk system, the power to deal with the potential technical risks is greatly strengthened.

Thirdly, risk assessment and response are carried out on the basis of objective analysis of risk description, causes and consequences. Through objective analysis, we have a clear and correct understanding of the situation and causes of risks. At the same time, the probability of occurrence of risks and the impact level of consequences are evaluated to determine the level of specific risk items, so as to define the person and team responsible for risk response. In order to solve the major potential technical risk in the early stage of flight test, it will be necessary to coordinate the engineering, manufacturing, ground test and flight test teams, etc. When the risk assessment result is high or serious, senior project managers will be assigned as the person responsible for this risk, and this risk will have sufficient management and technical resources to deal with this risk. In this way, the difficulty in coordinating the work of engineering, manufacturing, test and flight testing teams is properly addressed. Senior project managers, who are often also technical experts, can take the lead in solving difficult technical risks.

Fourth, after an objective analysis of the risk is made and the person responsible for the risk is appointed, the person responsible will draw up a response plan, which will be implemented after approval. In response plan, there are often ground test confirmation, problem re-occurrence and flight test verification for risk reasons. Large-scale and effective collaboration of product team, test team and flight team carried out according to the risk response plan, as well as scientific risk management procedures, are the reasons for the effective effect of risk management.

Fifth, risk monitoring and regular inspection reports are also a reason for the effective work of risk management. Each risk is continuously monitored until the risk item is closed, so that the risk responsible person and risk management team continue to work to address the risk. With risk monitoring and reporting, it is also easier to obtain decision support from the technical leader at the top of the project when risk management requires technical or management decisions. After making technical decisions, suppliers, manufacturers, assembly units and test and flight test units can better participate in the work of risk response. In this way, with the approval of the technical scheme, the implementation of the technical scheme can be more convenient to be implemented.

Finally, project risk management, based on a systems engineering approach, develops a strategy for dealing with potential technical risks. In the whole risk management, it is necessary to clarify the direct and root causes of technical risks, explain the technical mechanism of risk occurrence when determining the root causes, and repeat the potential technical risks in ground tests and flight tests, so as to clarify the root causes of technical risks. On the basis of clarifying the root cause, formulate the response plan for direct mitigation and elimination of technical risks, and carry out the response of risks on the basis of close control.

In this way, the potential technical risks of the project have been formally dealt with by the project team through the risk management mechanism, which is the main reason why the project risk management has achieved remarkable results. Comprehensive, this working procedure is in the process of project risk, identify the project risk, analyses the reason, description, and influence of the project risk, assess the project risk level of probability and consequence impact, and assess the severity of the risks, form the risk response plan, sustain risk response, at the same time continue to carry out the project monitoring, until closed the project risk.

Of course, the effective response to these risks in the early stage of the flight test is also due to the accumulation and improvement of the technical capabilities of China's civil aircraft development units. After the management measures are formulated and implemented accurately, the engineering team is able to use professional technology to solve the technical risks of the project.

6. Benefits of implementing risk management

The risk management mode is adopted for this type of civil aircraft. After the project enters the flight test certification stage, the project risks, mainly project technical risks, are successfully handled in the early stage of the flight test certification stage. Relative to the cost of risk management, the comprehensive benefit of timely and successful risk management is often huge.

The implementation of project risk management in the early stage of the flight test of this civil aircraft model will bring the following significant actual benefits.

6.1 Benefits of identify the timely opportunity of risk management implementation

Entering the flight test and airworthiness certification stage, the design has been frozen and becomes the aircraft in flight test period. During the flight test stage, a certain number of potential technical risks can be fully exposed through flight tests and physical evaluation of aircraft users. These potential technical risks must be addressed, and the sooner they are, the better.

After entering the initial phase of the flight test, the teams are preparing the outline and schedule of various research and development flight tests and certification flight tests. Several test aircraft are in the process of manufacturing, and there is still a certain period of time before the final assembly and delivery of these test aircraft. This is a very favorable time to initiate technical risk management during the flight test phase. It can involve as many designers and manufacturers as possible to correct the technical hazards of the aircraft without affecting the project milestones as much as possible. Practice has also proved that the timing of the risk response is very wise and the effect is very good.

6.2 Benefits of risk management of technical risks is comprehensive, which integrates the responsibilities of multiple risk management

After entering the initial stage of flight test, the technical risks exposed are comprehensive, and the measures of risk management are also highly integrated and comprehensive. Using the risk management procedures to manage the technical risks after entering the initial stage of flight test will bring very high project benefits. After entering the initial stage of flight test, the technical risks exposed need to identify the cause and mechanism of the risk, repeat the problem occurrence for locating the root cause, and the risk solution measures need to be tested and verified.

The measures to solve the technical risks are comprehensive decisions, which need to be verified through research and development tests and airworthiness certification tests. The management of technical risk is also highly comprehensive, including risk planning, risk identification, risk assessment, risk response and risk monitoring. These comprehensive measures are necessary to deal with the technical risks and problems exposed in the early stage of flight test. The project team well implemented the comprehensive measures of the project and completed the effective response to the large technical risks.

6.3 Benefits of effectively organize and manage technical risks

In this civil aircraft project, in the middle stage of the project, the product integration team (IPT) has undergone organizational reform, and the project organization based on IPT has been set up. After entering the initial phase of flight test, the risk management of technical risk is based on the project IPT organization. The team's general manager is reported directly from the project team and makes technical decisions across design, manufacturing, flight test and customer maintenance.

The engineering vice general manager of the project and the senior project manager of the engineering IPT team are responsible for treatment the technical risk at the center level and team level, identifying the cause and mechanism of the risk by using the technical management line of the engineering team, developing the design improvement plan, and then implementing the engineering change and engineering validation. The top level of technical management use the risk management line of the engineering team to monitor the risk, report the progress of the risk in time, and assist the risk supervision and decision.

This kind of risk management is very efficient. While using the project team personnel to solve technical problems and implement response plans, the human resources of very few part-time and full-time risk managers are utilized to complete the risk control of technical risks.

7. Conclusion

From the point of view of system engineering, project risk focuses on technical risk. The planning, identification, assessment, response and monitoring of risks have established an active and structured effective mode of risk management, and achieved good results in risk control. After

entering the initial stage of the flight test of the project, the civil aircraft project team made use of the risk management mechanism of technical risks to effectively deal with the problems of the previous project, the problems exposed through the flight test and the potential technical risks exposed by the user review.

In practice, the timing of risk management in the early stage is clear, the preset risk management mode is effective, and the risk management procedures and steps planned in the early stage are also effective. The technical risks exposed after the flight test of the aircraft are controlled successfully. In the early stage, the diagnosis of the management problem by the project managers is clear and effective, and the planning and implementation of the management measures by the project managers are also effective, thus the risk management practice of total technical risks is very effective. This practice of risk management which can cope with technical risks has opened up an effective way and precedent for the risk management of China's civil aircraft development projects.

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