

A Quantitative Risk Assessment Method of New Energy Civil Aircraft Program Based on RBS

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Abstract. New energy aircraft is a trend of aircraft development in the future. More and more countries and enterprises have carried out relevant research. This article summarizes the characteristics of the civil aircraft program life cycle development and combining with the technical characteristics of new energy aircraft, this risk management method based on RBS is proposed. Through analytic hierarchy process (AHP), quantitative assessment of the total risk of the project, this method can comprehensively quantitatively identify the typical risks in the whole life cycle, provide a feasible method for risk management of the new energy civil aircraft project.

1 Introduction

With the rapid development of aviation industry, a series of problems such as energy crisis and environmental pollution are also highlighted. The development of new energy aircraft is the fundamental measure to solve the problem of pollution and energy consumption, as shown in Figure 1 below. However, due to the high technical complexity, large investment scale, long development cycle and other significant characteristics of commercial aircraft program, new energy aircraft program has many risk sources and complex nature, and various factors highly cross and interact with each other, which makes risk management and control difficult.

By summarizing the characteristics of new energy civil aircraft program life cycle development and combining with the technical characteristics of new energy aircraft, this paper puts forward a set of risk management method based on RBS, which can efficiently and quantitatively assess all kinds of risks existing in the process of new energy aircraft development.



Figure 1. New Energy Aircraft in the Market

2 Creation of RBS matrix

2.1 The main risk point of civil aircraft development

According to the development process of new civil aircraft, the new life cycle includes demand and concept demonstration stage, preliminary design stage, detailed design stage, trial production and verification stage, batch production stage, as shown in Figure 2 below. Through the analysis of the main work in each stage of aircraft development, the main risk points in each stage are as follows.



Figure 2. Development Process for Civil Aircraft

2.1.1 Demand and concept demonstration stage

The main task is to analyse the commercial demand of the project and demonstrate the commercial feasibility of the project. the initiation and feasibility study of project are approved, and the conditions for transition to the preliminary design are met.

The main risk points are the accuracy of the market positioning of the project, the feasibility of the commercial strategy demonstration, and the impact of the proposed new technology, including the introduction of new energy technology.

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2.1.2 Preliminary design stage

The main task is to complete the definition of aircraft scheme, and to jointly define the aircraft plan with suppliers at all levels to determine the preliminary design plan of the aircraft, and to define the architecture of civil aircraft, and determine the final product and service proposals in cooperation with the major suppliers.

The main risk point assessment is to confirm the top-level performance indicators, evaluate the supplier's ability and sign business contracts, and make progress in key technologies, and so on.

2.1.3 Detailed design stage

The main task is to complete the detailed design of the aircraft, and to carry out the detailed design of structural parts and system equipment, release the most of product definition data, and prepare for the manufacturing.

The main risk points are the evaluation of manufacturability of each section of the aircraft and the complex interface relationship between the systems, and so on.

2.1.4 Trial production and verification stage

The main task is to complete the aircraft development and obtain the model certificate. to carry out the manufacturing, engineering verification tests, flight tests, and the development of customer service products, provide the support for the type certification and prepare for the delivery of civil aircraft.

The main risks lie in the production process, flight test schedule, and the rationality of flight test subjects, and so on.

2.1.5 Batch production stage

The main task is to maintain the aircraft batch production system and customer service system. to keep the stable production, continuously provide the customer service according to contract requirements, conduct the management after airworthiness certification, maintain the continuous airworthiness system, register the appropriate scientific and technological achievements, protect the intellectual property, declare the science and technology awards and organize the Project Acceptance. Demonstrate the aircraft improvement or serialization development if needed.

The main risk points are production line construction, customer service support, emergency response preparation and so on.

2.2 Risk breakdown structure

On the basis of the above analysis, systematically conduct a comprehensive risk analysis on each stage of the project, the concept of risk breakdown structure (RBS) is introduced to comprehensively analyse the key and difficult work in each development stage. The RBS lists the risk classifications and risk subclassifications that can occur in a typical project.

Considering the introduction of new energy technology, RBS focuses on the risks on new energy technology, provides a structural perspective, which can make all kinds of risks explicit and hierarchical. As shown in Figure 3 below.

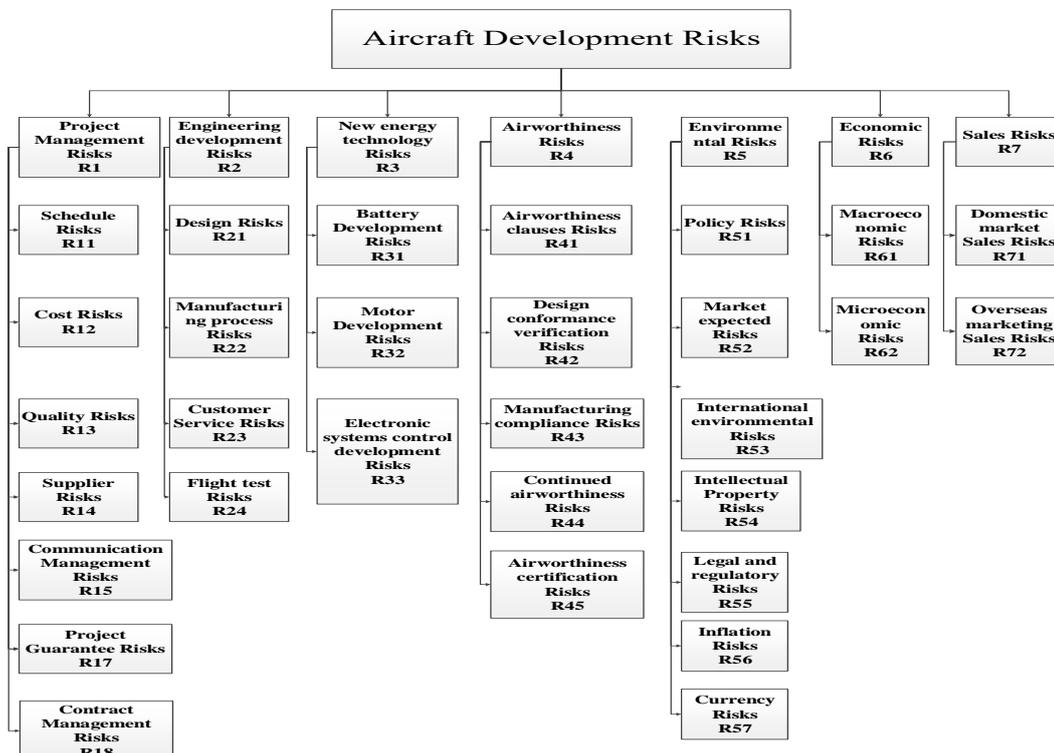


Figure 3. Risk Breakdown Structure (RBS)

3 Quantitative evaluation system of program risk

Combined with the characteristics of new energy aircraft development and general program risk management practices, the program risk evaluation system is established as follows, Risk evaluation index includes two independent variables, occurrence probability of risk and consequential impact of risk. In this program, both

the risk possibility and risk impact are divided into five levels, with criteria shown in the following table.

3.1 Risk probability level

The risk probability level is divided into 5 intervals according to 0-20%, 20% - 40%, 40-60%, 60% - 80% and 80% - 100%, and expressed by 1-5, as shown in Table 1 below.

Table 1. Criteria of Risk Probability

Level	Probability Description	Rules
1	Very low	Very low probability, next to impossible.
2	low	Low probability, relatively few, and the problems that occur can be individually isolated and addressed.
3	medium	Moderate probability, random, similar problems occur by chance.
4	high	High probability, repeated and frequent.
5	Very high	Very high, almost inevitable.

3.2 Risk impact consequence level

The level of risk impact consequence is subdivided and evaluated through the four dimensions of cost, schedule,

scope and quality, which are also represented by 1-5, as shown in Table 2 below.

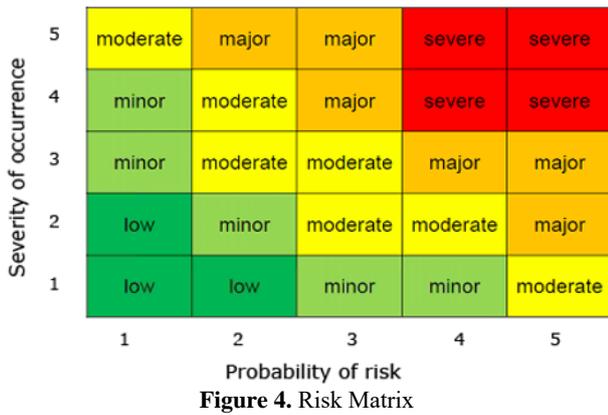
Table 2. Evaluation Criteria for Risk Impact and Consequence

Impact Level	1	2	3	4	5
	Very Low	Low	Moderate	High	Very High
Cost	Cost increase is not significant	Cost increase by less than 10%	Cost increase by 10%-20%	Cost increase by 20%-40%	Cost increase by more than 40%
Schedule	Schedule delay is not significant	Schedule delay by less than 5%	Schedule delay by 5%-10%	Schedule delay by 10%-20%	Schedule delay by more than 20%
Scope	Insignificant reduction in scope	The minor aspect of scope is affected	The main aspect of scope is affected	The scope is reduced to a level unacceptable to program sponsor	The program is finally impractical. outcomes are useless
Quality	Insignificant quality decline	Only demanding part is affected	The quality decline shall be examined and approved by program sponsor.	The quality declines to a level unacceptable to program sponsor.	The program is finally impractical. outcomes are useless

3.3 Quantitative risk measurement

After the risk possibility and risk impact is acquired, the risk matrix can be used to judge the risk level. The severity of risk is determined by the following matrix,

as shown in Figure 4 below. The quantitative value of risk is the abscissa multiplied by the ordinate.



4.1 Determine the weight proportion of each index in the evaluation system

Due to the complexity of program RBS system and the large amount of data, this paper takes the first level of RBS as an example, takes program management, R & D risk, new energy technology risk, airworthiness risk, economic and market risk, social environment, natural environment and other seven indicators as evaluation indicators, adopts Delphi method, organizes experts to conduct multiple rounds of evaluation, and converges to form weight values as follows:

$$\text{Weight value } W = [1.1 \ 1.2 \ 0.9 \ 0.8 \ 0.9 \ 0.7]$$

4 Quantitative assessment of program risk

In the initial stage of program, it is necessary to identify potential business opportunities through continuous comprehensive analysis, trade off analysis the potential business opportunities into feasible development program. This method can be used to make full use of expert resources to determine the scheme with the least risk, as follows.

4.2 Implementation evaluation

Step 1: organize experts to carry out evaluation

Organize experts to carry out the evaluation, and each expert shall fill in the evaluation form according to the table below.

Table 3. Expert 1 evaluation form

Risks	Project Management Risks (R01)	Engineering Development Risks (R02)	New Energy Technology Risks (R03)	Airworthiness Risks (R04)	Environmental Risks (R05)	Social Risks (R06)	Sales Risks (R07)
The Solution 1	5	10	10	15	5	10	5
The Solution 2	5	15	15	15	15	15	5
The Solution 3	10	10	10	5	10	10	5
The Solution 4	5	10	10	20	10	10	5
The Solution 5	10	15	15	15	15	15	5
The Solution 6	5	10	10	10	10	10	5

Table 4. Expert 2 evaluation form

Risks	Project Management Risks (R01)	Engineering Development Risks (R02)	New Energy Technology Risks (R03)	Airworthiness Risks (R04)	Environmental Risks (R05)	Social Risks (R06)	Sales Risks (R07)
The Solution 1	10	10	10	15	5	10	5
The Solution 2	10	15	15	15	15	15	5
The Solution 3	10	10	10	10	10	10	10
The Solution 4	5	10	10	20	10	10	5
The Solution 5	10	15	15	15	15	15	5
The Solution 6	5	10	10	10	10	5	10

Table 5. Expert N evaluation form

Risks	Project Management Risks (R01)	Engineering Development Risks (R02)	New Energy Technology Risks (R03)	Airworthiness Risks (R04)	Environmental Risks (R05)	Social Risks (R06)	Sales Risks (R07)
The Solution 1	10	15	10	15	5	10	5
The Solution 2	5	15	15	15	15	15	10
The Solution 3	10	10	10	5	10	10	5
The Solution 4	5	10	10	20	10	15	10
The Solution 5	10	15	20	15	15	10	5
The Solution 6	5	10	10	10	5	10	10

Step 2: standardization of evaluation matrix

In order to facilitate the calculation, the data of experts are normalized

$$A_1 = \begin{bmatrix} 1/5 & 2/5 & 2/5 & 3/5 & 1/5 & 2/5 & 1/5 \\ 1/5 & 3/5 & 3/5 & 3/5 & 3/5 & 3/5 & 1/5 \\ 2/5 & 2/5 & 2/5 & 1/5 & 2/5 & 2/5 & 1/5 \\ 1/5 & 2/5 & 2/5 & 4/5 & 2/5 & 2/5 & 1/5 \\ 2/5 & 3/5 & 3/5 & 3/5 & 3/5 & 3/5 & 1/5 \\ 1/5 & 2/5 & 2/5 & 2/5 & 2/5 & 2/5 & 1/5 \end{bmatrix}$$

$$A_2 = \begin{bmatrix} 2/5 & 2/5 & 2/5 & 3/5 & 1/5 & 2/5 & 1/5 \\ 2/5 & 3/5 & 3/5 & 3/5 & 3/5 & 3/5 & 1/5 \\ 2/5 & 2/5 & 2/5 & 2/5 & 2/5 & 2/5 & 2/5 \\ 1/5 & 2/5 & 2/5 & 4/5 & 2/5 & 2/5 & 1/5 \\ 2/5 & 3/5 & 3/5 & 3/5 & 3/5 & 3/5 & 1/5 \\ 1/5 & 2/5 & 2/5 & 2/5 & 2/5 & 1/5 & 2/5 \end{bmatrix}$$

$$A_n = \begin{bmatrix} 2/5 & 3/5 & 2/5 & 3/5 & 1/5 & 2/5 & 1/5 \\ 1/5 & 3/5 & 3/5 & 3/5 & 3/5 & 3/5 & 2/5 \\ 2/5 & 2/5 & 2/5 & 1/5 & 2/5 & 2/5 & 1/5 \\ 1/5 & 2/5 & 2/5 & 4/5 & 2/5 & 3/5 & 2/5 \\ 2/5 & 3/5 & 4/5 & 3/5 & 3/5 & 2/5 & 1/5 \\ 1/5 & 2/5 & 2/5 & 2/5 & 1/5 & 2/5 & 2/5 \end{bmatrix}$$

Step 3: calculate the evaluation results

$$S = \sum A_i W^T = A_1 W^T + \dots + A_n W^T = \begin{bmatrix} a1 \\ a2 \\ a3 \\ a4 \\ a5 \\ a6 \end{bmatrix}$$

a1-a6 corresponds to the solution 1-6 respectively, and the absolute value is determined. The best solution is selected from the multi solution that meet the business needs.

5 Conclusion

The risk of new energy aircraft development is highly complex, any risk may lead to the failure of the whole development project. In this paper, a quantitative risk assessment method of new energy civil aircraft program is established based on RBS, and its operability and effectiveness are verified through the aircraft program development, this method can be further improved in the future.

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