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Risk management assessment on a type of warship development

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ABSTRACT

The equipment research project risk management is an important field of knowledge to promote the rapid development of China's defense industry. It is related to completion of our mission to develop new equipment qualitatively and quantitatively. In order to effectively identify, analyze, reduce and control the risk of development of a new type of warship, on the basis of the clear risk management process and approach the paper makes an analysis of the development of a new type of warship program. It builds a new type of warship research risk management assessment index system from four areas of technical risk, human risk, schedule risk and cost risks. It makes fuzzy risk analysis assessment on a new type of warship development based on the method of risk management assessment. According to instance analysis validation, there is relatively a high risk in developing a new type of warship. Risk prevention and control measures should be taken in technical risks and human decisions. The paper provides a theoretical support for the new equipment development risk prevention.

KEYWORDS

Ships developed;
Risk management;
Assessment.

INTRODUCTION

The development of a certain type of warship is relatively complex system engineering with characteristics of long cycle, high technology and investment. There are a variety of risks in various stages in the development process, especially technical risk in the development process which is usually the main cause of " indicators decrease, drag the progress and more funding" and other issues in a certain type of ship development process. In order to develop high-performance, low-risk of new equipment, it is necessary to take full advantage of the theories and methods of project management and systems engineering. Effective planning, organizing, implementation and control risk management activities is very important[1].

RISK MANAGEMENT AND THEIR MEANINGS

In the process of equipment development, the risk is a potential problem that may endanger the development program. The equipment development target may not be achieved by this reason in determined funding, schedule, and technical constraints. Its mathematical expression is as followings:

$$R = f(D, P, C) \quad (1)$$

In this mathematical expression stands for risks;

stands for the causes of the risk; stands for the probability of occurrence of uncertain events; stands for the impact of the event[2].

Risk management is a policy in equipment development management and a process of optimization of resources by stepwise iterative. In risk management there is a clear identification of the roles and responsibilities of the personnel. We can plan, identify, estimate, evaluate, response and monitor risks encountered by the project. This process may help the project leaders, engineers, technicians and other research personnel deal with risk events in the aspects of scientific processing of management and engineering activities to protect the project proceed smoothly. Implementation of risk management is a comprehensive and holistic approach in order to maximize the benefits of the following areas.

1) Design, production, testing, use, maintenance, and the interfaces between them;
2) control of risks;
3) Management, cost and schedule[3].

Risk management process

Risk management process consists of six stages in the development process of a certain type of warship.

1) Risk identification

Risk identification is to change the uncertainty in the development process of the ship into a clear statement of the risk. In the early stages of warship research project, risk Identification may be made through such activities as risk checklist, regular meetings, and activities of daily records, etc.

2) Risk analysis

We can predict risks by analyzing risk drivers and identifying source of risks in developing warships. The risk may be assessed by the possibility of development and consequences. Possibility is defined as greater than 0 and less than 100, is divided into five levels (1,2,3,4,5). The consequences are divided into four levels (low, medium, high, and critical). Risks are divided into groups by possibilities and consequences.

3) Risk plan

In the process of a certain type of warship development, risk response plans are made by designing strategies and action steps of dealing with risks according to a prioritized list of risks. There are such risk response strategies as accepting, avoiding, protection, reduction, research, reserve and transfer.

4) Risk tracking

Risk tracking process in the development of a certain type of warship includes monitoring risk status and notification of risk response actions. Early indicators are used as a comparison value to judge the situation developed among development process. Timely notice of the start of risks is made in the development process. The person in charge is designated to deal with risks.

5) Risk response

Research and development units of the warship respond, avoid, withstand, reduce or share risk. The aim of all actions is to control risks in the main risk tolerance and risk capacity or less.

6) Risk control monitoring

Risk management in warship development process is not to eliminate risk source, but try to reduce the probability of the risk occurring to reduce affection of the risk to warship development. Full monitoring is achieved by risk management in the development process. If it is necessary, risk management measures may be amended to reduce the unnecessary time and expense wasted in the development process[4].

Risk treatment measures

A basic principle of risk management is based on the minimum cost to get the maximum protection. There are the following four methods in processing risks: risk aversion, risk prevention, risk preservation and risk transfer.

1) Risk aversion

Risk aversion is to take the initiative to avoid the possibility of the loss occurred. For example, if the possibility of increased costs in warship development occurs, we will not take into account to develop it. This is often because of risk aversion to take a lot of limitations to the development of the project. In order to enhance the combat effectiveness of the Navy, we must develop any kinds of ships, or else the coastal defense forces can not develop. So risk aversion is not feasible to some extent.

2) Prevent risks

Prevention of risk is to take preventive measures to reduce the likelihood of loss and the extent of the loss. In warship development process, the prevention of risk is involved in the comparison of current costs and potential loss of politics, economy, national defense force. In the process, if the potential loss is much greater than the costs to take precautions incurred, the measures should be used to prevent the risk. If we develop the newest warship in the world, the development of risk is relatively high, but compared with the success of the defense forces increased dramatically after the warship developed, loss pales in its development process.

3) Risk preservation

The risk preservation refers to actively bear risks irrationally or rationally. "Irrational" risk preservation refers to pay more attention to luck or underestimation of potential loss of the loss occurred thus exposed to the risk. "rational" risk preservation refers to the potential losses in the bear range through the correct analysis. To bear all or part of the risk is effective than buying insurance. Risk preservation is generally applicable to deal with small probability of occurrence and the loss of the low level of risk.

4) Risk transfer

The transfer of risk is to give all or part of the risks they face to the other through some kind of measures. This is the widest range of applications and the most effective means of risk management to get guarantee through the transfer of risk. In the warship development process, risk transfer can be made through the introduction of new technology and other means[5].

DEVELOPMENT PROGRAM OF A NEW TYPE OF WARSHIP

In a certain type of warship development process, it is necessary to use the system engineering approach to model development management. Project development work is made in strict accordance with the development program. Development process in a certain type of warship is generally divided into the demonstration phase, the program phase, the project development phase and the shaping phase.

Demonstration phase

The main task of the demonstration phase is the argumentation and the early phase of the trial to determine the new warship tactical and technical indicators, the overall technical programs, as well as the overall development funding, the development cycle, and security conditions. The general requirement of the warship is also made in this phase.

The new warship argument is made by the naval forces organization that will use it. The initial tactical and technical indicators as well as indicators for funding and development progress control should generally be proposed based on a medium-term plan and the main combat performance. Then we may invite one or more holders of warship production license to show multi-demonstration program until the best program and manufacturing unit is selected by selection or optimization and combination of all programs. Then we will conduct a risk assessment in accordance with relevant regulations.

At the end of the evaluation work, the Navy troops and the development units need report a certain type of warship total requirements and the argumentation report to the state authorities in charge of the development in accordance with the relevant procedures. After the reports approved by the state authorities, the general requirements of a certain type of warship will be issued as the basis of the follow-up phase of the development work.

The program phase

The main task of the program phase is to make demonstration and validation to form the warship development program books in accordance with the approved " The general requirements of a certain type of warship development ". In the program phase we will make the gradual decomposition of the warship to form a work breakdown structure which may determine the progress of the project, provide the basis for cost estimates and risk analysis of the development process. Meanwhile, the development specifications, the development of interface control documents and the general development plan of subsystems, equipment and support equipment of warship is made in accordance with the relevant national military standards. The significant technical improvement projects, the conditions of warship development and the introduction of technology

projects are proposed through budget on development funding, product costs and price estimate. The main work of the program phase is research, collaboration, processing, the introduction of technological innovation and the initial construction of the ship's plans. Finally, the mission statement is developed in accordance with the preparation of the national military standards.

The project development phase

The main task of the project development phase is the design, manufacture and test of the warship according to approved research task book. On the basis of the development of the mission statement, the naval troops and the research units sign the shaping stage of of the warship in accordance with the relevant provisions of the contract. In the project development phase, there is the following work.

1) Design

The development units carry out design work according to the requirements of the development contract. Its main task are to complete a full set of trial pattern, prepare product specification, process specifications and material specification draft in accordance with the relevant national standards, develop other related technical documentation, test related systems development, complete manufacturing sample test and the preparation of technical documents, make production plan, determine the human and material resources needed for the production, calculate the cost of manufacturing, design, organize production line, improve the comprehensive support scheme and make various security projects design, testing and identification.

2) Test and trial

The development units carry out the test and trial work according to the development requirements of the contract. Its main tasks are to prepare for trial production, carry out the design of the tooling, production, installation and commissioning work, carry out parts manufacture, components assembly and the final assembly and commissioning of weapons and equipment, make various types of development and testing such as static, dynamic, fatigue testing, engineering expertise test, system software testing, ground simulation test, etc, and carry out weaponry verification test.

The shaping phase

The work in the shaping phase includes two aspects of the design and the final production. The main task of the design is to make the comprehensive assessment of the warship performance and use requirements in order to confirm whether it is the same as mission statement and development requirements of the contract. The main task of the final production is to make comprehensive assessment on warship mass production conditions and stable quality in accordance with production standard. In the shaping phase, the official version of the product specifications, process specifications, materials specification the official full production pattern, relevant technical documents and directories are finally formed[6].

ASSESSMENT INDEX SYSTEM CONSTRUCTION OF THE WARSHIP DEVELOPMENT RISK

In the development process of a certain type of warship, design, manufacturing, testing, support, management and basic conditions are interrelated along with their respective risks. Because the basis of the products delivered meeting the requirements of tactical and technical indicators is development and production, design, testing and production constitutes a major source of risk.

The main causes of technology risk

In the warship development process, due to tactical and technical performance requirements and more strict requirements for reliability, maintainability, safety and protection, there are greater technical risks.

1) The design errors

In early stage of warship development, if the design is not in line with the actual tasks and naval warfare environment, it is likely to result in longer development cycle, more development funding. Universal, serialization and modular performance is not strong. Thus, careful design is firstly the guarantee of development of a certain type of warship.

2) Lack of technical preparations

The aim of advance research on the warship is to provide technical reserves for its development. The weapon development practice proved that only advance

research more fully, the technology used relatively mature, will it be possible to shorten the development cycle. Before some major key technology has yet to make a breakthrough on the hastily development, the result is very difficult to achieve the technical indicators.

3) The Technology is not proficient

If the technology of the development units is not proficient, the warship can not be developed to meet mission requirements. The result is deviation of designers, one-sidedness understanding of test and detection, limited verification means. The staff could not be implemented in strict accordance with the design and process requirements, and can not guarantee the complete success of the test tasks.

4) Tactical and technical requirements are too high

Tactical and technical indicators of the warship must be guaranteed for the completion of specific operational tasks and tactical technical performance and the use of maintenance performance. Before the development of the warship, tactical and technical indicators must be made the full needs analysis and feasibility study from the state of war, the military needs, goals and environment which will make the tactical and technical indicators technically feasible, affordable and achievable in time[7].

The main causes of the cost of risk

One of the reasons of risk of costs incurred in the development process of weaponry is insufficient investment and the use of unreasonable factors. The cause is mainly the macroeconomic environment, the maturity of the new technology and budget.

1) The maturity of new technology

In the warship development process, because of too much emphasis on the technical performance of the vessels, excessive use of new technologies, it tends to make some immature projects started. The development process will appear repeatedly for the success of the project which leads to the development cost exceed the budget.

2) Macroeconomic environment impact

Under the market economic system, prices fluctuate with market conditions. Together with inflation and other factors it results in increasing price of many raw material of the warship development soon. Meanwhile, the cost of manufacturing unit staff is increasing year by year. Various coordination costs continue to increase. All these factors make the cost of a certain type of warship development greatly improve.

3) Scientific budget assessment

China's defense spending is mostly the plan form which pays not enough emphasis on to the budget. The budget approach is lack of scientific and normative standard. We also lack of statistics data on the total life cycle cost of similar models of ships from abroad which is difficult to guarantee more accurate budget. In addition, the implementation of the contract makes the manufacturing units have to intend to drive down the budget in order to get the research project, which will undoubtedly increase the cost of risk.

The main causes of the risk in the progress

The risk in the progress is prevalent in the research and development of equipment which often leads to extended equipment development and cost overruns. There are the following common main reasons.

1) Unscientific schedule

Schedule risks in the development process of a certain type of warship mainly manifested in two aspects. First, the demonstration of program is inadequate. In order to get the research project, research and development units generally shorten schedule, and lack scientific argumentation. Secondly, the progress plan is developed inaccurately. The formulation of the schedule is lack of scientific forecasting and analysis. In addition, incomplete database of technical performance and schedule estimates for the warship results in the underestimation of the progress or diversion from reality.

2) Investment budget allocation is unreasonable

In the completion of modern equipment project, funding overruns increasingly common. Unreasonable project funding allocation or lack of development cost budget for some technology which lead to the delay of the progress of the development to increase the risk of development progress.

3) The infrastructure planning is improper

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Taking into account a certain type of warship the new model, if we do not fully consider the use of some available resources of previous similar model ships development on top-level design stage, such as factories, ports, production line, while just strive to build new resources, it will not only need funding for reinvestment but also time. It no doubt will delay the development schedule[8].

Human factors risks

In the warship development process, the causes of risks are complex and changing. Its cause elements are not the same. Human factors. occupy a more important part.

1) The decision-making is unscientific

In a certain type of warship development process,because the warship is new, the situation faced by the organizers is lack of experience and information. This will lead to errors in decision-making which causes risks in the development work[9].

2) Technicians' learning ability is not strong

Because of it is the new warship, the complexity degree of its development work. The development needs high, precise and advanced technology, which requires technical staff can not be total immerse in the knowledge learned a few years ago. They must continue to learn new knowledge related with the research project. Currently a lot of young technicians lack spirit of life-long learning practical experience. It is often difficult for them to independently undertake complex research and production tasks. Once the task assigned, it will cause a risk of lack of mature technology staff[10].

3) The organization and management is not good

In the process of development of a new type of warship, due to the development of new models, its organization and management mechanisms tend to be less effective. In addition, due to the lack of management experience, some staff work frequent changes will cause management process out of touch. And the management methods and techniques may not be entirely appropriate which will undoubtedly increase the risk of the project development[11].

Considering various factors, risk management assessment index system of a new type of warship development is established and shown in Figure1.

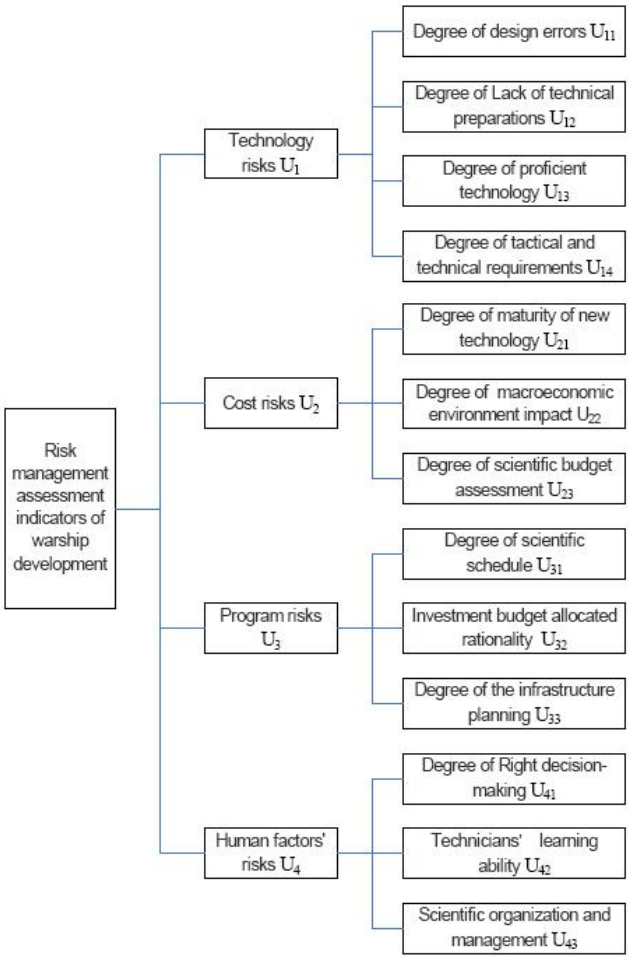

Figure 1 : Risk management assessment indicators system of warship development

FUZZY RISK ASSESSMENT OF WARSHIP DEVELOPMENT

Warship development risk management assessment is made through fuzzy comprehensive evaluation method based on the construction of the evaluation index system.

1) Establish the factors set

Based on the evaluation index system, the factors set can be expressed a total of 13 factors as $u_{11} - u_{43}$.

2) Establish the assessment set

The risk level of each indicator is divided into four levels, $V = \{v_1, v_2, v_3, v_4\} = \{veryhigh\ ,\ high\ ,\ middle\ ,\ low\}$.

Relative factors of weight coefficient is as follows

3) Establish the weight set

$\{0.05,0.3,0.1,0.05,0.1,0.05,0.05,0.05,0.02,0.03,0.1,0.07,0.03\}$.

4) Establish assessment matrix

A certain number of experts make evaluation. Fuzzy relationship matrix is as followings.

$$R=\begin{bmatrix}0.1 & 0.2 & 0.2 & 0.5\\ 0.5 & 0.3 & 0.2 & 0\\ 0.4 & 0.3 & 0.2 & 0.1\\ 0.2 & 0.3 & 0.3 & 0.2\\ 0.6 & 0.3 & 0.1 & 0\\ 0.3 & 0.3 & 0.3 & 0.1\\ 0.1 & 0.2 & 0.3 & 0.4\\ 0.3 & 0.3 & 0.2 & 0.2\\ 0.3 & 0.3 & 0.2 & 0.2\\ 0.2 & 0.3 & 0.3 & 0.2\\ 0.5 & 0.4 & 0.1 & 0\\ 0.3 & 0.3 & 0.2 & 0.2\\ 0.3 & 0.3 & 0.2 & 0.2\end{bmatrix}$$

5) Risk fuzzy comprehensive assessment

$B = AR = [0.392,0.300,0.198,0.110]$

The above results show that the risk degree of very high, high, middle, low of the warship development is 0.39, 0.30, 0.20, 0.11. Therefore, it is clear that there is high risk weights in warship development assigned by experts. It can be seen the technical risks, human decision-making needs to be well risk control[12].

CONCLUSIONS

1) In this paper, on the basis of clear risk management process and approach, a new type of warship development risk management assessment index system is built through the analysis of the warship program.
2) A new type of warship development risk management is assessed based on fuzzy risk analysis assessment method. Instances analysis proved the warship development risk is relatively high. The development needs to be well studied in risk response in the next step.

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