# **Consideration on the Design of Ship Equipment with Price Limit**

Zhuo'er Li<sup>1</sup>, Juqin Fan<sup>2</sup>, Guowei Chen<sup>1,\*</sup>, Chuyan Cao<sup>1</sup>

<sup>1</sup>Department of Management Engineering and Equipment Economics, Naval University of Engineering, Wuhan, Hubei, China <sup>2</sup>Teaching and research support Center, Naval University of Engineering, Wuhan, Hubei, China \*Corresponding Author. Zhuo'er Li and Juqin Fan contributed equally to this study.

Abstract: In order to better control the development and building cost of large ship equipment, according to the idea of fixed cost design management method, this paper puts forward the concept of price limit design for large ship equipment development, analyzes the main contents of price limit design work for large ship equipment combined with the tasks in each stage of large ship construction, sets the steps and processes of price limit design work, and sorts out the responsibility system of each research unit. It has an important guiding role in controlling the development cost of large ship, and provides an effective reference for making decisions and measures of the cost management of the whole life cycle.

# Keywords: Ship Equipment; Price Limit Design; LCC Management

#### 1. Introduction

The life cycle cost of ship equipment is calculated according to the sum of the costs of various stages in the life cycle of its development, construction, use, maintenance, etc. The decisive factor affecting the life cycle cost is the concept and economic concept in the early design stage [1]. The less likely it is to change the inherent factors such as equipment performance structural parameters, characteristics and use and maintenance conditions, so the early decision has a great impact on the construction and later use and maintenance costs. This can be seen from the famous "Paletto" curve [2]. Therefore, the price limit design is to combine the control of the whole life cycle cost with the design of the ship equipment, focusing on the control of the design stage. At the same time, the price limit design also has a great effect on reducing the purchase price of most ship equipment and reversing the

idea of "performance first", which must be paid attention to.

Price limit design refers to the design work such as integrated optimization, material selection and process improvement carried out by the research unit with the explicit ordering target price of the project as the upper limit on the premise of meeting the technical requirements [3]. At present, in the field of equipment, in order to promote the high quality, high efficiency, low cost and sustainable development of equipment construction, strengthen the price limit design management in the process of equipment development, highlight the low-cost source design concept, strengthen the target price index control, and promote the engineering of economic work. Implementation of the equipment approval of the order target price index requirements, equipment price limit design work began to gradually push forward. Therefore, in the aspect of ship equipment development, it is also worth exploring the work of price limit design.

Ordering target price refers to the expected price to be ordered determined by the supply and demand parties according to certain boundary conditions, which is an economic index and equally important as a technical index. "Order target price" is the "price" in the price limit design, it is not a value, but a target price as the center, both up and down have a certain margin of the range, including the highest price, target price, incentive constraints and other content. The target price consists of the target cost and profit, so the price limit is the cost limit. Costlimited design is a design idea that takes the whole life cycle cost of a product or the cost of a single product as the target cost ceiling, and clearly defines the cost or cost ceiling as equally important as the performance index [4]. In total life cycle management, there is a famous "Pareto" curve [5]. From this curve, we can see

that the sum of the costs generated in each stage of the life cycle of the equipment is its life cycle cost, and various factors in the early design stage can most determine the life cycle cost of the equipment, that is, the early design ideas, economic concepts, etc., have a great impact on the construction, use and maintenance of equipment, which is very worthy of attention.

# 2. The Basic Principle

To carry out the design of the price limit of ship equipment, it is first necessary to comprehensively demonstrate the cost, the performance of the equipment and the development progress, etc., and then carry out iterative calculation to obtain the upper limit of the target cost [6]. The specific working process generally follows the following five basic principles:

First, the cost economy of ship equipment and the advanced performance, quality reliability, equipment maintainability, etc. together, carry demonstration out synchronous design. comprehensive weighing policy, pay attention to the decoupling of software and hardware, and promote the iterative development of software instead of hardware. The second is to follow the basic principle of simplified design, as far as possible to meet the functional requirements of the equipment with the least components and parts, and give priority to the verified and mature technology design scheme. Third, in accordance with the idea of "generalization, serialization, modularization", priority is given to the selection of common standard parts to maximize the compression and control of raw materials, types and brands of components. The fourth is to encourage the use of advanced and applicable general standards, promote the use of generation-specific, can use mature equipment, components do not use special-grade equipment components. Fifth, promote scientific and orderly competition, encourage the units that lose the competition to raise their own funds, research and test, and participate in the next stage of competition, and try to retain more than two units to participate in the next stage of work.

# 3. The Main Content

Ship equipment price limit design work is mainly carried out in the engineering development stage, this stage is the key link. According to the development procedure, the project development stage covers five important steps, such as project demonstration, scheme design, technical design, construction and finalization, each step plays a decisive role in the effective implementation of the price limit design.

First of all, the project demonstration stage is the starting point of ship equipment price limit design. At this stage, the overall development unit and the main system and equipment supporting development units need to actively cooperate with the demonstration department to calculate the ordering target price. The importance of this step is that it is not only related to the economic feasibility of the entire project, but also directly affects the cost control effect of the subsequent design work.

In particular, each unit should be as clear as possible when putting forward the target price of the whole system or important supporting equipment ordering target price. This clarity facilitates more precise cost budgeting and control of individual subsystems in the subsequent design process. For the part that is not clear, it must be supplemented in the general requirements of development to ensure the smooth progress of subsequent design work.

Secondly, scheme design stage is the core link of price limit design. At this stage, the decomposition of the order target price index becomes the first task. According to the product price model, the ordering target price is detailed to each first-level system, second-level system, kev equipment and final assembly and construction costs, forming the ordering target decomposition price index system, and incorporating the price limit design and cost control report. This process requires not only deep expertise, but also the flexible use of cost control strategies to ensure that the design of each subsystem meets technical requirements while staving within budget constraints. At the same time, the development unit shall formulate the work plan of the price limit design, clarify the work items and requirements, and arrange the review and work progress. In addition, monitoring the price limit design process of the supporting units, as well as conducting the analysis of the difference between the budgeted price and the ordered target price, is critical to identifying and resolving significant control issues and risks.

Thirdly, the technical design stage is the deepening and refinement of the scheme design stage. At this stage, the development unit

continues to decompose the ordering target price into sub-systems, major stand-alone products and other supporting products, and carry out technical design work based on the ordering target price. This stage requires the development unit to form the overall preliminary technical plan, and constantly improve the product price model and order target price index system. The difficulty in the technical design stage is how to achieve effective cost reduction through technological innovation and design optimization without affecting the performance of ship equipment. Continuous monitoring of the price limit design work of the supporting units and submission of price limit design and cost control reports prior to design reviews help ensure transparency and control throughout the design process. For the difference analysis between the budget price and the ordered target price, optimization measures should be taken in time, and reported to the superior system when necessary, from the equipment to the sub-system, the overall system, and then from the overall system to the sub-system, the equipment, the technical status and funding for multiple rounds of iterative, in order to timely adjust the design strategy and cost budget.

Then, the general construction phase is the critical period to turn the design into a physical entity. At this stage, the overall development unit provides a decomposition system of the order target price index that has passed the technical design review, which is used as a reference basis for the general contractor to calculate the purchase price of materials and equipment. The general contractor shall calculate the purchase price according to the construction contract and related procedures. This process requires the general contractor to have a strong cost control ability and market analysis ability to ensure the rationality and economy of procurement costs. At the same time, the supporting units continue to decompose the ordered target price and execute in accordance with the established cost control work plan to ensure cost control in the construction phase. At this stage, any cost overruns may lead to the failure of the entire project cost control work, so strict cost monitoring and timely adjustment measures are essential.

At this stage, any cost overruns may lead to the failure of the entire project cost control work, so strict cost monitoring and timely adjustment measures are essential. At this stage, the general contractor provides the data and report after cost audit to the overall development unit, and is responsible for the preparation of the whole ship value engineering and cost analysis report, while the sub-system and equipment units prepare their own value engineering and cost analysis report as required [7]. These reports not only need to reflect the actual results of the design, manufacture and cost control of ship equipment, but also should provide experience and data support for the future price limit design of ship equipment. Through the analysis of these reports, we can sum up the experience and lessons, optimize the design process, and improve the efficiency and effect of cost control.

It can be seen that in the five links of the engineering development stage, each link has its unique task and goal, which are connected with each other and together constitute a complete price limit design system. This system not only ensures the effectiveness and rationality of ship equipment in design, construction and cost control, but also provides strong support for the sustainable development of the ship industry.

#### 4. The Steps and Processes

Price limit design is an important part of ship equipment design, construction and cost control, and its process mainly includes the following six steps, as shown in Figure 1.

The first step is to build a price model. On the one hand, according to the development progress, the price model consistent with the technical indicators of the equipment is established, including the overall system, system, subsystem and important key equipment [8]. On the other hand, using parameter method, engineering method, analogy method, etc., according to the unit level to establish the price model of each level. For example, the overall development unit should establish the price model of the overall level to the equipment, and the supporting development unit should establish the price model of the researched product at the unit level. At the same time, the price model should be adjusted and perfected with the progress of development work, the continuous enrichment of technical information and the change of economic level, as well as the improvement of equipment structure and technical status.

The second step is to break down the target price. According to the requirements of the development project, the overall development unit and the supporting development unit should clarify the decomposition method, standards and principles, set up a cross-professional team, coordinate the development, establish the order target price decomposition system, covering the main sub-systems and important supporting equipment. Moreover, according to the development progress, according to the clear content of the technical route of the project, in the program design stage and technical design stage, the order target price decomposition system is gradually iterated.



Figure 1. Work Flow Chart of Price Limit Design

The third step is to calculate the estimated price. The price model is used to calculate and preliminarily estimate the price of the whole, system, sub-system and equipment. After the trial production of the prototype is completed, the estimated price is calculated 4according to the cost data and the one-time research fee is deducted. Carry out price prediction and calculation simultaneously with each stage of design work, and iterate repeatedly in the development process to improve the accuracy of calculation.

The fourth step is to organize cost verification. In the whole development process, the superior system technical responsibility unit takes the lead in organizing the cost verification of the system and equipment that does not meet the standard of the price limit design. And the results are included in the system, equipment ordering target price index for management.

The fifth step is to make a difference analysis. After calculating the expected price, comparing the current expected result with the order target price index, finding problems, analyzing reasons, and proposing improvement measures.

The sixth step is to carry out iterative optimization. On the one hand, in combination with the deepening of technical schemes, the refinement of technical indicators and the gradual clarity of costs, the ordering target price index system is adjusted and refined, the price model is improved synchronously, the expected price scheme is refined, and the difference analysis is carried out dynamically. On the other hand, when the expected price does not meet the target price index of the order, it should give priority to carry out the internal or superior system technical plan and technical index distribution optimization in accordance with the basic principle of price limit design.

# 5. Responsibility System

For the price limit design and cost control of ship equipment, each research and production unit shoulders an important responsibility. In the overall research and development unit, the chief economist system is set up, and the system technical responsibility unit and the final assembly and construction unit participate as members. At the same time, their own economist system is set up to be responsible for the price limit design and cost control.

First, the chief economist system takes the lead in the price limit design work, reasonably controls the cost of the whole project from the overall perspective, and formulates the price limit design criteria as the standard followed by each sub-system and equipment development unit in the design process. And organize the subsystem and equipment development units to carry out price limit design at different levels to ensure the orderly design work [9]. At the same time, the overall development unit regularly organizes the assessment of the implementation of the price limit design of each sub-system and equipment to ensure that the design results meet the expectations, so as to provide guarantee for the cost control of the entire project.

Second, economists at all levels shall systematically formulate corresponding cost control work plans and clarify the work objectives and tasks at each stage. The chief economist system organizes the overall and the responsible units of the system and equipment to carry out the decomposition of the ordering target price, and implements the cost control responsibility to specific units and individuals. In the decomposition process, the overall balance of performance, quality, cost, schedule and other requirements to ensure that the project meets the premise of performance and quality, to achieve cost optimization. At the same time, organize the coordination of major problems, solve the cost control problems in the process of implementation, and ensure project the implementation of the target price index of equipment ordering.

Third, all responsible units need to promote the development of their equipment in strict

accordance with the price limit design criteria and cost control work plan. In this process, the subcontractor should incorporate the realization of cost control into the performance appraisal system of the research unit, so that the cost control results are linked to the interests of the research unit. At the same time, the realization of the order target price index is regarded as an important part of the performance evaluation of relevant teams and individuals, so as to stimulate the enthusiasm of team members and jointly contribute to the project cost control [10,11].

Through the above three aspects of measures, ship equipment in the price limit design and cost control can form a relatively perfect management system. Each research unit plays its own role in this system and jointly promotes the in-depth development of ship equipment cost control.

#### 6. Conclusion

Ship equipment manufacturing is a complex and comprehensive heavy industry. With the development of ship equipment manufacturing industry, the current competition in ship equipment manufacturing industry is particularly fierce, so improving the economic benefits of ship equipment manufacturing is an important way to enhance the market competitiveness of ship equipment manufacturing industry. In order to promote the sustainable development of ship equipment manufacturing industry, it is necessary to increase the cost control of ship equipment manufacturing industry. Carrying out limit in ship equipment price design manufacturing and reasonable control of manufacturing costs can effectively reduce the cost of enterprises, improve the economic and market competitiveness benefits of enterprises, and is also the most effective means to control the cost of ship life cycle.

#### Acknowledgments

This paper is supported by the Military Science of National Social Science Foundation (No. 2023-SKJJ-B-029), the Independent Research and Development Project by Naval University of Engineering (No. 202350A040). Thanks.

#### References

- J B Geng, J S Jin. Theory and Practice of Life Cycle Cost Technology. National University of Defense Technology Press, 2015.
- [2] L Zhou, W F Wang, L Zhang. Equipment Life Cycle Cost Analysis Method and Application. Northwestern Polytechnical University Press, 2024.
- [3] X D Liu. Equipment Life Cycle Cost Analysis and Control. National Defense Industry Press, 2008.
- [4] Z Y Wang. Cost Limiting Design in Aeronautical Equipment Development. Aviation Science and Technology, 2017, 28(12):61-64.
- [5] G W Chen, Y J Zhou L Ren. SD Optimization of Equipment Cost Structure Facing System Performance Maximization. Systems and Engineering and Electronics, 2021, 43(4):1022-1029.
- [6] G M Zhao, X J Liu. Application Research of Fixed Cost Design Method in USA. Flying Missile, 2012(11):92-96.
- [7] J Zhang. Analysis on the Fit Between Equipment Development Price Limit Design and Enterprise Target Cost Management. Accountants, 2015(4):69-71.
- [8] G B Xia, G W Chen, Y D Li, et al. Discussion on The New Era Equipment Price Audit Management. Modern Business Trade Industry, 2024, 45(14):130-133.
- [9] J S Wang, W Gao, L J Xi. Design and Control of Fixed Cost of Aviation Equipment Based on Life Cycle. Aeronautical Finance and Accounting, 2024, 6(5):45-49.
- [10]L L Wang. Research on Life Cycle Cost Control of Construction Projects Based on System Dynamics. Guangzhou University, 2017.
- [11]G W Chen, Z Y Du, Y J Zhou. Analysis on the Construction of Equipment Outlay Use Benefit Evaluation System. Jiangsu Science & Technology Information, 2022, 39(22):69-72.