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Methods and Measures for the Life Cycle Integrated Management of Equipment Economic

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Abstract: *With the accelerated development of modern science and technology and the continuous progress of new military changes, the economic management of equipment is particularly important in the development of military modernization and construction. Based on the analysis of the obvious shortcomings of the current equipment economic management, this paper elaborates the characteristics of equipment life cycle costs and the relationship with the economy; constructs the equipment life cycle and each stage of the economic analysis model; puts forward the measures and proposals to strengthen the equipment economic life cycle integrated management from four aspects: strengthening the concept of integrated management, innovating the integrated management method, weighing the cost and performance requirements, and closing the loop management data information. The measures and suggestions to strengthen the economic life cycle management of equipment are pro-posed.*

Keywords: *Equipment economic, Lifecycle costs, Integrated management, Benefits*

1. Introduction

With the accelerated development of science and technology, the new military transformation continues to advance, the tactical and technical performance requirements of equipment is unprecedentedly high, the system is increasingly complex, high-tech content is increasingly high. Equipment development, production costs and life cycle costs keeping rising, has become an important factor that can't be ignored affecting the national defense and military construction process and quality and efficiency. The current economic management of equipment still has obvious shortcomings: First, the equipment pricing is based on cost-plus approach, making the contractor to get more profit, constantly improve the cost of equipment, seriously hinder the use of equipment construction funds to improve efficiency. Second, the project justification process in the equipment only focuses on military needs and tactical and technical performance justification, the economic justification of the equipment is not sufficient, and the economic analysis of equipment is not specific, resulting in the equipment follow-up costs of each stage is difficult to effectively control. Third, the lack of economic affordability of equipment life cycle integrated analysis and effective management of each stage. Incentives, Constraints, Control, Evaluation mechanisms are missing, it is difficult to form a closed loop of management[1-2].

Life cycle management is the use of systems theory and systems engineering, operations research, project management and other theories and methods, the equipment "from conception to life to death" of the whole process, the implementation of systematic planning, comprehensive weighing and scientific management. In order to better resolve the above contradictions, there is an urgent need to implement integrated equipment lifecycle management and improve equipment economy under the premise of comprehensive consideration of combat and security effectiveness. Life cycle management has become the trend of equipment construction management and the important way of scientific development.

2. Characteristics of The Life Cycle Costs of Equipment and Their Relationship to the Economy

2.1. The Congenital of Life Cycle Costs

The cost of each stage of the equipment life cycle, from project demonstration, design and development, production deployment, use and security to end-of-life disposal, is certainly determined by the target needs of each stage. However, in the equipment life cycle, the work results of the front stage determine the subsequent stages of work content and resource requirements, therefore, the more the front stage, the more significant the impact on the subsequent stages and life cycle costs. In fact, life cycle

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costs in the equipment production before, has been determined by the project demonstration, design and development "innately" basically. In the use phase, the structure and performance of the equipment have been basically determined. The use and maintenance of safety and other costs of demand has also been determined. There is little room to reduce the use and maintenance costs. U.S. B-52 aircraft life cycle cost study shows that the impact of each stage on the life cycle cost is: the project demonstration phase can affect about 85%, the design and development phase engineering development process can affect about 10%, the production phase can only affect about 4%, to the use phase can only affect about 1%. Therefore, life cycle cost management must be considered as early as possible. In the equipment feasibility study or tactical technical index requirements demonstration, equipment life cycle cost should be estimates and control, to ensure the development of equipment necessary, feasible and affordable.

2.2. Secondary Costs Cannot Be Ignored

As the function of equipment is increasingly perfect and the performance continues to improve, the system structure of equipment is more complex, and its level of intelligence and information technology continues to improve. The development cost of equipment is increasing rapidly, and the cost of the production phase and the use phase have also increased significantly, even more than the growth of the original cost. The study of the U.S. Department of Defense shows that the cost of the project justification and design development phase of typical equipment accounts for only about 15 percent of the total cost, the cost of the production phase accounts for about 35 percent of the total cost, and the cost of the use phase accounts for about 50 percent of the total cost. It can be seen that the Secondary costs of equipment is considerable and can’t be ignored. Therefore, the life cycle management of equipment can not only consider the equipment acquisition costs in the initial development and production, but also need to pay attention to the secondary costs of the equipment, which is the basic guarantee of affordable and sustainable development of equipment[3-5].

2.3. Pursuit of Equipment Economy on the Basis of Meeting Military Benefits

The basic purpose of equipment design and development is to meet the requirements of military operations for the function and performance of equipment to perform the assigned mission to achieve the intended operational and security objectives. The economy of equipment must be pursued on the basis of meeting military benefits. Military effectiveness is the premise of the economy of equipment, if there is no military effectiveness, all the money spent on equipment will be meaningless. Equipment can’t achieve the set goals, can’t play a predetermined combat capability, will lost its real value. Economy should be a comprehensive measure of equipment effectiveness and resource consumption, only the economy of equipment and military effectiveness of the integrated consideration can achieve the true meaning of economy. Therefore, the life cycle effectiveness of the equipment can be used to analyze and evaluate the economy of the equipment.

3. Equipment Life Cycle and Economic Analysis Model of Each Stage

3.1. Main Parameters of Equipment Economic Analysis

Equipment economic research and management is mainly based on parameters such as equipment effectiveness and cost of each stage of the life cycle. Equipment life cycle can be divided into five management stages: project demonstration stage, design and development stage, production and deployment stage, use and maintenance stage, decommissioning and end-of-life stage. Equipment life cycle costs are divided into five parts: demonstration and design costs (including project demonstration stage, design and development stage), production and manufacturing costs, maintenance and service costs, and decommissioning costs.

Equipment Life Cycle Effectiveness is the ratio of equipment effectiveness to life cycle cost (resource consumption cost), which can be expressed as

$$Equipment\ Life\ Cycle\ Effectiveness = \frac{Equipment\ Effectiveness}{Life\ Cycle\ Cost}$$

Equipment economics can be analyzed and managed in each of systems and phases. Therefore, equipment effectiveness can also be studied in each of systems and phases. The measurement of equipment effectiveness at different stages can also use different indicators or a combination of multiple indicators, such as key performance indicators, quality level, combat effectiveness, and security

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effectiveness.

3.2. Model Related to Equipment Economic Analysis

Suppose there are a total of m attributes (or subsystems) of a piece of equipment, and the cost, effectiveness, and benefit model associated with the equipment life cycle of the i-th attribute (or subsystem) is as follows. i =1, 2, 3, …, m.

(1) Demonstrated Design Cost. The demonstrated design quality level of the i-th attribute (or subsystem) of the equipment is represented by Q_i, and the performance or capability requirements are represented by R_i. The demonstrated design cost is positively related to the demonstrated design quality level as expressed in equation (1).

$$C_{i1} = f_{i1}(Q_i, R_i) \tag{1}$$

Usually, $\frac{\partial f_{i1}(Q_i,R_i)}{\partial Q_i} > 0$.

(2) Manufacturing cost. The equipment of the i-th attribute (or subsystem) manufacturing cost C_{i2} is mainly related to its demonstration design quality level Q_i, performance or capacity requirements R_i and manufacturing quality control level, as expressed in equation (2), the better the quality control, the higher the product qualification rate.

$$C_{i2} = f_{i2}(Q_i, R_i, q_i) \tag{2}$$

In the formula, $q_i$is the manufacturing qualification rate of the i-th attribute (or subsystem).

(3) The use and support cost. The use and support cost C_{i3} of the i-th attribute (or subsystem) of the equipment is mainly related to its demonstration design quality level Q_i, performance or capability requirements R_i and use support level. The use and support level of the i-th attribute (or subsystem) can be measured by its use availability A_i. As expressed in equation (3).

$$C_{i3} = f_{i3}(Q_i, R_i, A_i) \tag{3}$$

Usually, $\frac{\partial f_{i3}(Q_i,R_i,A_i)}{\partial Q_i} < 0, \frac{\partial f_{i3}(Q_i,R_i,A_i)}{\partial A_i} < 0$.

(4) Maintenance Service Cost. The maintenance service cost c of the i-th attribute (or subsystem) of the equipment is related to its demonstrated design quality level q, performance or capability requirements r, failure rate v, and maintainability level m. The higher the demonstrated design quality level, the lower the failure rate, and the higher the maintainability level. In general, the higher the design quality level, the lower the equipment failure rate and the higher the maintainability level. As expressed in equation (4).

$$C_{i4} = f_{i4}(Q_i, R_i, \lambda_i, M_i) \tag{4}$$

Usually, $\frac{\partial f_{i4}(Q_i,R_i,\lambda_i,M_i)}{\partial Q_i} < 0, \frac{\partial f_{i4}(Q_i,R_i,\lambda_i,M_i)}{\partial \lambda_i} > 0, \frac{\partial f_{i4}(Q_i,R_i,\lambda_i,M_i)}{\partial M_i} < 0$.

(5) Decommissioning Cost. The decommissioning cost of the i-th attribute (or subsystem) of the equipment is related to the demonstration design quality level Q_i. Under the same service conditions, equipment with higher demonstrated design quality level has a higher residual value than that with lower quality level. As expressed in equation (5).

$$C_{i5} = f_{i5}(Q_i) \tag{5}$$

Usually, $\frac{\partial f_{i5}(Q_i)}{\partial Q_i} < 0$.

(6) Life Cycle Cost. The total life cycle cost C_{Ti} of the i-th attribute (or subsystem) of the equipment is composed of demonstration design cost, manufacturing cost, use support cost, maintenance service cost, and decommissioning cost. As expressed in equation (6).

$$C_{Ti} = C_{i1} + C_{i2} + C_{i3} + C_{i4} + C_{i5} \tag{6}$$

(7) Life Cycle Effectiveness. The effectiveness of the i-th attribute (or subsystem) of equipment Ei can be expressed in terms of the total number of times the attribute (or subsystem) will be used over its life cycle, the time or frequency of functioning, and the level of critical performance or capability. Effectiveness is related to its demonstrated design quality level, performance or capability requirements, failure rate, and maintainability level. As expressed in equation (7).

$$E_i = f_{i6}(Q_i, R_i, \lambda_i, M_i) \tag{7}$$

Usually, $\frac{\partial f_{i6}(Q_i,R_i,\lambda_i,M_i)}{\partial Q_i} > 0$, $\frac{\partial f_{i6}(Q_i,R_i,\lambda_i,M_i)}{\partial \lambda_i} < 0$, $\frac{\partial f_{i6}(Q_i,R_i,\lambda_i,M_i)}{\partial M_i} > 0$.

(8) The benefit of the i-th attribute (or subsystem) of the equipment. As expressed in equation (8).

$$\pi_i = \frac{E_i}{C_{Ti}} \tag{8}$$

(9) Equipment Life Cycle Benefits. Equipment life cycle benefits are derived from the product of the benefits of each attribute (or subsystem). As expressed in equation (9).

$$\pi = \prod_{i=1}^{m} \pi_i \tag{9}$$

3.3. Equipment Economy Optimization Model

Cost Objective Function:

$$min\, C_{Ti} = C_{i1} + C_{i2} + C_{i3} + C_{i4} + C_{i5} \tag{10}$$

or Benefit Objective Function

$$max\, \pi = \prod_{i=1}^{m} \pi_i \tag{11}$$

Constraints: E_i ≥specified requirement; Q_i ≥given value; R_i satisfies the specified requirement; λ_i ≤given value; M_i satisfies the specified requirement; A_i ≥given value. *i*= 1, 2, 3, ..., m.

The parameter values obtained from the solution of the equipment economic optimization model can provide planning objectives and control standards for the management of each stage of the equipment life cycle. The optimization model provides technical methods and means for the integrated management of the equipment economic life cycle[6-8].

4. Measures and Suggestions to Strengthen the Integrated Management of Equipment Economic Life Cycle

4.1. Strengthening of the Concept of Life Cycle Integrated Management of Equipment Economic

The equipment life cycle costs include the cost of each stage, but the cost of each stage constrains and affects each other. The management body of each stage should strengthen the concept of life cycle integrated management of equipment economic, and break the traditional management habits and work patterns of each stage by strengthening work cooperation and smooth data and information exchange channels. Life cycle cost and equipment effectiveness should be considered as an organic whole. Change the concept and practice of only paying attention to technology, ignoring the cost, and effectively maintain the equipment life cycle costs at a reasonable and affordable level.

4.2. Innovative Life Cycle Integrated Management Methods of Equipment Economic

Establish equipment economic life cycle integrated management mechanism, innovative equipment economic life cycle integrated management methods. Integrate the economy into the scientific management track of equipment system construction, reform the equipment price management model, and solve the problems of lack of mechanism and means in the past economic management. Timely detection and correction the improper decisions and deviations in the process of life cycle management.

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Use economic analysis and optimization methods of scientific life cycle to promote the quality and efficiency of equipment construction.

4.3. Comprehensive Trade-Off between Equipment Costs and Performance Requirements

The functional performance requirements of equipment are the premise and basis of equipment economy. The scientific and reasonable functional performance requirements of equipment directly affect the equipment economy. Life cycle management of equipment economy, first of all, must put forward scientific and reasonable military needs functional and tactical technical performance requirements in the demonstration stage of equipment project, and must weigh the equipment costs and functional performance indicators to put forward reasonable and feasible economic requirements, solving the problem of previous equipment economic demonstration is not sufficient, analysis is not specific. If the equipment economy and performance can't meet the requirements at the same time, give prior-ity to the realization of the performance requirements of equipment to ensure the effectiveness of equipment, achieve the expected benefits, and improve the economy of equipment[9-10].

5. Conclusions

Equipment economy is designed and improved through integrated management. This paper discusses the characteristics of equipment life cycle costs and the relationship with economy, constructs a model for life cycle and economic analysis of each stage, and proposes measures to strengthen the economic life cycle management of equipment. Equipment economy and life cycle management are closely related, that can ensure the effectiveness of equipment and the economy of equipment and can achieve sustainable development of the equipment system. Carry out equipment economy research, can provide a basis for decision-making and technical method support for the development of equipment construction.

References

[1] Yan W., Zhang H., Xiong S. Analysis of the ways and methods of controlling the economy of equipment. (2015) (09), 133-134.

[2] Yu P., Zhao G., Shi H. Thoughts and Research on Technical Economic Design of the Equipment. (2013) 43(01), 68-70.

[3] Chen G., Gao C. Reflections on strengthening equipment whole life management under military-civilian integration strategy. (2018), 6-11.

[4] Zhou H., Wang X. Analysis on rail transportation procurement based on whole life cycle cost. (2022) 54(01), 74-78.

[5] Huang Z., Xie Y., Liu Z., Chen L. Engineering Reflections on the Economy of Aviation Equipment. (2022) 4(05), 11-16.

[6] He L., Liu M. Research on whole life cycle cost estimation and control method for military aircraft. (2017) (35), 152-154.

[7] Zou C., Peng J. Improving equipment economy. (2021) 03, 41-42.

[8] Qi Z., Yang P., Lin J. Economic life analysis of equipment. (2016) 37(32), 193-194.

[9] Liu Y., Zheng Q., Guo N., Xu C. Discussion on the Method of Equipment Standardization Benefit. (2021) 16(03), 239-243.

[10] Tian J., Hu L. On Cost Control and Management of the Life Cycle of Weapon System. (2014) 33(24), 158-159.