The Warship Equipment Life Cycle Design Based on the Supportability System Engineering for the People’s Armed Police Coast Guard

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Abstract. According to the actual requirement and the existing situation of the Warship Equipment Support, the article makes its main research on the People’s Armed Police Coast Guard, and describes the concept and connotation of the warship equipment support design. It proposes the life cycle design based on the supportability system engineering in order to make the later costs lower, which includes the Project stage, the Argument stage, the Design stage, the Usage stage, the Maintenance and Support stage and the Scrapped stage. Finally it summarizes the project and technological approaches which can realize the support target from the project demonstration phase to the using support phase. The warship equipment life cycle design aims at solving the generated problem of the system of systems support capability, and can improve the logistical support system, innovative the support model, enhanced the logistical support capability.

1. Introduction
On July 1, 2018, the Maritime Police people, equipment and its functions under the leadership of the State Oceanic Administration (China Maritime Police Bureau) were all assigned to the Armed Police Force according to the method of first handover and later reorganization. The coast guard warship as the main equipment of the Maritime Police is the multi-system, multi-functional super-large equipment, and it is also the complex system composed of multiple platform systems and multiple weapon systems, which has the characteristics of complex types, huge system, and technology intensive. At the same time, the system structure is highly integrated, the functions are interleaved, the levels are multiple, the mission profile is complex, the reliability model is diverse, the failure distribution function is difficult to determine, and the effect of spare parts is large. It belongs to the category of large repairable complex equipment systems. Therefore, its characteristics and operational environment require fewer failures in use, and should be repaired in time if a failure occurs.

2. Research Objectives
At present, the warship equipment of the People’s Armed Police Coast Guard mainly has the difficulties in long-distance repair and maintenance, high maintenance costs, long maintenance and support cycles, and low efficiency. The statistical information structure of various types of equipment maintenance is complex, distributed, and difficult to share, making it more difficult to achieve effective management and comprehensive use. At the same time, considering that the combat mode is changing from the traditional platform-centric to the network-centric, naval equipment is changing...
from platform construction to system construction, the support model is changing from combining ship-to-shore support to ship-based support. Therefore, the development trend of the new generation of coast guard warship equipment must meet the requirements of informatization, networking and intelligence, and eventually form a system. The warship equipment design must shift from focusing on functional performance design to a combination of functional performance design and support design, and focus on the full life cycle design, which can ensure the rapid formation of combat capability and support capability when the new ship is delivered.

![Warship composition](image)

**Figure 1.** warship composition

The purpose of the coast guard warship equipment maintenance and support is to maintain, restore and improve the combat maintenance performance of the whole ship through the use of various resources and maintenance support methods to ensure that the ship is in good condition at all times. With the support of various maintenance management work such as scientific research, maintenance funding, maintenance strength, usage and maintenance information, maintenance personnel training, we can establish a maritime police ship equipment maintenance support system combining plane support and three-dimensional support, combining organizational support and leapfrog support, combining concomitant support and self-support, combining mobile support and fixed-point support, and combining independent support and support. It meets the requirements of timely support, rapid maintenance, reliable quality, reduced resource consumption, and increased ship's voyage and participation rate.

3. Design Requirements

The support capability requirements are derived from the ship's combat mission requirements, and then the support target requirements and support design requirements are determined. This part of the work is mainly completed during the comprehensive demonstration of the project and the demonstration of the general requirements for research and development. The main work includes clarifying operational use plans, formulating preliminary support plans and constraints, and transforming support capability requirements into support performance requirements, and then into support design requirements, including support design requirements and support resource design requirements. When determining the requirements, we need to pay attention to the following issues:

First, the supportability goal is generally a requirement for the use at the system level. It must be used from the perspective of use, considering its true use and support conditions. The support performance requirements derived from the support capabilities should be system-level and top-level requirements. At the same time, this process needs to translate support performance requirements into support feature requirements, including support design requirements and constraints, which can provide design basis and constraints as equipment support design and support resource design. As a ship design unit, it should carry out the use research work of the developed equipment and write the use research report in accordance with the national military standard GJB1371 "equipment supportability analysis" 200 series of work items. In order to reduce the content of use and support work and improve the ship's intact rate, the support plan must play a binding role in the design plan.

The second is the key to determine the support target requirements and design requirements which must repeat the trade-offs between use plan, design plan, and support plan. Combat mission requirements are the input for formulating usage plans. The operational use process can be clarified
through the use plan, which means the mission profile. Then it can determine the environmental profile and test profile. A lot of practice shows that the unclear requirements of combat missions are an important reason for delaying progress, increasing funds, users complaining and being dissatisfied.

Third, all the requirements must be clear, unambiguous and verifiable, and the timing and method of verification of each requirement must be given at the same time, otherwise the requirements may be invalid. For example, in order to improve the availability of a ship (sometimes called onboard rate), a request that has not been made in the past must be made, in addition to controlling the number of preventive maintenance and workload. Such as without additional resupply, no need to dock, no need for external personnel to provide assistance on board, etc., the ratio of repairing repairs (failure repairs) and preventive repairs (also known as the crew-level repair rate) that can be completed using the personnel, equipment, equipment tools, technical information and other resources onboard the ship. The US military also requires this indicator, which require 90% failures to be repaired on board, which is very critical to improve the availability of ships. This requires a lot of measures from the design of the ship itself and the design of the support system, and that indicator not only needs to be designed, but also needs to be verified.

4. Warship Supportability Life Cycle Design
The combat readiness and the mission success are the comprehensive manifestation of the combat capability of the warship, while the reliability, maintainability, and supportability (RMS) are also important factors that affect the completeness of the equipment system's combat readiness and mission success. Therefore, it has great significance to improve the warship's combat capability from analyzing and evaluating the characteristics of the warship's RMS at different stages of its life cycle.

![Figure 2. life cycle of the warship supportability](image)

4.1. Demonstration stage design
In the demonstration stage, according to the mission requirements of the equipment, we should keep on the mission requirements analysis and feasibility analysis and tactical technical indicator demonstration, and determine the usage requirements, supportability constraints, preliminary supportability requirements, which can propose the preliminary overall technical plan finally. These tasks can be summarized into three items: task requirement analysis, demonstration and determination of preliminary RMS requirements, and preliminary overall technical solutions.

4.2. Plan stage design
The plan stage is mainly to carry out equipment function analysis, RMS index allocation and trade-off optimization guarantee plan. Through the function analysis, we can determine the usage function and sub-function, maintenance function and sub-maintenance function. We can allocate and determine design criteria for the usage of availability, reliability, maintainability, cost, and parameters of the main support system and support resources. Through the evaluation and trade-off analysis of the alternative use plan, design plan and guarantee plan in the overall development plan, the system plan is optimized, the best use plan, design plan and guarantee plan are determined, and the supportability index is finally determined.
4.3. Engineering development stage design
The engineering development stage is mainly to carry out the detailed design and development of the main equipment and support system, equipment system design finalization, small batch trial production and production finalization. The supportability analysis at this stage is mainly to continue the detailed support resource analysis and formulate comprehensive technical support documents and revise the support plan based on the supportability analysis records. In addition, the comprehensive technical support plan and the comprehensive support plan must be revised.

4.4. Production deployment stage design
This stage is mainly to carry out mass production of equipment, revise material specifications and process specifications after mass production; guarantee the production, procurement and supply of resources; deploy equipment and distribute supply guarantee resources according to the deployment guarantee plan, establish and allocate guarantee institutions, and Perform initial supply of deployed equipment; perform necessary supportability analysis such as support analysis after production shutdown, continue RMS test and evaluation, collect usage and support data, evaluate whether the initial combat capability is formed, and propose corrective measures for the supportability problems found; revision Comprehensive technical support plan and comprehensive support plan, etc.

4.5. Usage and supportability stage design
This stage is mainly to use and maintain equipment according to the formulated support plan and support system; support the reproduction, repurchase and subsequent supply of support resources; collect use and maintenance support data, revise and supplement the supportability analysis record database, and check the problems found Take corrective measures; make technical improvements to equipment when necessary.

4.6. Decommissioning stage design
This stage is mainly the decommissioning of main equipment and support resources; the collection, use and maintenance support data are stored in the RMS analysis record database and archived.

5. Warship Support Design Engineering
5.1. Supportability design and shipboard support system design
The fundamental purpose of ship supportability design is to ensure that the ship has good supportability by design and reduce the dependence on support work. Such as in figure 3, supportability design features include many features, mainly as the reliability, maintainability, testability, environmental adaptability, commonality, self-guarantee, transportation, etc. The design of these characteristics into the ship is the key to ensure its easy support. Reliability design is the most important work. Reliability must be considered from the beginning of program selection, because the product structure has the greatest impact on reliability. Once the product structure, materials, and processes are determined, the reliability of the product is determined that the follow-up work has a limited impact on its reliability. The basic purpose of maintainability design is to design the systems, subsystems, equipment and facilities, so that they can be repaired in the shortest time, at the lowest cost and with the least amount of support resources. Maintainability is also greatly affected by product structure deployment, therefore, the maintenance design must start at the equipment planning stage. For the coast guard ships, the maintenance design also needs to consider the maintenance work space, storage and workshop, maintenance support equipment, maintenance information, maintenance outline, etc.
When we need design a support system, we must first formulate a support plan. Overall consideration of the set of support resources the equipment support resources are required to provide minimized, which can meet the operational requirements and adapt to the equipment design, this process implements the support characteristics requirements into specific product design schemes, support schemes and support resource requirements. Finally, it can form the support resource requirement list and ship life cycle support plan, support in order to plan the support work and support resources for the entire life cycle of the coast guard ship. When design the supportability and the support systems of coast guard ships, the design department should listen to the opinions of the front-line troops and support personnel.

5.2. Supportability design verification and support target evaluation
According to the small number of ship development, the continuous shortening of the development cycle requirements, high performance requirements, and the usage and support away from shore, etc., it has increased the difficulty of supportive design and support target verification and evaluation. In view of this situation, it is necessary to overcome various difficulties and do as many test verifications as possible, because if the test verification is insufficient, once there is a problem after the ship is delivered. It will definitely affect the effectiveness of the combat effectiveness. In order to solve these problems, it is necessary to establish more test verification and design analysis verification. The test verification should be rigorous and close to actual combat multi-factor, complex environment and meteorological. The design analysis verification needs to be arranged, low-level, and using computers modeling and simulation test, accelerated life test, physical and semi-physical simulation test, which can evaluate the support efficiency of the ship. The figure 4 gives an idea of the experimental plan.
Experimental conditions are getting closer to actual combat
System experiment
System test
Subsystem test
Large parts Single element Equipment experiment
Component experiment
Components Parts Raw material test
Test Number

The number of experiments is gradually increasing

5.3. Maintenance, monitoring and improvement of support capability
After passing through multiple tests and verifications, the qualified ships are delivered to the Coast Guard Force and enter the stage of use and support. The crew's advance training on the ship to carry out adaptive training is also an important part of checking the suitability of the warship. In the view of support, the warship can enter the operation stage of the support system. This stage is sometimes longer, and the end of the process should indicate that the initial ability to perform tasks can also be referred to as the formation of initial combat capabilities and support capabilities. After the initial action capability is formed, a period of operation, adjustment, and optimization, the ship can form a comprehensive combat capability and support formation support capability, and finally achieve the initial support target proposed by the troops. Then enter the stage of evaluation, monitoring and improvement of the support capability and support system to ensure that the ship can complete the combat mission to the maximum extent.

6. Conclusion
In the future, as the country's "second navy," the Coast Guard is an important force for realizing the dream of a strong country and a strong military, and a force that requires key development. How to realize the transformation of the Armed Police and Coast Guard warship equipment from scale and quantity to quality and efficiency, it is the key to solving the successful transformation and improving the support efficiency of ship equipment. In order to improve the support efficiency of ship equipment, it is necessary to update traditional concepts and establish the concept of large support and life cycle support design. This will form the support capability as the starting point and landing point for the development of ships, which can innovate in management mechanisms, organizations, design concepts, design methods, test methods, and guarantee methods. Also it can break through a batch of key technologies, and fully implement warship support system engineering.

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