Research on Dynamic Causes of The Evolution of Warship Equipment’s Maintenance and Support System

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Abstract. This paper analyzes the process of China’s Warship Equipment Maintenance and Support System’s development, which considers the evolution of the system as the results of the combined effects of internal and external factors. A basic conceptual model of dynamic causes of the evolution of Warship Equipment’s Maintenance and Support System has been built based on the theory of Dynamic core competence. It has answered the question “why the Warship Equipment’s Maintenance and Support System evolves.

1. Introduction
In order to meet the national military strategic needs, equipment development needs, and adapt to changes in the external environment, China’s Warship Equipment’s Maintenance and Support System has experienced a development process from scratch, from germination to maturity, from barely adapting to demand to functioning large-scale Emerge. It has obvious evolution characteristics. This evolution is the result of the interaction between internal and external factors of the system. Through the analysis of the development process of China’s ship equipment maintenance and support system, combined with the dynamic core competence theory, the internal and external motivations of the system evolution can further solve China. The question of why the ship equipment maintenance system evolved, and at the same time, can lay a qualitative research foundation for further quantitative research on the evolution of the system.

2. Analysis on the construction of Warship Equipment’s Maintenance and Support System
The Warship Equipment’s Maintenance and Support System refers to the comprehensive contradiction of maintenance in order to meet the needs of naval warship’s support tasks, which are composed of a large number of operationally interactive and functionally independent maintenance elements[1]. It consists mainly of three parts, which includes warship’s equipment maintenance &support forces, warship’s equipment maintenance &support theory and warship equipment’s maintenance and support organization. The basic construction is as follows:
3. The fundamental contents of the Warship Equipment’s Maintenance and Support System

3.1. Evolution category
As a complex open system, The Evolution of Warship Equipment’s Maintenance and Support System (WEMSS) is completed in the interaction of internal and external environments. The maturity of the evolution of the system is equivalent to the fitness to the environment. From the perspective of evolutionary actions, it can be divided into the evolution of elements and the evolution of structure. From the perspective of the status, it is divided progressive evolution and radical evolution. In the process of its evolution, the system will follow the successful experience of the past to develop and allocate capabilities, knowledge and resources according to the established success paradigm. It has the characteristics of path dependence and robustness. When faced with a conflict crisis or during the war, once the needs of missions are not met, the system has to undergo a large-scale reconstruction, which is reflected in flexibility.

3.2. The process of China’s Warship Equipment’s Maintenance and Support System’s development
The development of WEMSS has gone through four stages, namely the initial construction period (1949-1956), the growth and development period (1956-1976), the modernization period (1977-2008), and the jump period. (2008-present).

The WEMSS was established while battling. During the initial construction period, the Navy has experienced the liberation combats of several Islands. At this time, the Navy's main warships mainly came from the Soviet Union or seized from the enemy. The maintenance technology was mainly from the Soviet Union. In terms of maintenance forces, dozens of new shipyards have been built, taken over and requisitioned. Most of the early maintenance staffs were transferred from the ground forces. Through the training of the Soviet army, in the missions, and with the independent innovation, hundreds of warships were repaired and modified to cope with the tasks of protecting the escort, rescue and disaster relief, and liberating the island. In 1953-1960, a total of dozens of maintenance regulations and regulations were issued, and a four-level security system for the military-fleet-base-ship force was established.

1956-1976 is the growth and development period of the WEMSS. From 1956 to 1966, the Navy
focused on the expansion and transformation of the original old factories, and accepted several general machinery factories allocated by the state. The warship equipment’s maintenance and support force has reached a new level. During this period, the Navy’s first “Ship Repair Regulations” was issued, and the maintenance work went to a programmed road. During the Cultural Revolution, the Navy still focused on strengthening the construction of repair workshops, dozens of new repairs were built. The supply of warship equipment is sufficient, and branches of accessories developing, processing, manufacturing and procurement have been established in several cities.

During the period of modernization, China entered the period of reform and opening up and joined the WTO. After the Third Plenary Session of the Eleventh Central Committee, the Warship equipment repair work began to be rectified. In 1980s, the three-level maintenance management system of the naval-base-compilation brigade was implemented. The naval strategic policy has shifted from "near-shore defense" to the current "offshore defense". The frequency of naval foreign affairs activities has increased dramatically. During this period, the warship equipment’s maintenance works began to be incorporated into the naval system-wide life-cycle management, and the “Two-In-Two-Force” construction was carried out, gradually changing the inconsistency of “making”, “reforming”, “repairing” and “using”. With the support of high-tech represented by RMS engineering and network and information engineering, the warship equipment strength has been improved at a high speed, and the independent research and development capability of ship equipment has been greatly improved. With the support of high-tech, the WEMSS has changed from mechanization to informatization and integration, from the emphasis on scale advantage to the emphasis on quality and efficiency, and the whole has shown a trend of reconstruction and development.

At the beginning of the 21st century, warship equipment entered a new era of development. The emergence of new types of warships has sprung up, and aircraft carrier battle groups have emerged. The high-tech integration and high complexity of ship equipment have brought new challenges to the WEMSS. It is difficult to complete all the support tasks by relying solely on the military maintenance force. During this period, the military equipment support to take the military-civilian integration development path has become a new objective requirement to actively adapt to environmental changes, and civilian support has become an external support for the WEMSS. In addition, the rapid development of big data technology, artificial intelligence technology, remote sensing technology and other high-tech in the 21st century has given the evolution of the WEMSS strong technical support. During this period, China's independent research and development capabilities have greatly improved. In 2008, the Navy began escort operations and carried out evacuation operations in the event of a major crisis abroad. The frequency of participation in diplomatic activities increased. Under the planning of the naval strategy, the development of equipment, the change of mission structure, and the support of economy and technology, the development of the ship equipment maintenance support system has entered a period of leaps and bounds.

4. Analysis of dynamic causes of the evolution of WEMSS

According to the statement above, the WEMSS can be regarded as a dynamic and open complex system. In the process of its operation and development, there is energy, information and resource interaction with the external environment all the time. The origin of its evolution is the origin of this interaction. A perfect concept of power should include the internal causes of power generation, external incentives, and self-coordination of actors [2]. The process of affecting the evolution of the WEMSS is shown in the following figure:
The initial evolution basis is the basic state of the WEMSS at a certain time point. The process of organizational evolution is also the result of the organizational behavior pattern's change, and the process layer is the result of the combined action of internal motivations and external incentives.

4.1. Intrinsic motivation for the evolution of Warship Equipment Maintenance & Support system
The internal motivation for the evolution of WEMSS is the force generated by the maintenance support system in the process of formation and realization of the support system of the maintenance support system to promote its evolution. The internal motivation of evolution, as a kind of willingness to actively innovate, directly affects the behavior pattern of the maintenance organization, and plays a decisive role in the evolution path and process of the ship equipment maintenance support system[3]. Its main content can be simplified into four items, namely personnel and technical level, organizational factors, innovation factors and equipment R&D (research and design) participation.

4.1.1. Personnel and technical level
As the most active factor in WEMSS, maintenance staffs are not only the undertakers of maintenance tasks and maintenance risks, but also the main body of maintenance organizational learning[4]. The training, cultivating, management and incentives of maintenance support personnel determine the level of their technical level. In addition, maintenance staffs are also the driving force behind the system's innovative behavior. The country's economic and scientific capabilities need to be transformed into support by maintenance support personnel. The evolution of the ship equipment maintenance support system is also the process of maintenance support personnel and their technical level improvement and organizational learning enhancement.

4.1.2. Organizational factors
The organization influences the synergistic effects of various elements inside and outside the organization through constraints on information exchange and rights distribution, so as to achieve the purpose of promoting the dynamic adaptive evolution of the core competence of enterprises[5]. The organizational factors for the evolution of WEMSS can also be described as the system mechanism of the ship equipment maintenance support system. It will play the following two roles in the evolution of the ship equipment maintenance support system: 1. Lay the organizational foundation for evolution.
2. Enhance the coordination and adaptability of the system.

4.1.3. Innovation factors
In essence, the evolution of the WEMSS is also a process of continuous innovation. On the one hand, the WEMSS, through technological innovation, carries out independent research and development and localization and assembly work while introducing a large number of new technologies and new equipment. On the other hand, through institutional and management innovation, the system is built to form a ship's equipment maintenance support capability, focusing on system reshaping, structural optimization, resource integration, and mode transformation, and perfecting and adapting to the modern naval missions. The organization's institutional innovation capability and technological innovation capability directly determine the degree of organization's adaptability in the environment.

4.1.4. Equipment R&D (research and design) participation
Under the changes of the war environment and the technical environment, the upgrading of ship equipment is getting faster and faster, and the maintainability and supportability design of warship equipment has gradually become an important issue in equipment construction. The equipment R&D participation of the ship equipment maintenance support system affects the adaptation speed of the system to the environment, thus affecting the completion rate of maintenance tasks. If the maintenance workers can be deeply involved in the acquisition of new equipment as early as possible, the life cycle cost of the equipment will be further reduced, and the matching of the WEMSS with the development of the ship equipment will be greatly improved, that is what we called the equipment's "eugenics and superior education".

4.2. External motivation for the evolution of Warship Equipment Maintenance and Support system
The evolution process of WEMSS not only needs to obtain relevant information such as maintenance demand, competition status, technical dynamics and economic factors from the external environment, but also needs to achieve its strategic objectives by means of the external environment.

4.2.1. Military demand
Military demand is the most critical and core driving factor in the evolutionary dynamics. The most direct manifestation of the military demand factor for the evolution of the WEMSS is the military mission demand. The increasingly diversified military tasks exert influence on the planning and deployment of the human, financial and material resources of the system, as well as on the technical and institutional mechanisms, and promote the process of the WEMSS to motorization and integration; Secondly, the demand for military equipment, the new high-tech integrated warship equipment puts forward higher requirements for WEMSS; Last but not least, it proposes direct construction requirements to the development of the system, such as the preparation system.

4.2.2. Military economic level
The military economic level is the material basis for the system to form a support capability. The high cost and high-tech features of the warship's equipment system have brought about a jump in maintenance support costs and increased cost dependence. In 2005, the US military spent $81 billion to support a $300 billion weapon system. The size of the country's investment in the WEMSS directly affects the development speed, scale, quality and capacity of the system. If the military economy is not well, maintenance activities will be difficult to carry out and will directly lead to a decline in combat effectiveness. For example, Russia was forced to sell the aircraft carrier, because it was difficult to support the maintenance of the aircraft carrier.

4.2.3. Technical incentives
The development of science and technology has directly brought about changes in the theory and methods of the WEMSS. With the improvement of ship equipment and the change of combat methods,
the methods of maintenance are constantly changing and developing. Since the mid-to-late twentieth century, the development and extensive application of RMS engineering, intelligent diagnosis and comprehensive support engineering technology have ensured that in many cases, the maintenance of ships and equipment is no longer required. Maintenance methods such as improved maintenance, preventive maintenance came into being. In addition, the development of technology has brought about a change in the ideas. For example, the development of system science has made the guiding ideology of the WEMSS shift from focusing on scale to focusing on quality and focusing on overall efficiency. The development of remote sensing and radio frequency technology and information systems has brought a technical foundation for the generation of precise guarantee ideas.

4.2.4. Natural environment

The sea is the main activity area for warship equipment. The special hydrological, meteorological conditions and marine geographical environment not only affect the technical and tactical performance of ship equipment, but also affect the development of ship equipment maintenance support activities to varying degrees. The transformation of China's naval development strategy from near-shore defense to "offshore defense" has directly led to the increase of the mission intensity and frequency of the navy. The operation time of the warship equipment in the "blue water" field has been greatly lengthened. The humid, high-salt and climatic environment of the ocean has increased the natural wear and tear of ship equipment. The catastrophic climate such as typhoon will directly affect the safety of maintenance & support missions.

The personnel and technical level and technical incentives played a major role in the budding period of the WEMSS. Organizational factors and military economic level are important reasons for the transition from the germination period to the growth and development period. Technical incentives, innovation factors, and equipment R&D design engagement are key factors in making the system transition from a rapid development period to a leap forward. The influence of military demand and natural environment has been continuous throughout the system, but military demand as the most critical driving factor plays a leading role in the evolution of the whole system. From the history of China’s WEMSS, the authors found that the evolution of the system is the result of the internal and external factors of the system. The evolution trend chart of our warship equipment maintenance support system is shown in the following figure:

![Fig.3 Trend of the evolution of China’s Warship Equipment’s Maintenance and Support System](image-url)
5. Conclusion
This paper combines the development process of China’s WEMSS, and uses the dynamic capability theory to establish the basic model of the evolution of the system. It is believed that the evolution of the system is the result of the synergy between internal motivation and external incentives. The internal motivations are personnel and technical level, organizational factors, innovation factors and equipment R&D design participation. External incentives include military demand, military economic level, technical incentives and natural environment. However, this paper lacks the corresponding quantitative research foundation and the discussion of the deep interaction between the drivers. The next step is to quantitatively model and simulate the evolution of the system, and further explore the evolution of the WEMSS.

Acknowledgments
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References
[1] Zhang Xi, Research on Dynamic Adaptability Evolution Mechanism and Control of Enterprise Core Competence [D]. Sichuan: Sichuan University, 2006(in Chinese)
[2] Cao Yuzhen, Jiang Huiyuan. Research on the symbiotic evolution mechanism of logistics in the middle reaches of the Yangtze River [J]. Reform, 2015(10)(in Chinese).
[3] Wang Junwei, Wu Wei. Research on American Depot-Level Maintenance Core Ability[J]. Ordnance Industry Automation, 2010(29)(in Chinese).
[4] Tong Yuting, Evolution of Core competence of Logistics Enterprise Based on Service Innovation Dynamics Modeling and Simulation[D]. Jiangxi: Jiangxi University of Finance & Economics, 2017(in Chinese).
[5] Li Chaoming, Zhou Chunxiang, Study on Dynamic Evolution Process of Enterprises’ Core Capability[J]. Science and Technology Management Research, 2012(10)(in Chinese).