

Demonstration of Weapon System Requirements Based on System Engineering

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Abstract. Based on the thoughts and methods of system engineering, this paper explore a new model of weapon equipment system demand demonstration. A research framework for the demonstration of weapon equipment system requirements is proposed, including military background analysis, mission field requirements analysis, capability field requirements analysis, demand plan analysis, and system structure optimization design, and the specification process, theoretical principles, and technology of weapon equipment system requirements demonstration are clarified. The method and related system structure products clarify its practicability and effectiveness, and provide theoretical method support for the demonstration of weapon equipment system requirements and top-level design.

1 Introduction

With the development from "platform confrontation" to "system confrontation", the scale of weapon equipment systems is getting larger and larger, the connections between systems are becoming more and more complex, and the requirements for interconnection, intercommunication, and interoperability are getting higher and higher. In the equipment system, the lack of any one component system will cause a significant drop in the efficiency of the entire system, or even failure. Integrated joint operations require weapon equipment systems to complete flexible combat missions at different strategic and tactical levels, and must have flexible reorganization capabilities. In order to better carry out the construction of weapons and equipment systems and control development risks, it has become a consensus to strengthen top-level design. This requires the demonstration of major equipment to be carried out from a higher level, that is, from the system. As a result, the method of system engineering came into being, and has begun to be applied to the demonstration of weapons and equipment, and the method of demonstration technology has also been further developed [1]. At present, the system engineering method has become an important supporting technology for the development of weapon equipment system requirements demonstration in western developed countries, and the US military's "joint capability integration and development system, command, control, communications, computer, intelligence, surveillance and reconnaissance architecture framework. The U.S. Department of Defense's system structure framework, etc., has achieved a series of theoretical and practical results, and formed a relatively complete research framework, which represents the leading level of system engineering

research in the world. Other countries, such as the United Kingdom, Australia, and Norway, have also carried out relevant research on their own reality and formulated corresponding national standards. At home, research on the architecture, development process and evolution mechanism of weapon equipment systems started late, and some research institutions are tracking US military weapons and equipment. On the basis of system research results, some useful attempts and explorations have been made on issues such as weapon equipment system requirements demonstration, system structure analysis and design, and comprehensive evaluation, and preliminary results have been achieved [2]. However, the work done and the models developed are limited to certain For specific issues or partial links of the issue, there is no overall and holistic weapon and equipment system requirements demonstration research framework for guidance. This has a large gap in standardizing the weapon equipment system requirements demonstration and meeting the requirements of weapon equipment system construction. Therefore, learn from System engineering thoughts and methods, combined with weapon equipment requirements demonstration engineering practice, explore and study the research framework of weapon equipment system requirements demonstration suitable for national and military conditions, including military background analysis, mission field demand analysis, capability field demand analysis, demand plan analysis and System structure optimization design, clarify the specification process, theoretical principles, technical methods and related system structure products of weapon equipment system requirements demonstration, provide theoretical methods and technical support for weapon equipment system requirements demonstration and top-level design, which has important theoretical value and practical significance [3].

2 Weaponry system and system engineering

2.1 Weapon System

The word system is related to a specific research field, so there is no precise definition or description of the system yet. Summarizing the U.S. Department of Defense and other more authoritative definitions, combined with the characteristics of the military field, this article defines the weapon equipment system as "in an uncertain environment, in order to complete a specific mission or task, a large number of functions are mutually independent and operational. Multiple independent weapon equipment systems with strong interaction, under certain constraints, a higher-level system composed according to a certain mode or method, the lack of any one of the subsystems will cause serious degradation of the overall combat effectiveness or even fail." It can be seen that for a specific level of research object, the lowest level of the weapon equipment system should be the weapon equipment system, including the weapon equipment system that has been finalized, produced or installed, and the weapon equipment system to be developed. The higher level is based on The highest level of the types or categories of weapon equipment systems divided by certain rules is the functional level that corresponds to the level of the research object and has the closest connection to the combat mission.

2.2 System Engineering

In order to cope with a series of new problems in the planning, design, analysis, organization, and integration of the "system", such as interconnection, interoperability, interoperability, complexity, orientation emergence, development evolution, etc., researchers develop systems engineering The theoretical method puts forward the concept of system engineering. Compared with system engineering, system engineering pays more attention to the study of the system structure of complex large-scale systems, the coordination and interoperability of various components, the relationship with the environment, and the development and evolution of the system, as well as the improvement of the overall capacity of the system. Like the understanding and knowledge of the system, there are many differences in the concept of system engineering. It can be seen that system engineering is to design, develop and integrate complex large-scale systems to complete specific tasks and obtain desired results to achieve capabilities, missions or Theories, methods and techniques of expected results. Its core ideas include two aspects: capability-based system requirements development and architecture design methods. Capability-based system requirements development refers to: in order to achieve combat objectives and effects as much as possible, planning capabilities and various projects to achieve capabilities, and exploring optimal capabilities solutions and system development programs. Under the guidance of this demand development ideology, the focus of determining military needs has changed from focusing

on "who is the enemy and when and where the war will occur" to focusing on "how the war will be carried out". The shift from "threat-based" to "capability-based" is to proceed from the country's long-term interests and develop its weaponry system with the goal of safeguarding the national interests due to military strength. Therefore, the focus of the weapon equipment demand demonstration has shifted from the traditional single-platform and single-model demonstration to the system and system demonstration, to the improvement of the overall combat capability, and constantly looking for the defects of the entire system, and solving them through the development of equipment. Architecture method is a systematic research method that integrates the interaction between human behavior, system functions, technical specifications and expected capabilities. This method constructs models of requirements, system behavior patterns and related technical specifications and standards from different perspectives such as combat, system and technology, and supports the realization of the top-level design process of complex large systems by introducing computer modeling and simulation technology. It can be said that the architecture method provides a standardized research method for the top-level design of complex large systems, builds a bridge for communication between different fields and different personnel, and improves the predictability and manageability of system design; at the same time, it provides The technology and methods that can be quantitatively analyzed are used to verify and evaluate the scientificity and accuracy of the design, reduce design risks due to personal experience and capacity limitations, improve the quality of system design, and reduce system development costs [4]. At present, the Ministry of Defense architecture framework and NATO's architecture framework released by the United States, Britain and other countries are the latest research results that guide and standardize top-level design.

3 The research framework of the weapon equipment system demand demonstration

The research framework of weapon equipment system requirements demonstration is a specific description of the normative work process and related theories, technologies, and methods determined for the development of weapon equipment system requirements demonstration. The significance of constructing the research framework is to clarify the requirements demonstration process, main research content, theoretical principles, Technical methods and demand demonstration products facilitate the division and coordination of personnel in different fields in the demand demonstration process.

3.1 Analysis of Military Background

Military background analysis is the prerequisite and starting point for the demonstration of weapon equipment system requirements, including three parts: military situation analysis, concept development, and operational specification revision. The main task of military

background analysis is to clarify the status, role and positioning of the system, clarify the mission tasks that the system needs to undertake under the conditions of future integrated joint operations, analyze the requirements of future mission tasks for system capabilities, and identify the capability level of the existing system, build a conceptual system that meets mission tasks, revise existing operational specifications, and determine the mission, scope, goals, and scenarios of the system requirements project.

a) Analysis of the military situation. Military situation analysis is the peripheral analysis and research of weapon equipment system requirements, an important basis for correct understanding of military struggle tasks, policies, and strategies, and a prerequisite and constraint for subsequent combat mission analysis and capability demand analysis. The output of military situation analysis is a series of standardized documents, including: national security environment analysis document, military threat analysis document, battlefield environment analysis document, equipment development trend analysis document, weapon equipment system combat concept, capability concept, and description of typical combat scenarios Documents etc.

b) Concept development. According to the missions and tasks faced by the weaponry system, the imaginary opponent's weaponry and equipment construction, and the requirements of doctrines, concepts are developed on the basis of military situation analysis. There are three main types of concepts: combat concepts, equipment concepts, and user concepts. Apply the developed concept, and build a comprehensive conceptual system of weapon equipment system according to the application situation.

c) Amendments to operational specifications. Based on previous analysis, this stage will revise and adjust various related operational specifications, especially those of joint operations, to generate operational specifications systems that meet the new mission and capability requirements.

3.2 task area demand analysis

The mission area analysis is based on the in-depth analysis of the military threats facing, studying the characteristics and laws of future combat methods and combat system confrontations, and studying the combat force structure, deployment, operations, combat elements, processes, and command relationships in specific combat concepts And information flow, etc., dig out a general joint combat task list, clarify specific combat styles, specific combat phases (seasons), specific battlefield environment and specific requirements that specific undertakers need to meet for specific objectives. The main task of this stage is to dig out a common joint combat task list through comprehensive analysis of various typical combat styles in the future, and provide metrics for the ability to perform tasks, determine the organizational structure of the task combat unit and Information exchange relationship, etc., so as to clearly understand the combat mission field involved in the system.

a) Mission and task analysis. According to combat missions, various conceptual systems, as well as the scope

of capabilities and objectives of imaginary opponents, the mission-task-activity hierarchical analysis method and scenario-driven technology are used to analyze various typical combat styles at future time nodes to clarify the combat Rules, operational node connection relationships, organizational relationships, and information exchange requirements can dig out a list of common joint operations tasks and clarify specific requirements for completing operational tasks.

b) Analysis of combat activities. Using event-driven process analysis and IDEF0 modeling technology, the typical combat style at future time nodes Activity modeling, formulating combat action plans, describing the dynamic execution process of combat activities, establishing combat activity models, and analyzing the mapping relationship between combat activities and capabilities.

c) Information flow analysis. While analyzing combat missions and combat activities, analyze the information flow relationship between combat missions and combat activities, and use information modeling technology to describe the content and attributes of the information flow supporting key missions and activities, so as to gradually clarify the combat The information exchange relationship between nodes establishes an information exchange matrix.

3.3 Analysis of demand for competence areas

The ability domain requirement analysis is based on the analysis of the military background of the weapon equipment system and the analysis of the combat mission domain, extracting the needs to support the combat requirements. Abilities, decompose and describe in detail. The main task of this stage is to analyze the capabilities of the system, generate a capability catalog, analyze the gaps in system capabilities, determine the key performance parameters of the capabilities, and establish a priority list of capability requirements

a) Capability integration. According to the specific requirements of the comprehensive conceptual system and typical future combat styles, combined with the various factors involved in the development of the system such as personnel, training, organization, concepts, tasks, information, equipment, etc., the analysis method of activity-capability mapping and a comprehensive integrated system are adopted. Methods to generate a catalog of capabilities.

b) Ability assessment. According to the specific requirements of typical future combat styles, evaluate and confirm the ability of the existing equipment system to complete missions at future time nodes, describe the deficiencies or shortcomings of current capabilities to meet missions and tasks, and propose capabilities improvement solutions.

c) Ability gap analysis. On the basis of capability assessment and identification, further analyze the deficiencies and deficiencies of the capabilities, determine the ability gaps in the existing equipment system to complete future combat tasks based on the key performance parameters of the capabilities, sort the capabilities deficiencies and deficiencies, and prioritize

the establishment of capability requirements A list of levels and a clear timetable for eliminating inadequacy or defects.

3.4 demand plan analysis

The demand plan analysis is based on the scientific analysis of combat missions and capability requirements, and analyzes the non-equipment factors that affect the combat capabilities of the existing equipment system.

Analyze and evaluate the combat principles, organization, training, establishment system, leadership, education, personnel and facilities) and equipment factors, propose countermeasures or measures that should be taken to achieve combat capability requirements through equipment channels, and clarify the functions and main performance indicators of the equipment system And technical constraints, generate a set of equipment requirement plans, evaluate and optimize the best plan. The main task of this stage is to explore a reasonable construction plan for a weapon and equipment system that meets the requirements of the capability field, analyze and evaluate alternative plans, clarify the key projects and key system functions of the system construction, and confirm and recommend the best plan.

a) Analysis of non-equipment options. Analyze and judge whether it is possible to eliminate the capability gap or partially compensate for the lack of capability by changing non-equipment factors closely related to the combat capability of the equipment system, such as the operating principles, organization, training, establishment system, leadership, education, personnel, and facilities.

b) Analysis of equipment plan. On the basis of military background analysis, mission area analysis, capability area analysis, and non-equipment program analysis, equipment solutions are determined in the following order of priority: first, analyze the improvement of existing equipment or facilities; then consider introducing cross-departmental or foreign equipment And so on; the last is to start a new equipment demand project analysis. The equipment plan is a broad plan, which mainly involves four categories: system goals, system requirements, key equipment requirements, and equipment structure requirements. The equipment plan analysis should clarify the system's functions, main performance parameters and technical constraints, and the output is a set of equipment alternatives.

c) Evaluation of demand plan. According to the system's mission, scope, goals, scenarios, and capability field plans, to meet the system's combat capability requirements as the goal, the set of alternative equipment options is evaluated in terms of technological maturity, development necessity, time and economy, etc. Select and recommend the most satisfactory solution.

3.5 system structure optimization design

The main basis of the architecture design is the various requirements documents and analysis models completed in the system requirements analysis phase. Before

developing the architecture, the system structure

The architect must understand its intended use and purpose, collect relevant field information, and try to figure out some questions as much as possible, such as what questions are expected to be answered by the architecture, and stakeholders who are interested in developing the architecture Such as users, purchasers, designers, implementers and maintainers, etc.) as well as their concerns and perspectives, determine the scope and focus of the architecture design, and give a development plan for the architecture. The system structure optimization design includes three stages: system structure design, system structure verification and evaluation, and system structure optimization. Each stage has relatively independent goals, but the three stages have a strong logical relationship.[5]

a) Architecture design. According to the various requirements specification documents and requirements solutions obtained in the requirements analysis stage, the system architecture is established step by step from the four perspectives of combat requirements, capability planning, system construction, and technology development. The related view products are shown in Figure 1. Among them, the combat perspective describes combat nodes, organizational relationships, combat missions or combat activities, and the information that must be exchanged to complete combat missions; the capability perspective describes capability conception, capability classification, mapping between capabilities and combat activities, and the relationship between capabilities; The system perspective describes the system concept, functional structure, system development and evolution; the technical perspective describes the technical standards, key technologies and their development forecasts. It can be seen that these four types of views cover the demonstration domain, mission domain, capability domain, system domain, and technology domain of weapons and equipment. Standing on a global level, they discuss the necessity, feasibility, and system of weapon equipment development from different perspectives and dimensions. Construction concept and technical route.

b) System structure verification and evaluation. The task of architecture verification is to determine whether the architecture solution meets the system requirements and military requirements. Architecture evaluation includes the establishment of an evaluation index system and the selection of evaluation methods. The task is to provide a scientific basis for decision makers to choose the best option from a variety of candidate architecture options.

c) Optimized design of system structure. According to the recommendations of the system structure verification and evaluation, the system structure is improved and the optimal system structure scheme is recommended.

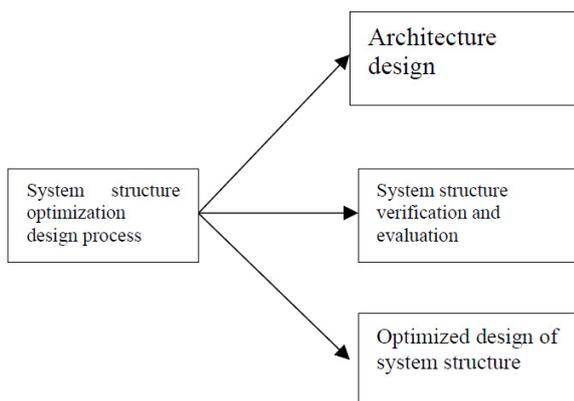


Figure 1. System structure optimization design process

4 Conclusion

The innovation and development of weapons and equipment demonstration methods have important research value and practical significance for the development of weapon equipment system construction and development risk control. Based on the basic theories and methods of system engineering, combined with the practice of weapon equipment demonstration engineering, this paper proposes a research framework for weapon equipment system and system requirements demonstration, establishes a process model for weapon equipment system requirements demonstration, and gives related system structures. The products have enriched and developed the theory and technical method system of weapon equipment demonstration. Based on this research framework, a multi-perspective and multi-resolution requirements demonstration model for the weapon equipment system can be established to standardize the requirements demonstration process and content expression, facilitate the division and communication of personnel in different fields, and help the weapon equipment demonstration personnel to clearly grasp the mission of the weapon equipment system Mission requirements, capability requirements, system requirements, and key technologies involved in the system and their development trends, so as to effectively enhance the systematic, scientific, and forward-looking nature of the weapon equipment system requirements demonstration.

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