

Research on exploratory evaluation method of combat capability of weapons SoS

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Abstract: Joint operations under the condition of information make the protagonist position of the system confrontation in the future battlefield more and more prominent. Based on a brief introduction to the evaluation methods of common combat capability, this paper mainly focuses on the evaluation process of combat capability exploratory method of equipment system and the working ideas of each phase, designs the evaluation process framework of exploratory method, and provides the simulation modeling ideas for battle-level weaponry system. From a practical point of view, it provides an effective methodological process for exploratory capability evaluation, which provides a reference for researchers engaged in the evaluation of the combat capability of weapon equipment systems.

1. Introduction

In the new situation of the reform of the strong army, our army formed a new joint combat command system of the Military Commission - the war zone - troops. The new system is a new command mode of joint combat under the conditions of informationization. The traditional evaluating method of the weaponry systems combat capability usually uses the optimization model to find the only optimal solution, and then uses the sensitivity analysis method to investigate the sensitivity of the optimal solution to small changes in parameters in order to understand the potential impact of uncertainty^[1]. Though the best solution of system capability evaluation can be obtained, it can not provide us with many alternatives. The exploratory evaluation method can make up for the shortcomings of traditional evaluation methods. Through repeated exploration of the uncertain factors of the equipment system, it obtains the equipment system scheme under the combination of various level influence factors.

2. Combat capability evaluation of the weapons system of systems(SoS)

2.1 Weapons system of systems(SoS)

Weaponry is the general term for weapons, weapons systems, electronic information systems and technical equipment, equipment, etc. used in combat, support and other military operations. It mainly refers to the warships, aircraft, missiles, radar, tanks, artillery, vehicles and engineering machinery in the preparation of the armed forces^[2]. Weapons system of systems(SoS) is a higher-level system composed of a variety of weapon equipment systems, and their systems are functionally interrelated and interacting, which is better than the simple superposition of system efficiency in performance.

2.2 Combat capability

Combat capability, namely fighting force, is the ability of the armed forces to carry out combat



missions. It is composed of basic elements, such as man, weapon equipment, and the combination of man and weapon equipment^[2]. It is generally believed that the combat capability of weapons SoS refers to the strength of the weapons SoS in the execution of a certain combat mission under a specific environment. It is a relatively static concept.

2.3 Combat capability evaluation

Combat capability evaluation refers to the comprehensive evaluation of all components of the combat capability^[3]. It is also for understanding the combat effectiveness of the army, recognizing the weaknesses in the short board, ensuring the right remedy, improving the combat capability scientifically to evaluate and estimate the daily combat readiness level and the comprehensive combat level of the army.

3. Common methods of evaluating combat capability

After many years of extensive research, experts and scholars at home and abroad have achieved some achievements in the evaluation of the combat capability of the weapons SoS. At present, the more common methods include qualitative evaluation method, analytical evaluation method, index evaluation method, statistical evaluation method and the evaluation method of index system.

3.1 Qualitative evaluation method

The qualitative evaluation method is , based on the relevant characteristics of the weapons SoS and its combat application by the assessors, using their own qualitative experience directly to determine the combat capability of the weapons SoS. It mainly includes expert judgment method, Delphi method, fuzzy comprehensive evaluation method, grey evaluation method, set pair analysis method, etc.

3.2 Analytical evaluation method

The analytic evaluation method divides the whole combat capability into all kinds of basic indicators from top to bottom, and then calculates them one by one through analytical expressions, and ultimately obtains the evaluation value of system combat capability^[4]. Mainly random fighting theory and Lanchester equation method as the representative.

3.3 Index evaluation method

The index evaluation method divides weapon equipment system into various equipment modules, and builds the parameter formula by using the performance parameters of each equipment module to evaluate the capability, and ultimately obtains the evaluation value of the combat capability of the performance system. It mainly includes the comprehensive index method, the weighted index method and the power exponent method.

3.4 Statistical evaluation method

The statistical assessment method takes the data and material obtained in the course of war history exercises, military exercises and equipment tests as the reference, and uses mathematical statistics to analyze and process the data to obtain the evaluation reference results. It mainly includes the experimental statistics method, the exercise data statistics method and the war history data statistics method and so on. The specific statistical methods mainly include sampling survey, parameter estimation, regression analysis, hypothesis testing and related analysis.

3.5 The evaluation method of index system

The evaluation method of index system adopts the way of establishing index system to decompose the operational capability of the whole system step by step into the sub-capability indicators of each sub-system, equipment unit and so on. Then, the capacity indicators that can be independently quantified and collected are taken as the basic indicators. Finally, determining the evaluation value of the system's combat capability by using the weighted comprehensive method. Its essence is

dimensionality reduction of multidimensional index space.

4. Research on Evaluation Method of Combat Capability Based on Exploratory Method

The exploratory method is to fully consider the influence of various uncertainties of the system on the model calculation under the condition of having a macroscopic and overall understanding of the weapon equipment system and to study and analyze the different quantitative results in various factors, so as to complete the influence of various uncertain factors on the combat capability of the studied system, and provide quantitative basis for the formulation and revision of strategic decisions. It focuses on the use of mathematical models and system analysis experience. By interacting with a large number of input variables, we can effectively obtain feasible solutions, optimal solutions and approximate optimal solutions for complex problems of users, which is an effective way to solve complex military problems^[5]. The main limitations of the method are as follows: researchers are required to have a deep understanding of system macroscopies, the difficulty of simulation modeling is relatively large, and the complexity of the model increases rapidly with the growth of uncertain variables, the requirement of huge computing resources, the ability to analyze and process mass data, and be dependent on the experts.

4.1 Evaluation process

The exploratory evaluation of the weapons SoS combat capability is in a certain military background and mission, With a small amount of uncertainties that have an important influence on the system, the exploratory evaluation of the equipment system simulation model has been conducted many times to obtain the system capacity results under various scenarios. And then through the comprehensive evaluation and analysis finally realize the optimization of equipment structure and the improvement of combat strategy. Figure 1 gives an evaluation process for the weapons SoS combat capability based on exploratory method.

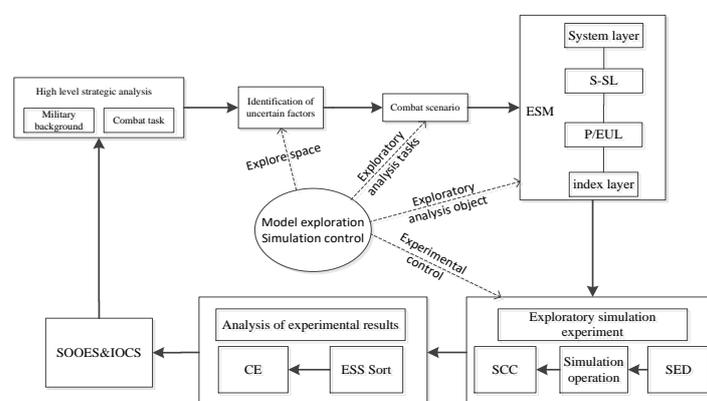


Figure 1. Evaluation process of the weapons SoS combat capability based on exploratory method. ESM, Equipment system modeling; S-SL, Sub-System layer; P/EUL, Platform / Equipment unit layer; SED, Simulation experiment design; SCC, System combat capability; ESS, Equipment system scheme; CE, Comprehensive evaluation; SOOES&IOCS, Structural optimization of equipment system and Improvement of combat strategy.

4.2 High level strategic analysis

Combat capability is a complex system that is affected by multiple factors in a certain military background and combat tasks. In the new era, joint combat is a confrontation between system and system^[6]. Aiming at the strategic and systematic analysis of the weapons SoS for a specific military background and operational tasks, it is necessary to make a general understanding of the weapons SoS and its combat style, and to identify the decision-making goals explored by exploratory methods and obtain as much information as possible about the weapon system and experimental context in

exploratory methods.

4.3 Identification of uncertain factors

Considering the influence of uncertain factors such as the main equipment performance parameters, natural environment, system synergy and operational strategy, we find out the uncertain factors that influence the target result, and consider it as the uncertainty space of the experiment. On the premise of other known factors, the range of the value of each uncertain factor is analyzed, and the scheme space formed by a combination of various values is formed.

4.4 Combat scenario space

In the process of establishing and setting the combat scenario, we should first conduct a threat analysis, mainly analyzing the background, environment, tasks and targets of the combat, focusing on analyzing the scale and structure of the armed forces, the configuration of the weapon equipment, the main combat styles, the combat intention, the battle record, key operational areas as the basis for the development of the scenario. The scenario can be classified by the different stages of the mission, and then refined by the different combat stages, so as to determine the combat plans, input forces and weapons equipment adopted by the participating parties in various stages.

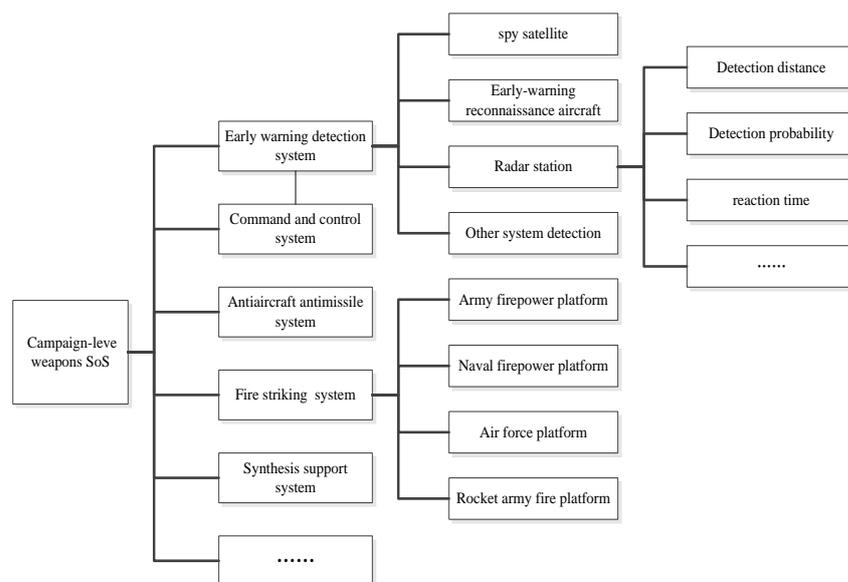


Figure 2. Campaign level equipment system model.

4.5 Modeling of equipment system

Under the specific operational background and operational task conditions, the design of the equipment system scheme is carried out according to the combat scenario. The weapons SoS is mainly composed of several weapon equipment systems which are composed of several weapon platforms or equipment units. The combat capability representation of the equipment under the minimum granularity of the system is

directly reflected in the evaluation index. According to the sequence division of the resolution from high to low, the equipment system model is divided into system layer - sub-system layer - platform / equipment unit layer - index layer, as shown in Figure 2, It should be stressed that the equipment system model established here is not a simple hierarchical overlay but a comprehensive consideration of the characteristics of systems confrontation, and a comprehensive and detailed description of the complex interactions between layers and the same layer such as command and control, reporting, pass through, combat coordination, information support, material support^[9] and other relations to fully

reflect the actual conditions of the system confronting needs.

4.6 Exploratory simulation experiment

According to the simulation model of the weapons SoS, the simulation experiment design is carried out. Aiming at the uncertain factors that are sensitive to the target problem, we do some exploratory research. We get the systematic result of the combination of various uncertain factors in the scheme space, that is, the influence of uncertain factors on the combat capability of the system^[8]. In the literature [1], based on some kind of scenario, around the influencing factors, missiles' hitting probability and fire range are determined as the exploration space and the simulation experiment is carried out. By adjusting the fire range and hit probability under different numerical values, we can get a certain amount of experimental results on missile launch quantity, hit quantity, miss quantity and interception probability.

4.7 Analysis of results

The information is excavated from the experimental results. By understanding the effect information of combat effectiveness of the equipment system under different levels of influence factors, We can systematically infer the optimal combat capability performance of the equipment system under a specific combat background. Thus, it can play an important role in optimizing the formation of the operations and giving full play to the effectiveness of the equipment system.

4.8 Structural optimization of equipment system and improvement of combat strategy

According to the results of exploratory research, we put forward proposals for optimizing the structure of weapon system, or giving operational strategies that enable system capability to meet the requirements of operational tasks, so as to provide assistance for high-level decision-making. Of course, an exploratory approach to other uncertain factors can be continued on this basis.

5. Conclusion and Prospect

In the selection of combat capability evaluation methods, we should make rational choices based on the purpose of the evaluation and the characteristics of the evaluation system. The application of exploratory method to the evaluation of combat capability of equipment system is under the conditions of informatized war system confrontation needs based on complex system theory and system engineering, and the top decision-making support for the global forecast of complex battlefield in the future. Based on the brief introduction of the common evaluation methods of the weapons SoS combat capability, this paper focuses on the evaluation process of the exploratory method and the theoretical thinking of each stage, and provides a set of effective methodological process for exploring capability evaluation from a practical point of view. The next step is to combine the simulation requirements of equipment system in complex battlefield environment, and study the main influencing factors, the granularity of equipment simulation and the refined algorithm of simulation experiment.

References

- [1] Cao Zhimin, Zeng Qing, Han Yu. An exploratory analysis method of air defense capability of aircraft carrier formation based on simulation [J]. command and control and simulation, 2015,37 (03): 13-19.
- [2] Military terminology management committee, Academy of military science. Chinese people's Liberation Army military [M]. Beijing: Military Science Press.2011.
- [3] Li Chuanfang, Xu Ruiming, Mai Qunwei. Operational capability analysis method research [J]. system engineering, 2009,23 (03): 72-77.
- [4] Lu Gao,Hongmin Yu,Hongfeng Wang.Evaluation System and Concept Model of Military Equipment HRM Based on DBCMS[A].//Proceedings of 2008 IEEE International Symposium on Knowledge Acquisition and Modeling Workshop[C].2008:4.
- [5] Yan Zongrui, Wu Yinhua, Chen Yong, Dong Jianshu.Research on Exploratory Simulation

- Experiment of Equipment Operational Requirements [J]. *Journal of System Simulation*, 2015,27 (08): 1888-1894.
- [6] HU Xiaofeng, YANG Jingyu, WU Lin, SI Guangya. Demonstration of Capability Needs and Exploratory Simulation Analysis of Weapon System [J]. *Journal of System Simulation*, 2008 (12): 3065-3068.
- [7] Honabarger J B. Modeling Network Centric Warfare(NCW) with the SEAS[D]. Air Force Institute of Technology, 2006.
- [8] Wei Jicai, Zhang Jing, Yang Feng, Mao Zhaoshun. Research on Combat Capability Evaluation of Weaponry System Based on Simulation [J]. *Journal of System Simulation*, 2007 (21): 5093-5097.
- [9] Li ZhiFei. Multi-dimensional and multi-granularity exploration method and application of competency-based weapon equipment system trade-off space [D]. National University of Defense Technology, 2015.