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Research on the Complexity of Weapon and Equipment Operational Test

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Abstract. The operational test of weapon and equipment involves many factors and has complex interrelationships, so it can be regarded as a complex system and be studied by complexity theory and method. First of all, the complexity of operational test is analyzed on the basis of the concept of operational test. Then, the hall for workshop of meta-synthetic engineering, the theory of military complex adaptive system and the Agent modeling and simulation technology are discussed, and the corresponding operational test research methods and steps of weapon and equipment are proposed. The operational test of weapon and equipment is of great significance and develops rapidly. The above method and technology can provide feasible theoretical methods and technical means for solving the complex problems in the process of operational test, which have important theoretical and application values.

Introduction

With the acceleration of the new military reform, the development of new weapon and equipment of the world's military powers has shown the characteristics of systematization, informatization and intelligence. These changes put forward new requirements for the operational test of weapon and equipment. The single-item test of equipment based on standard method can no longer meet the demand of modern weapon and equipment test, so more factors must be considered and more complex test environment must be set up. In the 1980s, the USA army put forward the idea of equipment operational test, and after years of practice, it has formed a test system including test system, regulations, standards, contents and methods [1]. Although the research on Chinese army's equipment operational test started late, it has also achieved fruitful results [2][3].

Weapon and equipment operational test is a large-scale, comprehensive and very strong test activity, involving many factors, can be regarded as a complex military system, can also be called weapon and equipment operational test system. The comprehensive integration research method combining qualitative and quantitative analysis, the theory of military complex adaptive system, and Agent modeling and simulation technology have become an important means to solve complex problems and can be applied to combat experimental research. Therefore, this paper analyzes how to use these three methods to study test, so as to provide a new idea for solving various complex problems in the process of operational test.

Definition and Process of Weapon and Equipment Operational Test

Definition of Operational Test

Operational test refers to the weapon and equipment in the process of the whole life cycle, in order to determine the suitability and effectiveness of weapon system, by the operational test institutions based on task requires training and weapon system, construct, realistic test environment similar to the field, by means of a variety of testing methods, field test and evaluation of weapon equipment integrated process.

The operational test of weapon and equipment has the following characteristics: Firstly, in the time period, the operational test runs through the whole life cycle of weapon and equipment, including the model demonstration stage, scheme design stage, prototype development stage, finalizing stage and service support stage; Secondly, the operational test is to determine the combat suitability and combat effectiveness of weapon and equipment, so as to provide a basis for improving the overall

effectiveness of equipment and finding or improving the design defects of equipment. Thirdly, in terms of test environment, operational test requires realistic test environment, including natural conditions, battlefield interference and enemy threaten.

Operational Test Process

The implementation process of weapon and equipment operational test mainly includes four stages, including test demand analysis, test plan formulation, test organization and implementation, and test result evaluation. It can be seen that the whole operational test focuses on the generation of combat capability of weapon and equipment, and improving the overall effectiveness of equipment is the starting point and landing point of operational test. In addition, the work of each stage in the test process is not one-way, but a cyclic process of multiple iterations and optimization. Problems found in the application process that the plan is not reasonable or cannot be realized must be returned to the previous stage, or even the previous stage for adjustment and modification. The whole operational test process is continuously advanced in the dynamic feedback.

The Complexity of Operational Test System

According to the concept of system science, operational test can be regarded as a system, that is, operational test system. The so-called operational test system is an organic whole composed of material resources, human resources, information resources, management means and other software and hardware elements required by the test, with the function of test identification. It is composed of experimenter, experimental object and experimental means. Operational test is a dynamic process full of uncertainty, involving many factors and influencing relations between factors are complex. It is a typical complex system with complex characteristics such as hierarchy, uncertainty and adaptability.

The Hierarchy

The operational test system includes the test equipment system, test command system, test overall analysis system, measurement and control system, communication system and other subsystems. There are many system elements, each of which is a system itself and can be further subdivided. The combined action of the above elements constitutes a multilevel operational test system. The complex relationship of comprehensive interlacing of the test system is formed by the longitudinal dependency and the lateral interaction and mutual restriction among the various levels of the system. It is the multi-level structure complexity of the system that brings great difficulty to the operation and management of the operational test system.

The Uncertainty

The operational test requires that the test environment should be fully close to the expected operational environment, including natural environment, battlefield interference, enemy threaten and other artificial environment, which determines the uncertainty of the operational test process. It’s obvious that the uncertainty of the test natural environment increases the uncertainty of the operational test process. What is more important is that the uncertainty of the enemy's tactical tactics further increases the uncertainty of the operational test process. Ignoring the uncertainty of test environment and test conditions, it is difficult to achieve the target of operational test. Ignoring the uncertainty of tactical tactics, operational test results may be meaningless; Ignoring the uncertainty of training and operational mission profile, the test flow according to the plan is often impracticable [4].

The Adaptability

The adaptability of the operational test system is mainly reflected in three aspects: Firstly, with the continuous development of high and new technology, the operational test system must adapt to the development of weapon and equipment and meet the test requirements of new weapon and equipment; Secondly, the natural environment is the objective condition of the operational test system. Thirdly, in the test process, the feedback and adjustment and optimization of the latter stage to the former

stage also reflect the adaptability of the operational test system. Therefore, the operational test system must constantly adjust the internal structure and behavior of the system according to different test task requirements and natural environmental conditions, so as to give full play to the function of the operational test system.

Operational Test Research Based on the Complexity Theory

The complexity of the test system means that the traditional thought of qualitative description and empirical assumptions may not be able to fully meet the needs of modern weapon equipment operational trials, complexity theory and a variety of methods based on the theory, technology and the model could reflect advantages, so that can be used to test system of operations research. Among them, the hall for workshop of meta-synthetic engineering, military complex adaptive system theory, Agent modeling and simulation technology are feasible.

The Hall for Workshop of Meta-synthetic Engineering

Focusing on the requirements of the operational test system of weapon and equipment, this paper adopts the collaborative working mode of expert system, knowledge system and machine system, synthesizes various factors and methods in the operational test, discusses various problems in the operational test stage comprehensively and forms solutions. The hall for workshop of meta-synthetic engineering mainly includes:

Expert system -- composed of experts in relevant aspects of operational test, including weapon and equipment development experts, operational test experts, etc., these experts represent the three important units involved in operational test.

Knowledge system -- it is mainly composed of the experience knowledge, perceptual knowledge, relevant application technology, technical science, basic science and system engineering thought and wisdom of the relevant personnel involved in the combat experiment.

Machine system -- can make full use of expert experience knowledge, knowledge base of various resources, to achieve data mining, decision-making, simulation, comprehensive evaluation and online discussion and other functions, to provide application platform and decision support for expert discussion.

Military Complex Adaptive System Theory

Military complex adaptive system theory [5] is based on the complex adaptive system theory and guidance, with modern high technology military operations as the background, from the point of view of complex adaptive system investigation of modern military system composition, structure and dynamic behavior. And which uses various methods to study of various factors on complexity theory behavior process and the effects of the military system, understands the general characteristics of the modern military system behavior, the nature and law of conditions suitable for modern military struggle of military system management, planning, and the command decision-making method.

According to Dr. Ilachinski's formulation [6], the application of the military complex adaptive system theory in the operational test research of weapon and equipment can be divided into eight levels:

(1) To re-understand the basic nature and behavior characteristics of the operational test system, that is, the basic nature and behavior characteristics of the operational test system, such as hierarchy, integrity and unpredictability.

(2) To revise the principles for developing operational tests of weapon and equipment, and shift from the past practice of seeking the best solution for specific threats, environments and operational scenarios to the practice of taking robustness, flexibility and adaptability as the criteria for evaluating the merits and disadvantages of a plan.

(3) To improve the operational test model and method of traditional weapon and equipment, some complexity research methods and tools can be applied to the traditional military system model, in order to obtain new results.

(4) To strengthen the research on the complexity of weapon and equipment operational test system,

so as to study the general rules of system behavior, the effectiveness of weapon and equipment operational test, and the effect of planning schemes.

(5) To improve the technical level of some operational tests, such as developing various unmanned systems to undertake high-danger tasks on the basis of agent-based military system models and simulation experiments.

(6) To assist in operational decision-making, such as applying genetic algorithm to design and optimize operational test schemes.

(7) To improve the operational test environment of synthetic weapon and equipment. Under the guidance of complex adaptive system theory, a high-level system model is established for combat training and experimental research.

(8) To carry on the fundamental innovation of the concept of operational test, so as to promote the in-depth development of operational test of weapon and equipment.

Agent Modeling and Simulation

SWARM, a software tool to simulate the actual performance of complex systems, was developed by the Santa Fe institute [7]. It is based on the theory that adaptive micro-individuals are designed to interact with each other according to a few rules, so that unpredictable macroscopic overall characteristics can emerge through self-organization in the process of evolution. In this way, the local rules are expressed by the computer, and the system model based on the computer is established, so that the simulation experiment can be carried out on the computer to observe how the overall characteristics emerge. This modeling and simulation technology can be applied to the operational test research of weapon and equipment.

Step 1: to create an operational test system environment for weapon and equipment. It includes time and space setting, management mechanism, operation method, etc. The operational test Agent is distributed in the environment in a certain way and can be active in it.

Step 2: to create the Agent. It includes agents of various types of weapons, agents of combat trainers, agents of test environment, etc., which conduct interactive activities such as detection, observation, communication, strike and defense with other agents in the operational test system environment.

Step 3: to run the simulation system. Various agents are moved in the operational test simulation environment according to the set method, and interactive results are obtained according to the interactive process and evaluation mechanism.

Step 4: to carry on large sample test. According to the results of the third step, modify the Agent and environmental parameters of the operational test, and observe the corresponding operational test results. If necessary, change the relevant Settings and go back to the third step.

Step 5: to collect data. The running conditions of the whole process are recorded, including the time, place, form and result of various interactions between agents and between agents and the operational test environment.

Step 6, to analyze. The collected data will be processed and checked against the existing operational tests of weapon and equipment in the real world. After the discussion between technical personnel and test personnel, the Suggestions for improving operational tests and the methods for improving simulation tests will be obtained.

Summary

This paper analyzes the complexity of the operational test system of weapon and equipment, and considers that it is necessary to adopt targeted research methods. It mainly includes: Firstly, the hall for workshop of meta-synthetic engineering can realize seamless communication and resource sharing of experts in various fields, fully integrating expert knowledge with data of army combat use, military equipment, simulation and range test; Secondly, the military theory of complex adaptive system by investigating the weapon equipment operational test system of the composition, structure and dynamic behavior, study the influence of various factors on the behavior process and result, and then find the general characteristics, properties and laws, and explore scientific and effective system of weapon equipment operational test management, planning and command decision-making method;

Thirdly, Agent models, simulates, and designs micro individuals with adaptability. If they interact with each other according to a few rules, unpredictable macro overall characteristics can emerge through self-organization during the evolution process, so as to find the characteristic rules and implementation plans of weapon and equipment operational test. These three theoretical methods and technical means provide new ideas and new ways to solve the complex problems of weapon and equipment operational test, which have important theoretical and application value.

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