Research on integrated test and Evaluation of information system equipment

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Abstract—The integrated test of weapons and equipment is an urgent need for the development of weapons and equipment under the contemporary information conditions, because it can reduce the resource requirements, test cost and risk, as well as improve the test efficiency and the degree of confidence. This paper based on the objective requirements of integrated evaluation of information system equipment test, aims at performance test for information system equipment. For the same equipment testing, test means to analysis the factors that affect performance. The implementation is based on prior knowledge and expert experience response parameters, including regression model building, and the credibility of the weighted multi-source data fusion evaluation method research. It provides technical and theoretical support for the integrated test evaluation of information system equipment multi-source test.

1. Introduction

Integrated Test and Evaluation (IT&E) was first proposed by the Arnold Engineering Development Center (AEDC) of the United States Air Force. The purpose is to adapt to the requirements of equipment development, improve the efficiency of test and evaluation, and better develop the potential of test resources. Its core is the seamless combination of r&d test and combat test identification, as well as the combination of real test and modeling and simulation. Through one test, the requirements of r&d test and combat test can be met as much as possible[1].

The integrated test of information system and equipment is an important direction of the transformation of traditional weapons and equipment test work under the background of contemporary new military revolution, is also an urgent need for the development of weapons and equipment under the contemporary information conditions, because it can reduce the resource requirements, test cost and risk, as well as improve the test efficiency and the degree of confidence. It plays a very important role in ensuring the actual combat effectiveness of newly developed weapons and equipment and avoiding the risk of weapons and equipment development. It has become an important trend in the field of weapons and equipment test and evaluation[2].
2. Overview of equipment integration test evaluation

2.1. The concept of integrated testing and identification of equipment

In the 1990s, the U.S. Military put forward and vigorously promoted the integrated test and evaluation method for equipment, which clearly required a reasonable allocation of test items and test resources, and carried out integrated test and evaluation for information warfare equipment. In the book "Weapons and Equipment Test Theory and Test Methods", the integrated test identification is defined as: Developed a unit (industrial department/plant) is responsible for the scientific research and test, the country's range is responsible for the type test, using the forces responsible for the use of the test, and combine the training exercises, comprehensive coordination of field test and analysis, mathematical modeling and analysis, the simulation experiment and analysis, and other analysis methods. Modeling and simulation are used as the knowledge base of test and evaluation, as well as the communication and feedback tools between each test process, so that the structure simulation, virtual simulation and actual test are organically combined to carry out the test and evaluation method[3]. This definition is basically the same as that of the United States Army on integration test identification.

2.2. Technical connotation of equipment integration test and appraisal

The integrated test can improve the traditional test identification, which is independent of each other, the information sharing is insufficient, the limited test resources are difficult to make full use of, and the test identification has the problems of disconnection and repeated tests to a certain extent. The new Regulations on Equipment Test and Appraisal of the PLA defines the concept of integrated test and appraisal of equipment test and appraisal, which consists of three loops: "performance test -- status appraisal", "operational test in line and set", and "in-service assessment -- improvement and upgrade". The integration is mainly embodied in the following four aspects[4]:

One is the integration of test types: the emphasis is on the integration of performance test, combat test and in-service assessment, which is the most core basic content of integration test.

The second is the integration of test stage: the previous test and identification in the finalization stage will be extended to the life cycle of the entire weapon system, and the integrated test design will be carried out from the equipment demonstration stage. The integration of demonstration test, development test, finalization test and combat test will be considered, and a reasonable integration test plan will be formulated.

The third is the integration of test means: this is the key content of the implementation of integrated test, emphasizing the combined use of a variety of test means, focusing on the application of modeling and simulation in weapon equipment test and identification. The test means include ground test, flight test and simulation test. The significance of integration lies in the comprehensive utilization of various test methods to obtain as much reasonable and reliable test data as possible with less test consumption.

The fourth is the integration test between each unit of the weapon system: stress on the test of the basic performance, boundary performance and combat effectiveness of the entire weapon system under realistic combat conditions.

3. Equipment integration test and evaluation framework

One of the important ideas of integrated test and evaluation is to start the unified planning from the early stage of equipment development, properly integrate equipment performance test and combat test, and share test data, so as to save test cost. Integration test to evaluate fully using the modeling and simulation, the small sample test evaluation, multi-source information fusion, heterogeneous population parameter evaluation, performance evaluation and other techniques and methods, make full use of each stage, various testing information of class, build integrated test evaluation system, performance and operational use of weapons and equipment tactical and technical performance of comprehensive evaluation[5].

According to the objective requirements of integrated evaluation of information system equipment test, for the performance test of information system equipment, the factors affecting the performance
of the same equipment are analyzed for multiple test stages and multiple test methods. Based on the analysis of experimental variables and combined with various historical data, the integrated response function model was established by using parametric modeling and non-parametric modeling. Combined with the test data, the multi-source integration test evaluation was carried out. The general idea of integrated multi-source test evaluation for information system equipment is shown in Fig.1.

![Fig.1 Equipment integration test design and evaluation framework](image)

It mainly includes the following details:

1. Determine the performance index of the whole performance test and its related influencing factors;
2. Based on the physical mechanism, expert experience and prior knowledge, the functional form between each performance index and the corresponding influencing factors was determined, namely, the regression model of sub-response parameters was constructed;
3. Based on the current data and prior knowledge, the integrated response model of each performance index is constructed;
4. Combined with the Bayes method based multi-source test integration evaluation technology, the evaluation results are obtained.

4. Equipment integration test and evaluation of key technologies

4.1. Integrated response model construction

The integrated test response model is the basis of the integrated test data analysis, and is the functional relationship between the evaluation index of information system equipment performance and the influencing factors. A sub-response parameter regression model based on prior knowledge and expert experience was constructed, and the integrated response model of equipment performance evaluation of information system was established by using the methods of variable screening and sparse component analysis in regression analysis.

Specifically include:

1. Establishment of performance index system
Indexes are classified according to performance, stratified, found out related influencing factors, and classified according to controllable, uncontrollable, quantitative and qualitative methods.

(2) Construction of regression model of sub-response parameters with prior knowledge and expert experience

For an index, if the function form of the relationship between it and influencing factors is known based on the accumulation of experience, only the parameters in the function need to be determined by new tests, and the response model can be constructed as a parameter regression model. Further, according to the improvement of the test information system equipment, the prior distribution of parameters is extracted from the historical data, and the value range of each influencing factor is determined.

(3) Construction of integrated response model

Combined with the coupling relationship between each response, the integrated response model of information system equipment performance evaluation was established by using the methods of variable screening and sparse component analysis in regression analysis. It is worth noting that the integrated response model should be continuously adjusted and improved in terms of model structure and variable selection according to the overall dynamic changes of the whole performance test.

4.2. Multi-source data fusion based on Bayes

The integration test should solve the problem of multi-source test information fusion and comprehensive evaluation[6]. The basic idea of multi-source data fusion of integrated experiment is to use appropriate methods to fuse the prior information of large sample and the confirmatory test information of small sample for comprehensive analysis and evaluation. The core theory is Bayes method[7].

Bayes fusion evaluation is mainly to make full use of all kinds of prior information, such as the available historical information, simulation information, expert information and other heterogeneous information before the test, while using the field information. However, the prior information obtained under different experimental conditions are often of different types and subject to different overall distribution, and can only be used after certain processing. Therefore, in the engineering application of Bayesian method, the following points need to be paid attention to:

- Compatibility test of prior information;
- Credibility measurement of prior information;
- Determination of the prior distribution;
- Prior probability calculation.

The basic process of multi-source information data fusion based on Bayes is shown in Fig.2.
5. Conclusion

According to the objective needs of integrated evaluation of information system equipment test, this paper aims at the integrated evaluation of information system equipment performance test with multi-test stages and multi-test means to carried out the equipment integration test evaluation method research. We introduce the concept and technical connotation of equipment integration test and appraisal, study the framework of information system equipment integration test evaluation, research the mathematical theory of integrated response model construction and the multi-source data fusion process and key technologies based on Bayes. It can provide theoretical and methodological reference for the design and evaluation of multi-source integrated experiment under different scenarios.

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