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Construction of intelligent weapon system effectiveness evaluation index system based on Delphi method

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Abstract: In view of the lack of efficiency evaluation index system of intelligent weapon system and insufficient quantification and refinement of technical indexes, the research on the index system will be carried out from the perspective of completing the task of intelligent weapon system, and the verification index system will be established to realize the evaluation of weapon system efficiency, clarify the use background of intelligent weapon system, and analyze the strength composition of intelligent weapon system, Finally, Delphi method is used to build the effectiveness evaluation index system of the intelligent weapon system, which can be used as a reference for the comprehensive evaluation of the capability of the weapon system.

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1. Introduction

With the rapid development of intelligent technology, its application field is more and more extensive. Under the condition of information technology, the comprehensive effectiveness of weapon system plays a key role in the victory and defeat of war, so more and more countries attach importance to it. It can be seen that the effectiveness evaluation of weapon system is an essential work in the process of equipment development. Only by establishing a reasonable and comprehensive evaluation index system, can we evaluate the effectiveness level of weapon system scientifically and test the level of equipment system construction. In this paper, the intelligent weapon system model of the research object is preset as a weapon system integrating reconnaissance, strike and evaluation, which can realize complex situation awareness, whole network communication transmission, intelligent online decision-making, cooperative strike coordination and other tasks. The evaluation of its overall effectiveness is an objective reflection of its ability. It can be considered that without the establishment of a scientific and reasonable index system, the evaluation of its effectiveness will be impossible.

The evaluation model is divided into evaluation index model and evaluation relationship model. In this study, we choose evaluation index model. In the early stage, a special research group was set up, which was composed of five members. Its main work was to collect relevant research data, consult literature, formulate consultation questionnaires, determine experts, issue collection questionnaires, discuss consultation results, make statistical analysis of data, and finally summarize opinions to form an indicator system.



2. consulting experts and methods

2.1. selection of consulting experts

According to the research needs, 15-20 experts from scientific research institutions, research institutes and the army engaged in relevant professional research work are selected as the consulting objects. Selection conditions: one is to engage in long-term research work in related fields, which mainly involves the research and demonstration of weapons and equipment and system effectiveness evaluation; the other is to work with a serious attitude and high enthusiasm, which plays an important role in the efficient completion of consulting work.

2.2. the design of the consultation

Questionnaire is based on consulting the relevant materials and the preliminary discussion of the members of the research group. The expert consultation questionnaire of intelligent weapon system effectiveness evaluation system is designed. Firstly, the background information of intelligent weapon system research is introduced. Based on the principles of systematization, hierarchy, conciseness and feasibility, the effectiveness evaluation index system of intelligent weapon system is divided into 4 first level indexes and 11 second level indexes. Using Likert's 5-level scoring method to score the evaluation index from two aspects, namely importance and feasibility. If the importance and feasibility are graded from high to low, for example, very important, very important, generally important, not very important and unimportant, 5 points, 4 points, 3 points, 2 points and 1 point shall be assigned respectively. Feasibility can also be divided into very feasible, feasible, generally feasible, infeasible and infeasible, and the assignment is the same. At the same time, it is necessary to investigate the authority of experts, mainly including the professional level and scoring basis. The judgment basis is divided into practical experience (0.5, 0.4, 0.3), theoretical knowledge (0.3, 0.2, 0.1), literature (0.1) and subjective judgment (0.1). The professional level is divided into very professional (1), professional (0.8), comparative professional (0.6), general (0.4), and little understanding (0.2). Experts can adjust the evaluation indexes and give reasons in the consultation process. After collecting the results of the first round of consultation, the members of the research team made changes to the index system and added the description of the situation, and promptly distributed the second round of consultation questionnaire to the experts ^[1].

2.3. the investigation method

The expert consultation form can be distributed and recycled by mail or face-to-face direct distribution ^[2]. The result of the consultation requires a reply within one week. The positive coefficient of experts is expressed by the recovery rate of the questionnaire. When the positive coefficient is greater than 70%, it indicates that the enthusiasm of experts is high and the survey results are available. The authority degree of experts is expressed by authority coefficient Cr. in Delphi method, when the authority coefficient Cr is greater than 0.7, it indicates that experts have high authority.

Index screening criteria: according to the results of the consultation questionnaire, through the data analysis of SPSS software, the evaluation indexes with the mean value of index calculation ≥ 3 and the coefficient of variation ≤ 0.25 are retained. The indexes with high mean value but large coefficient of variation can be discussed and exchanged. When the experts reach an agreement after two rounds of consultation, the consultation ends.

2.4. statistical analysis method

Excel was used to input the data of paper-based questionnaire, SPSS 25.0 was used to process and analyze the data, and the relative weight of each influencing factor was calculated. Mean, standard deviation, coefficient of variation and percentage were used to describe the data. The expert authority coefficient (Cr) is determined by the expert's judgment coefficient (Ca) of the index and the expert's familiarity with the evaluation content (Cs), $Cr = (Ca + Cs) / 2$ ^[3]; the coordination degree of the expert's opinion is expressed by the coordination coefficient (Kendall's τ) and the variation coefficient;

the degree in the expert's opinion set is expressed by the importance assignment ($\bar{x} \pm s$) and the full score rate. The weight of the first level index is calculated by the method of priority chart, and the weight of the second level index is calculated according to the judgment of experts on the importance of each index [4].

3. Results

3.1 basic information of the experts

15 experts are mainly from scientific research institutions, research institutes and the army familiar with the effectiveness evaluation of weapon system. As shown in Table 1, the average age of experts was (40.25 ± 10.12) years, and the average working time was (18.24 ± 9.01) years. There are five people with intermediate titles (33.3%), six people with deputy senior titles (40.0%), and four people with senior titles (26.7%). There are two undergraduates (13.3%), six Masters (40.0%), seven Doctors (46.7%).

Table 1. basic information of experts

Basic situation	Classification	Number	Constituent ratio/%
Age	<38	3	20.00
	38-45	7	46.67
	>45	5	33.33
Education	Undergraduate degree	2	13.33
	Graduate degree	4	26.67
	Doctoral degree	9	60.00
Title	Intermediate title	5	33.33
	Vice high title	6	40.00
	Senior title	4	26.67
Working life	<10	1	6.67
	10-20	9	60.00
	>20	5	33.33

3.2. the positive coefficient of experts and the positive coefficient of authoritative

Experts are reflected by the questionnaire recovery rate, which represents the importance of each expert to the questionnaire [5]. As shown in Table 2 and table 3, in the first round, 15 questionnaires were distributed and 14 were recovered, with a recovery rate of 93.3%. In the second round, 15 questionnaires were sent out and 15 were recovered, with a recovery rate of 100%. It shows that experts attach great importance to this investigation project and take a more serious attitude. Among the experts who took part in the questionnaire, 42.4% and 17.8% respectively put forward opinions and suggestions, and the authority coefficient of experts was 0.75.

Table 2. enthusiasm coefficient of experts

Consultation rounds	Number of questionnaires distributed	Number of questionnaires recovered	Rate of recovery
First rounds	15	14	93.3%
Second rounds	15	15	100%

Table 3. authority coefficient of experts

project	Coefficient of judgement (Ca)	Familiarity (Cs)	Authority coefficient (Cr)
First rounds	0.847	0.828	0.812
Second rounds	0.852	0.859	0.867

3.3 .Concentration and coordination of expert opinions

After two rounds of consultation, the degree of concentration and coordination of expert opinions has changed the importance and feasibility scores of some evaluation indicators. According to the data statistics, the importance and feasibility coordination coefficient of each evaluation index in the first round of consultation are 0.301 and 0.314, and the results after the second round of consultation are 0.327 and 0.347 respectively, as shown in Table 4.

Table 4. coordination degree of expert opinions

Project	Coordination coefficient	X2	Freedom	P
First rounds				
First level index	0.118	52.718	4	<0.001
Two level index	0.134	98.229	16	<0.001
Second rounds				
First level index	0.315	68.548	5	<0.001
Two level index	0.328	112.367	16	<0.001

3.4 .Index screening and its weight

After two rounds of expert consultation, the experts evaluate the importance and feasibility of the indicators. According to the criteria of indicator selection^[6], the first level indicators are adjusted from the original four to five, and the "supply guarantee" is added. Among the secondary indicators, from the original 11 items were adjusted to 17 items, and the secondary indicators were added to "supply guarantee": "emergency repair ability", "emergency financing ability", "guarantee effectiveness" and "vulnerable parts reserve". "Network communication ability" added two indicators: "network establishment time". "Air detection capability" added two indicators: "detection error". In "collaborative control ability", the "perception ability" is adjusted to "response time". Through adjustment, intelligent weapon system effectiveness evaluation index system is obtained, as shown in the figure, as shown in Table 5 and table 6.

Table 5. first level evaluation index system and its weight

First level index	Importance assignment ($\bar{x} \pm s$)	Coefficient of variation	Weight coefficient
Air detection capability	3.73±0.70	0.189	0.187
Networking communication capability	3.60±0.54	0.151	0.184
Collaborative control capability	4.00±0.66	0.164	0.205
Cooperative strike capability	4.27±0.59	0.139	0.223
Supply support capability	3.92±0.66	0.168	0.201

Table 6. secondary evaluation index system and its weight

Two level index	Importance assignment ($\bar{x} \pm s$)	Coefficient of variation	Weight coefficient
Tracking and positioning capability	4.20 ±0.56	0.133	0.064
Detection error capability	3.80 ±0.56	0.147	0.052
Probability of finding target	4.60 ±0.63	0.137	0.071
Network establishment time	4.33 ±0.62	0.143	0.043
Maximum data transfer rate	3.73 ±0.59	0.158	0.021

Transmission delay	4.33 ± 0.62	0.143	0.055
Dynamic planning time	3.87 ± 0.52	0.134	0.028
Response time	4.27 ± 0.59	0.138	0.037
Protective ability	4.33 ± 0.62	0.143	0.107
Environmental adaptability	4.13 ± 0.64	0.155	0.098
Damage probability	4.67 ± 0.49	0.105	0.056
Recognition probability	4.07 ± 0.59	0.145	0.075
Duration of attack	4.07 ± 0.70	0.172	0.092
Rush repair capability	4.07 ± 0.59	0.145	0.051
Emergency financing capacity	4.00 ± 0.65	0.162	0.045
Guarantee effectiveness	4.40 ± 0.63	0.143	0.062
Storage capacity of vulnerable parts	4.20 ± 0.77	0.183	0.043

4. Discussions

The index selection criteria of this study comprehensively consider the importance and feasibility of the index, with the purpose of selecting effective indexes that can take both into account [8]. For the first level indicators, five first level indicators and 17 second level indicators are obtained after modification according to the screening criteria. In the first round of consultation, the experts put forward that there is still a lack of comprehensive consideration indicators for weapon system evaluation, and relevant content of equipment support should be added. In recent years, the importance of equipment support has been valued by more and more countries and professionals, and put forward a variety of protection methods and support theories. According to the experts' opinions, after discussion by members of the research group, in the second round of consultation The first level index "supply guarantee" is added to the volume, and on the basis of the first level index, four second level indexes are added, and a small coefficient of variation is obtained in the consultation. Next, on the basis of building a reasonable and comprehensive evaluation index system, the effectiveness evaluation model of the intelligent weapon system is established as shown in Figure 1. At the same time, according to the importance judgment, the dispersion degree of each index is determined as shown in Figure 2 and figure 3.

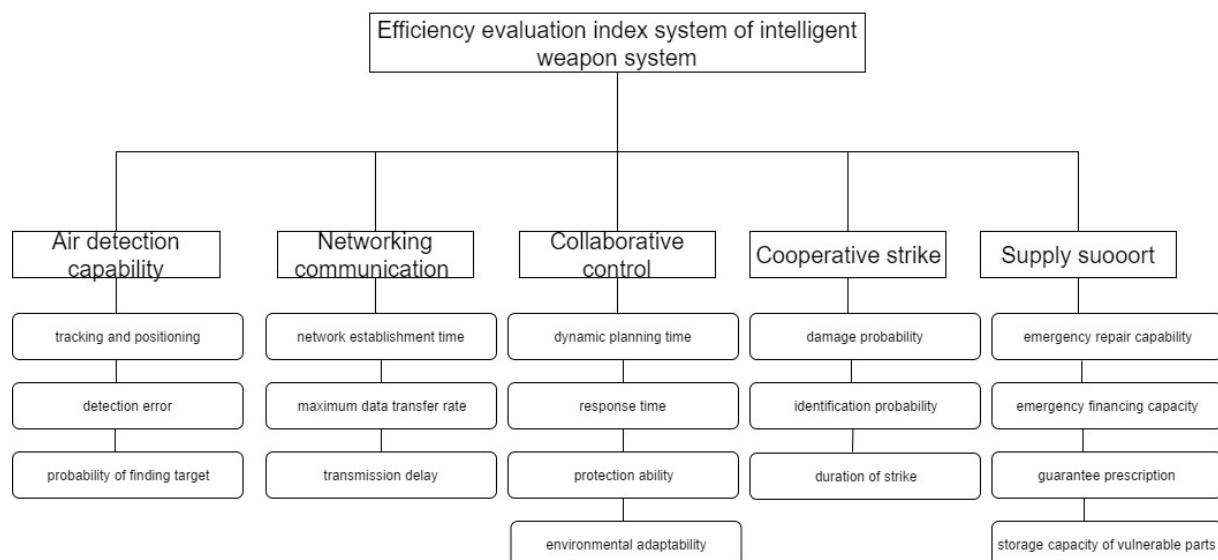


Figure 1 effectiveness evaluation index system of intelligent weapon system

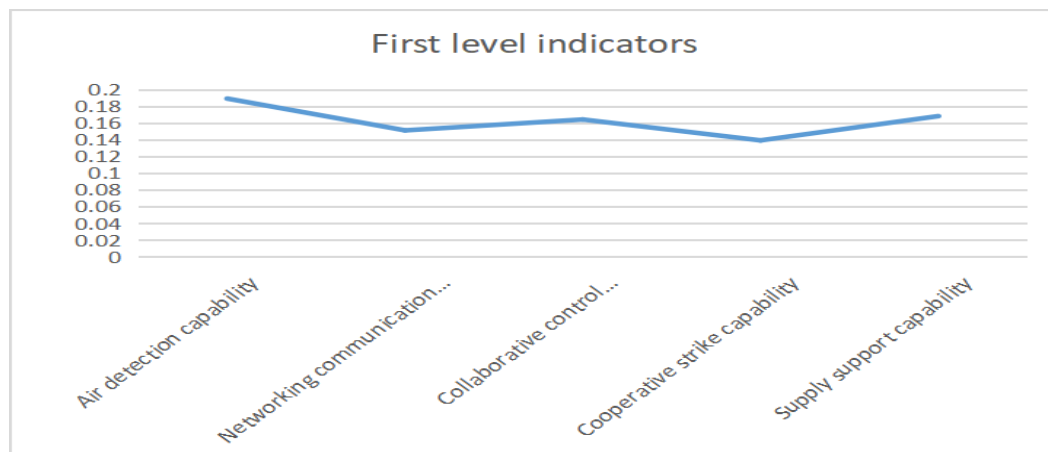


Fig. 2 fluctuation of primary index with coefficient of variation

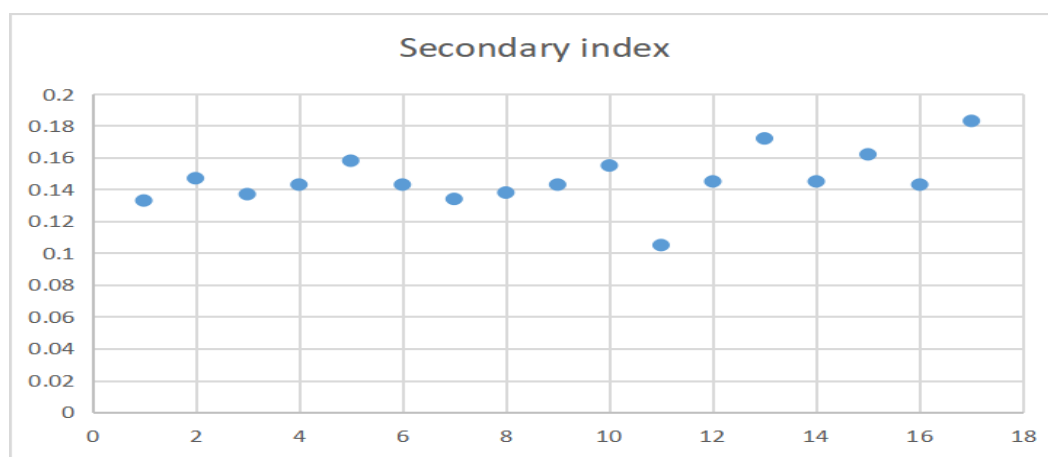


Figure 3 fluctuation of secondary index with coefficient of variation

5. Summary

This research mainly aims at the investigation of the factors affecting the effectiveness of intelligent weapon system. On the basis of consulting the relevant literature in the early stage, Delphi is adopted. In the actual operation of the acquisition system, various factors that may affect the effectiveness of the system are comprehensively analyzed. At the same time, the importance of the support ability to the effectiveness of the weapon system is considered. For the factors that have differences in the consultation process, according to the opinions of the expert group, after the discussion of the project group members, combined with the criteria of index selection, the index is finally adjusted. The experts selected in the consultation are representatives and professionals in relevant research fields, so the consultation results are highly authoritative. At the same time, after two rounds of consultation and opinion adjustment, the final expert scoring results basically tend to be consistent, and the coordination coefficient is high, which has strong operability and feasibility for the construction of intelligent weapon equipment effectiveness evaluation index system^[7].

Delphi method, as a method of anonymous inquiry, mainly refers to the authoritative persons in relevant industries, and experts do not communicate with each other, so it can avoid the influence of each other and learn from others. At the same time, after several rounds of inquiry, the opinions and suggestions fed back by experts were timely communicated and adjusted, and statistical methods were used to delete indicators with low coefficient of variation and low mean value. The results were more fair. In addition, the cost of this method is low and it is economical and practical. The disadvantage lies in that it is artificial scoring, which is subjective to some extent. Therefore, in this study, when

experts are invited to score, experts are required to give judgment basis according to practical experience, theoretical knowledge, data collection and subjective evaluation. Meanwhile, for the indicators deleted after the first round of consultation, all experts are informed of the reasons during the second round of consultation, as much as possible with the consent of the majority^[9]. The most important thing is that the validity and reliability of the research index system still need to be further verified in practice. At present, only from the perspective of theory and experience, it is still lack of persuasion. Through the construction of the effectiveness evaluation index system of intelligent weapon system, it will lay the foundation for the next performance evaluation and practical application of the system, which is conducive to improving weapon performance and combat capability.

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