ATLANTIS PRESS
Advances in Intelligent Systems Research (AISR), volume 151
2018 International Conference on Computer Modeling, Simulation and Algorithm (CMSA 2018)

Research on the Operational Effectiveness Evaluation Method of Multi-information Oriented Weaponry System

Tao Wang, Liuying Wang, Gu Liu and Haiqing Chen
High-Tech Institute of Xi'an, Xi'an Shaanxi 710025, China

Abstract—**In this paper, the operational capability analysis method of weapon equipment system oriented to multiple information is constructed by establishing the network model of weapons and equipment operations. Through the establishment of weapons and equipment for the effectiveness of network multi-information model, propose a weighted weapon system entropy method based on the active participation in combat, to solve the weight problem calculation system effectiveness edge, realize the overall operational efficiency of weapon system of comprehensive evaluation and analysis. Finally, taking the effectiveness evaluation of a missile weapon system as an example, the effectiveness of the proposed method is verified, and the effectiveness and availability of the method are verified.**

Keywords—weapon system; multi-information; system effectiveness; comprehensive analysis

I. INTRODUCTION

Since entering the twenty-first Century, the mode of operation has changed greatly with the development of science and technology. Under the future information-based conditions, the operation will be the multi-dimensional and networked war of information, land, sea, air and electricity. In the highly developed modern warfare of information technology, the coordination degree between weapons and equipment is increasing. The confrontation between the two sides of the war is more prominent. The overall effectiveness of the combat system is the key [1]-[3] to decide the battle outcome. How to effectively evaluate the operational effectiveness of the weapon equipment system has become a hot and difficult problem in the research of the weapon equipment system.

The combat effectiveness of weapon system is usually considered inherent attributes of weapon system and weapon equipment is mainly decided by the connection between the relationship and the tactical index method, is now using the static evaluation index system is established by [13], the tactical index parameters of equipment based on the relative level of the evaluation of operational effectiveness of weapon system but it is not clear, the quality of the tactical and technical index in the completion of combat missions, has certain defects.

Due to the uncertainty of war strong combat mission complex, often composed of a plurality of operational activities, weapon system through the completion of related operational activities in order to complete the mission, to combat ring based literature [9], is proposed to describe the operational efficiency of the whole system efficiency index based on different focus, but due to various operational activities. To complete the tasks of different contribution, there is some weight, so the weapon system to complete the task performance weight should be product of complete performance index and its corresponding operational activities, must be comprehensive analysis of weapon equipment involved in the operation activities of the performance indicators and the weight can be more comprehensive evaluation of combat effectiveness of the ring. Therefore, the traditional static evaluation is difficult to solve the actual effectiveness evaluation of all the equipments in the weapon system under the background of the task, so the operational effectiveness evaluation is lack of effectiveness and pertinence.

This article from the weapon system of activities, through the establishment of a weapon system combat mission "the ***operation loop*** " model based on the analysis and equipment of every operational node and combat the active edge of the tactical and technical indicators as the basis, the comprehensive evaluation of weapon system to complete the combat effectiveness of combat missions, to the combat effectiveness of equipment evaluation of weapon system, so as to reflect the equipment in complete combat mission in the contribution rate, provide the basis for follow-up of weapon system construction and development.

II. OPERATIONAL ANALYSIS OF WEAPON EQUIPMENT SYSTEM

A. Analysis of Operational Process of Weapon Equipment System

According to the operational requirements of weapons and equipment system, a lot of systems cooperate with each other to accomplish the task of striking. All kinds of equipment systems accomplish the whole operation process by executing their operational functions simultaneously. In this paper, the operational process of weapon equipment is summed up as three main stages, early warning detection, operational decision and operational action, such as [4], as shown in Figure I.

1) the stage of early warning detection. The main operational task at this stage is the continuous transmission of information to the intelligence center and the joint operational command center.

2) the stage of operational decision. The main operational tasks of this stage are to formulate operational plans and make operational decisions.

3) stage of operational action. The main operational task at this stage is to determine the operational scheme and to strike against the enemy's targets.

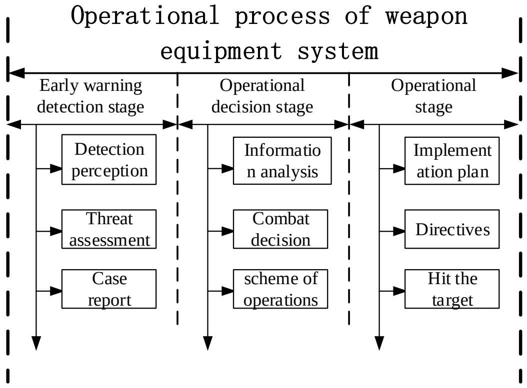

FIGURE I. A SCHEMATIC DIAGRAM OF THE OPERATIONAL PROCESS OF THE WEAPON SYSTEM

B. Establishment of Combat Network Model

According to the general Combat network theory [5] and the operational process of the weapon equipment system, this paper abstracts the weapon and equipment in the combat system into 4 types of entity [6]:

1) Reconnaissance aircraft (Surveillance, S): the main function of reconnaissance equipment system is to collect intelligence on the battlefield space, provide information support for decision-making departments, including early warning satellite, radar, AWACS and other reconnaissance equipment; according to the launch platform can be divided into four categories: land, sea and air based and space-based.

2) The decision - making entity D (Decision, D): the command and decision center at all levels. It can accept decision support information from satellite entities, analyze and decide the situation of the battlefield, and release operational commands to the operational entities. Including command center, integrated command platform, military command, brigade battalion command post.

3) Combating entity I (Influence, I): weapon equipment system attack system is mainly composed of weapon equipment system, and its weapon system mainly includes weapons, ground equipment, communication command system and so on.

4) The target entity T (Target, T): the target of the attack in the combat activities mainly includes the discovery of the enemy's incoming targets and the attack on the enemy's targets.

In the weapon system, the entity and the entity are connected by the operational activities, and the edge of the combat ring is formed. There are mainly following relations: T/S early warning and reconnaissance activities, S/D information transmission activities within the equipment, S/D information sharing activities, D/I decision-making and command activities, and I/T combating confrontations.

In the actual combat activities, due to the complexity of the battlefield environment and the equipment of the tactical and technical indexes of the interface between the various equipment between complex equipment [7], convey information sharing, instruction and other various connections of the entire combat system contribution between the various entities connected relationship has certain weight, so to consider the problem of weight in the side of the actual combat effectiveness calculation of the ring.

III. THE OPERATIONAL EFFECTIVENESS EVALUATION OF MULTI - INFORMATION ORIENTED WEAPON EQUIPMENT SYSTEM

A. Entropy Weight Method to Determine the Edge Weight of " the Combat Network "

In this paper, the entropy weight method is used to calculate the weight of the "battle ring" edge. The entropy weight method[8] is an objective method of empowerment. It is a method to determine the weight of the index by the judgment matrix constructed by the evaluation index under the objective condition. Through the analysis of the equipment for the weapon system to complete the operational tasks, we select the main technical indexes of the equipment involved in the operation activities, and determine the weight of the combat activities by constructing the judgement matrix of the main battle index.

The main evaluation index m of the equipment of each node in the "battle ring" is the value of each index : $r_{ij}(i=1,2\cdots m,\ j=1,2\cdots n)$, and the index sequence is $A=(r_{ij})_{m\times n}$.

By constructing index evaluation matrix and normalizing evaluation matrix array, the normalized judgment matrix is obtained $C=(c_{ij})_{mn}\ (i=1,2\cdots m;\ j=1,2\cdots n)$.

According to the definition of entropy , the evaluation index entropy of M equipment and N evaluation index H_j is obtained according to its judgment matrix C, and entropy weight of evaluation index ω_j is obtained by evaluating index entropy.

$$\omega_j=\frac{1-H_j}{n-\sum_{j=1}^{n}H_j} \tag{1}$$

$$W=(\omega_j)_{1\times n} \text{ and } \sum_{j=1}^{n}\omega_j \tag{2}$$

The W vector is the weight of the equipment index. According to the level from the bottom up to the aggregate, normalized by each index, the weight is aggregated to describe the side of the whole campaign activity, and the actual weight of the vector is as follows:

$$W_j * = \sum_{i=1, j=1}^{n} C_{ij} W_j \tag{3}$$

B. Efficiency Index Calculation for Multi Information Oriented Combat ring

Through the research and analysis, the relation between the target[9] of the operational effectiveness of weapons and equipment, the number of operational nodes and the number of operational rings are as follows:

1) Cooperative relationship network index:

This synergistic relationship in ring network mainly refers to the combat Reconnaissance Detection, reconnaissance and detection is the basis of the relationship between system combat, reconnaissance to search more nodes, the greater the probability of the target node, but at the same time the information processing time is longer, so in the Scout node reaches a certain quantity, the detection ability of surveillance will not increase, thus reducing the system effectiveness. So the reconnaissance detection capability is related to the number of rings, the number of reconnaissance nodes and the number of target nodes. Based on the number of operational nodes, we add the number of rings to define the cooperative relation network index [9]：

$$M_{T \to S} = \frac{\overline{S}}{\lg(N_S + N_T)} \tag{4}$$

In the above formula: $M_{T \to S}$ is reconnaissance and detection; N_S is the number of reconnaissance nodes; N_T is the number of target nodes; $\overline{S}$ is the number of combat rings.

The operational effectiveness index of a Reconnaissance Detection in the combat ring is the target of the operational effectiveness:

$$M_{T_i \to S_i} = M_{T \to S} - M_{T_{(-i)} \to S_{(-i)}} \tag{5}$$

In the above formula: $M_{T_i \to S_i}$,is the effectiveness index of the combat $T_i \to S_i$ activity and $M_{T_{(-i)} \to S_{(-i)}}$ is the efficiency index of removing the overall combat ring after the $T_i \to S_i$ side are removed.

In actual combat due to their connections between equipment in complex battlefield environment is a system for weight contribution, the final effectiveness by the combat effectiveness of common indicators and weights into actual performance and combat activities as the product of the performance indicators and the weight of the edge. So the actual effectiveness of the $T_i \to S_i$ operational activities is as follows:

$$M^*_{T_i \to S_i} = M_{T_i \to S_i} \times W^*_{T_i \to S_i} \tag{6}$$

2) Accusation network index:

The relationship between network charges index mainly reflects ring information transmission between nodes in the operational activities, information transmission activities exist in the equipment, reconnaissance node and between nodes, nodes and charges against the relationship between nodes, information sharing, transmission, integrity and accuracy of more nodes to share information more, but the information collection of the longer treatment time, so when the node number exceeds a certain value when the system efficiency of slow growth there was an extreme point of the membership function for the qualitative indicators can be directly used fuzzy mathematics as its function [10]:

$$M_X = \overline{S} - \frac{2\overline{S}}{e^x + e^{-x}} \tag{7}$$

$$M_{x_1 \to x_2} = \sqrt{M_{x_1} \times M_{x_2}} \tag{8}$$

In the above formula: $M_{x_1 \to x_2}$ is the performance index for the information transmission activity; x is the number of the corresponding nodes.

$$M_{X_i \to Y_i} = M_{X \to Y} - M_{X_{(-i)} \to Y_{(-i)}} \tag{9}$$

In the above formula: $M_{X_i \to Y_i}$ is the effectiveness index of the combat $X_i \to Y_i$ activity and $M_{X_{(-i)} \to Y_{(-i)}}$ is the efficiency index of removing the overall combat ring after the $X_i \to Y_i$ side are removed.

The actual effectiveness of the operational activities :

$$M^*_{X_i \to Y_i} = M_{X_i \to Y_i} \times W^*_{X_i \to Y_i} \tag{10}$$

3) The target of combating the relationship network

Under the condition of information war, the scope and dimension of the battlefield are expanding. The Firepower Strike equipment must rely on strong information support to play its role, that is to say, the combat node that constitutes the combat ring can play a substantial role. The combat effectiveness is the measure of the efficiency of the combat nodes in the combat system. Therefore, based on the measurement index of the operational ring, the effectiveness index [11] of the combat capability is proposed.

$$M_{I \to T} = \frac{\overline{S}}{N_I}[1 - \prod_{i=1}^{N_T}(1 - P_{ij})] \tag{11}$$

In the above formula: $M_{I\to T}$ is the effectiveness of the campaign, N_I is the number of nodes, N_T is the number of target nodes, $\overline{S}$ is the number of combat nodes, and P_{ij} is the probability of damage to the target i node are taken as the targets to combat the activities.

For a combat $I_i \to T_i$ ring in the combat ring, its operational effectiveness index is:

$$M_{I_i\to T_i} = M_{I\to T} - M_{I_{(-i)}\to T_{(-i)}} \tag{12}$$

In the above formula: $M_{I_i\to T_i}$ is the effectiveness index of the combat activity and $M_{I_{(-i)}\to T_{(-i)}}$ is the efficiency index of removing the overall combat ring after the $I_i \to T_i$ side are removed.

$I_i \to T_i$ is the actual effectiveness of the operational activities:

$$M^*_{I_i\to T_i} = M_{I_i\to T_i} \times W^*_{I_i\to T_i} \tag{13}$$

For the operation loop i, the effectiveness of a single combat ring system is described by the reconnaissance effectiveness index, the information transmission relation effectiveness index and the effectiveness of combat relationship effectiveness for each combat ring to describe [13]:

$$E_i = f(M_{T_i\to S_i}, M_{S_i\to D_i}, \cdots M_{D_i\to I_i}, M_{I_i\to T_i}) = \sum_{i=1}^{n} M_i^* \tag{14}$$

IV. Example Analysis

In order to verify the feasibility and effectiveness of the proposed method, this chapter takes a certain missile weapon equipment system as an example.

A. Effectiveness Weight of Operational Activities

The missile weapon system combat is divided into three stages, combined with the specific task of actual combat of each stage of the analysis, constitute the main equipment system of the weapons are: there are five main types of nodes: radar reconnaissance radar, radar S1, S2 S3, Space-Based Surveillance System S4 and Information Center D1; decision control there are three main nodes: General Command Center D2, command center D3, D4; combat class node is equipped with six combat unit has M type of weapon equipment. It is considered that the combat unit I1 and I2 are directly controlled by the operational command center. The strike units I3 and I4 are the main targets of the enemy's four main objectives, namely, the attack unit I5 and I6 are respectively operated by D1 and D2 of the operation command center. The combat system uses early warning and reconnaissance equipment system to identify enemy incoming targets T1, attack I1 and I2 against target T2, attack unit I3 and I4 to attack target T3, and attack unit I5 and I6 to attack target T4.The operational network model of a certain missile weapon equipment system can be set up.

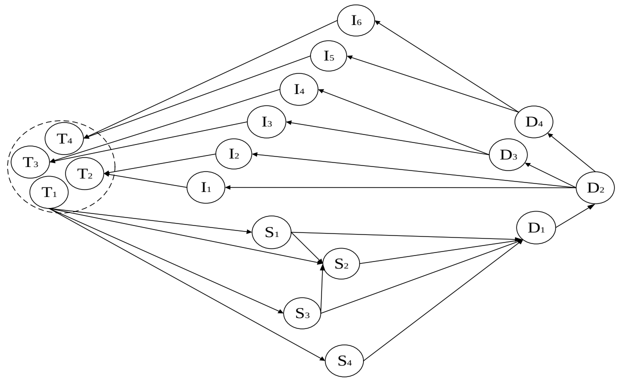

FIGURE II. A SCHEMATIC DIAGRAM OF A NETWORK MODEL FOR A CERTAIN TYPE OF WEAPON EQUIPMENT

The analysis shows that there are mainly 6 kinds of operations in the above models. This paper selects the key evaluation indicators to complete a certain operational activity and form a multiple evaluation information table. The list of evaluation indicators for the above operational activities is as follows:

TABLE I. $T->S$ RECONNAISSANCE AND DETECTION

Operational activities	Indicator1	Indicator2	Indicator3
$T_1->S_1$	3800	0.6	0.6
$T_1->S_2$	2000	0.9	0.8
$T_1->S_3$	3200	0.6	0.65
$T_1->S_4$	4000	0.9	0.55

TABLE II. S INFORMATION TRANSMISSION BETWEEN EQUIPMENT

Operational activities	Indicator1	Indicator2	Indicator3
$S_1->S_2$	1.4	2.4	0.05
$S_3->S_2$	1	2	0.1

TABLE III. $S->D$ INFORMATION SHARING ACTIVITIES

Operational activities	Indicator1	Indicator2	Indicator3
$S_1->D_1$	1.6	3	0.1
$S_2->D_1$	1.2	2	0.05
$S_3->D_1$	1.4	2.4	0.05
$S_4->D_1$	1	2	0.1

TABLE IV. D INFORMATION TRANSMISSION BETWEEN EQUIPMENT

Operational activities	Indicator1	Indicator2	Indicator3
$D_1->D_2$	1.6	3	0.05
$D_2->D_3$	1.4	2.4	0.1
$D_2->D_4$	1.4	2.4	0.1

TABLE V. $D->I$ INFORMATION SHARING ACTIVITIES

Operational activities	Indicator1	Indicator2	Indicator3
$D_2->I_1$	1.4	3	0.05
$D_2->I_2$	1.4	3	0.05
$D_3->I_3$	1	2	0.1
$D_3->I_4$	1	2	0.1
$D_4->I_5$	1	2	0.1
$D_4->I_6$	1	2	0.1

TABLE VI. $I->T$ COMBATING ANTAGONISM

Operational activities	Indicator1	Indicator2	Indicator3
$I_1->T_2$	550	90%	300
$I_2->T_2$	450	85%	300
$I_3->T_3$	500	90%	200
$I_4->T_3$	400	90%	200
$I_5->T_4$	450	95%	350
$I_6->T_4$	500	80%	350

The weight of the descriptive index of the operational activity is found in Table Ⅶ by the formula (1) - (3):

TABLE VII. INDEX WEIGHT OF DESCRIPTION OF BATTLE RING EDGE RELATION

Operational activities	Indicator1 weight	Indicator2 weight	Indicator3 weight
$T->S$	0.324	0.38	0.296
$S->S$	0.33	0.33	0.34
$S->D$	0.4	0.375	0.225
$D->D$	0.33	0.33	0.34
$D->I$	0.33	0.33	0.34
$I->T$	0.326	0.352	0.322

B. Operational Effectiveness Evaluation of Weapon System Based onCombat Network Model

It is known from the model diagram that the total number of closed loop operations of the missile weapon system is 36.

By formula (4) - (13), the edge effectiveness indexes of different operational activities can be obtained respectively.

TABLE VIII. EFFECTIVENESS OF OPERATIONS OF A MISSILE WEAPON SYSTEM

Operational activities	weight	efficiency index	efficiency
$T_1->S_1$	0.78	11.64	9.12
$T_1->S_2$	0.84	1.67	1.4
$T_1->S_3$	0.75	11.64	8.77
$T_1->S_4$	0.91	1.67	1.52
$S_1->S_2$	0.83	5.87	4.87
$S_3->S_2$	0.85	5.87	4.99
$S_1->D_1$	0.95	5.87	5.58
$S_2->D_1$	0.66	11.86	7.86
$S_3->D_1$	0.76	5.87	4.48
$S_4->D_1$	0.73	5.87	4.26
$D_1->D_2$	0.83	34.68	28.78
$D_2->D_3$	0.89	15.06	13.45
$D_2->D_4$	0.89	15.06	13.45
$D_2->I_1$	0.83	6.09	5.05
$D_2->I_2$	0.83	6.09	5.05
$D_3->I_3$	0.8	6.09	4.85
$D_3->I_4$	0.8	6.09	4.85
$D_4->I_5$	0.8	6.09	4.85
$D_4->I_6$	0.8	6.09	4.85
$I_1->T_2$	0.94	1.22	1.14
$I_2->T_2$	0.86	1.22	1.05
$I_3->T_3$	0.81	1.27	1.03
$I_4->T_3$	0.75	1.27	0.96
$I_5->T_4$	0.94	1.21	1.14
$I_6->T_4$	0.91	1.21	1.11

According to table VIII and formula (14), according to the idea that the M missile weapon system is finally achieved by the idea of edge aggregation, the effectiveness of each Combat network in the three kinds of combat rings is shown in Table IX.

TABLE IX. COMBAT NETWORK EFFICIENCY OF A CERTAIN MISSILE WEAPON SYSTEM

Serial number	Operation loop	efficiency
1	$T_1 \to S_1 \to D_1 \to D_2 \to I_1 \to T_2$	49.97
2	$T_1 \to S_1 \to D_1 \to D_2 \to I_2 \to T_2$	49.87
3	$T_1 \to S_1 \to D_1 \to D_2 \to D_3 \to I_3 \to T_3$	63.10
4	$T_1 \to S_1 \to D_1 \to D_2 \to D_3 \to I_4 \to T_3$	63.02
5	$T_1 \to S_1 \to D_1 \to D_2 \to D_4 \to I_5 \to T_4$	63.20
6	$T_1 \to S_1 \to D_1 \to D_2 \to D_4 \to I_6 \to T_4$	63.17
7	$T_1 \to S_1 \to S_2 \to D_1 \to D_2 \to I_1 \to T_2$	56.83
8	$T_1 \to S_1 \to S_2 \to D_1 \to D_2 \to I_2 \to T_2$	56.73
9	$T_1 \to S_1 \to S_2 \to D_1 \to D_2 \to D_3 \to I_3 \to T_3$	69.96
10	$T_1 \to S_1 \to S_2 \to D_1 \to D_2 \to D_3 \to I_4 \to T_3$	69.88
11	$T_1 \to S_1 \to S_2 \to D_1 \to D_2 \to D_4 \to I_5 \to T_4$	70.06
12	$T_1 \to S_1 \to S_2 \to D_1 \to D_2 \to D_4 \to I_6 \to T_4$	70.03
13	$T_1 \to S_2 \to D_1 \to D_2 \to I_1 \to T_2$	44.24
14	$T_1 \to S_2 \to D_1 \to D_2 \to I_2 \to T_2$	44.14
15	$T_1 \to S_2 \to D_1 \to D_2 \to D_3 \to I_3 \to T_3$	57.37
16	$T_1 \to S_2 \to D_1 \to D_2 \to D_3 \to I_4 \to T_3$	57.29
17	$T_1 \to S_2 \to D_1 \to D_2 \to D_4 \to I_5 \to T_4$	57.47
18	$T_1 \to S_2 \to D_1 \to D_2 \to D_4 \to I_6 \to T_4$	57.44
19	$T_1 \to S_3 \to S_2 \to D_1 \to D_2 \to I_1 \to T_2$	56.60
20	$T_1 \to S_3 \to S_2 \to D_1 \to D_2 \to I_2 \to T_2$	56.50
21	$T_1 \to S_3 \to S_2 \to D_1 \to D_2 \to D_3 \to I_3 \to T_3$	69.73
22	$T_1 \to S_3 \to S_2 \to D_1 \to D_2 \to D_3 \to I_4 \to T_3$	69.65
23	$T_1 \to S_3 \to S_2 \to D_1 \to D_2 \to D_4 \to I_5 \to T_4$	69.83
24	$T_1 \to S_3 \to S_2 \to D_1 \to D_2 \to D_4 \to I_6 \to T_4$	69.80
25	$T_1 \to S_3 \to D_1 \to D_2 \to I_1 \to T_2$	48.22
26	$T_1 \to S_3 \to D_1 \to D_2 \to I_2 \to T_2$	48.13
27	$T_1 \to S_3 \to D_1 \to D_2 \to D_3 \to I_3 \to T_3$	61.35
28	$T_1 \to S_3 \to D_1 \to D_2 \to D_3 \to I_4 \to T_3$	61.28
29	$T_1 \to S_3 \to D_1 \to D_2 \to D_4 \to I_5 \to T_4$	61.46
30	$T_1 \to S_3 \to D_1 \to D_2 \to D_4 \to I_6 \to T_4$	61.43
31	$T_1 \to S_4 \to D_1 \to D_2 \to I_1 \to T_2$	40.75
32	$T_1 \to S_4 \to D_1 \to D_2 \to I_2 \to T_2$	40.66
33	$T_1 \to S_4 \to D_1 \to D_2 \to D_3 \to I_3 \to T_3$	53.88
34	$T_1 \to S_4 \to D_1 \to D_2 \to D_3 \to I_4 \to T_3$	53.81
35	$T_1 \to S_4 \to D_1 \to D_2 \to D_4 \to I_5 \to T_4$	53.99
36	$T_1 \to S_4 \to D_1 \to D_2 \to D_4 \to I_6 \to T_4$	53.96

C. *Discussion Conclusions*

Through the comparative analysis of data in Table VIII and table IX, we can know the influence of corresponding nodes on the effectiveness of the whole combat system.

1) Performance analysis of reconnaissance nodes S1, S2, S3 and S4: From table VIII and table IX, we get the efficiency of the reconnaissance nodes S1, S2, S3 and S4 as the 5, 6 and 7 of the reconnaissance nodes by the weighted average method of the operational effectiveness of the same equipment. See the table X.

TABLE X. RECONNAISSANCE NODE EFFECTIVENESS VALUE

	S1	S2	S3	S4
5 edge loop	6.8	4.63	6.63	2.89
6 edge loop	6.52	4.78	6.08	2.89
7 edge loop	6.99	5.9	6.88	0

From Figure III, Figure IV shows that the effectiveness of reconnaissance node S4 Space-Based Surveillance System is relatively low, because of its participation in complete combat missile combat ring number and information transmission capacity of Space-Based Surveillance System S4 index 1 is relatively weak, so S4 is one of the vulnerable equipment need to improve the information transmission ability and the improvement their participation in the structure of combat ring system.

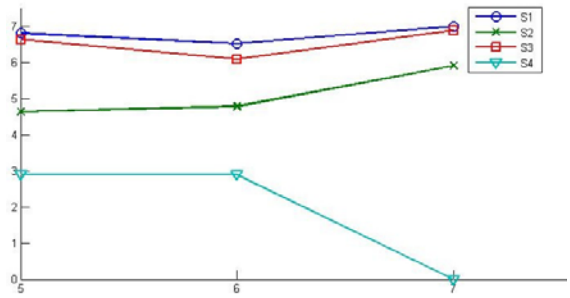

FIGURE III. RECONNAISSANCE NODE EFFECTIVENESS VALUE ANALYSIS

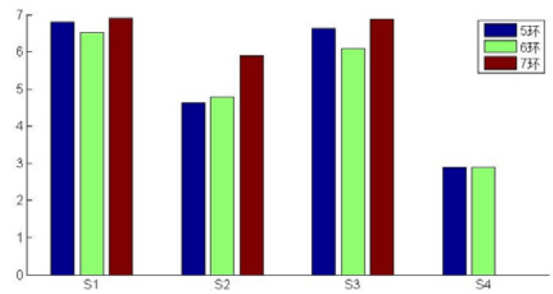

FIGURE IV. EFFICIENCY ANALYSIS HISTOGRAM OF RECONNAISSANCE NODE

2) Attack nodes I1, I2, I3, I4, I5, and I6 performance analysis:

Based on data from table VIII and table IX, we get the hitting nodes I1, I2, I3, I4, I5 and I6 by means of the weighted average method of the operational activities of the same equipment. When the number of battle circles is 5, 6, 7, the efficiency is shown in Table XI:

TABLE XI. COMBAT NODE EFFECTIVENESS VALUE

	I1	I2	I3	I4	I5	I6
5 edge loop	3.1	3.05	0	0	0	0
6edge loop	3.1	3.05	2.94	2.91	3	2.98
7 edge loop	3.1	3.05	2.94	2.91	3	2.98

As can be seen from Figures V and VI, the number of striking nodes involved in the combat ring is basically the same. The main reason for its different effectiveness lies in the advantages and disadvantages of the combat technology. However, the performance of striking node I4 is relatively low, because its performance such as hit accuracy and hit probability is lower than other strike equipment, so I4 is also a weakness. The equipment needs to improve its target 1 and index 2.

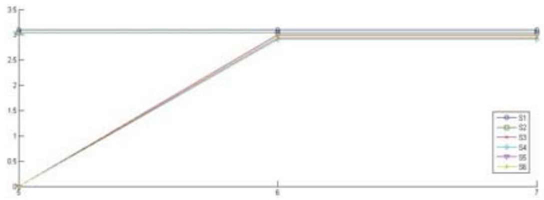

FIGURE V. ANALYSIS OF THE EFFECTIVENESS OF THE STRIKE NODE

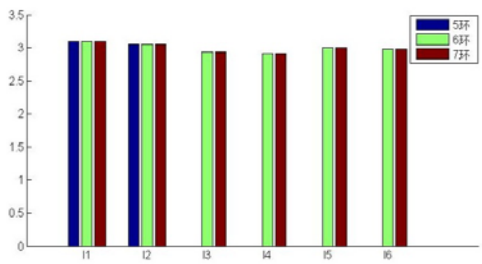

FIGURE VI. ANALYSIS HISTOGRAM OF ATTACK NODE EFFECTIVENESS

Through the analysis, the missile weapon system combat the equipment operational effectiveness and the level of the number of rings involved in combat and its corresponding tactical and technical indexes of the more the number of action in the ring, related equipment and technical indexes of the advantages and its operational effectiveness is stronger, and the same equipment in different operational activities the performance of different, for operational effectiveness of weak operational activities, we should improve the system structure and the upgrading of equipment and technical indexes of optimized processing.

V. CONCLUSION

In this paper, a combat ring model of weapon system is built, and the operational effectiveness analysis of weapon system is realized through analyzing the activities of operation ring node and operation ring side. It is different from the traditional static operation effectiveness analysis method based on the establishment of weapon equipment index system. It focuses on the relationship between the number of operational nodes and the number of operational rings in combat activities, so as to get the operational effectiveness of the whole system. At the same time by using entropy method to describe the relationship between the interface equipment a few key tactical and technical indicators as the basis, calculated the weight between the equipment efficiency system platform edge operational activities, to solve the problem with edge weights ignore the traditional calculation method for system effectiveness, and assess when considering the impact of resistance hit the target node to complete the task. It not only reflects the operational effectiveness of the weapon system, but also reflects the strength of the interface relationship between the equipment. It provides a basis for improving the inferior equipment in the future.

REFERENCES

[1] Hang S C, Kang H X, Li W M. Intercepting operation effects analysis of anti-BM weapon systems with aerospace information support[J]. Systems Engineering and Electronic, 2012, 34(3),pp.508-511.. *(references)*

[2] DELLER S, TOLK A, RABADI U, et al. Improving C2 effectiveness based on robust connectivity[M]. Grant T J, Janssen R H P, Monsuur H. Network topology in command and control: organization, operation, and evolution. Pennsylvania: IUI Global, 2014 .

[3] HUY T T, DIMITRI N M. A system-of-systems approach for assessing the resilience of reconfigurable command and control networks[C] //Proc. of the AIAA Science & Technology Forum & Exposition, 2015:1-14.

[4] Fan Y T, Wang M L, Wen M M,et al. Analysis of ballistic missile penetration effectiveness based on firefly algorithm-analytic hierarchy process[J].Systems Engineering and Electronic, 2015, 37(4): 846-847.

[5] R. Cares, J. An Information Age Combat Model. In: ICCRTS, 2004

[6] C, J. Distributed Networked Operations. In: Foundations of Network Centric Warfare, Alidade, 2005.

[7] Ren Ch Sh. A Evaluating Approach for Technology Maturity of Weapon System of Systems[D]. Changsha: National University of Defense Technology, 2010.

[8] Chen X H, Xu X H,Zeng J H. I Method of multi-attribute large group decision making based on entropy weight[J].Systems Engineering and Electronic, 2007, 29(7): 72-75.

[9] Zhang Ch H. Network Modeling and Efficieness Analysis of Operational System-of-systems based on operation loop [D]. Changsha: National University of Defense Technology, 2012.

[10] Zheng T. Integrated Missile and Anti-aircraft Gun Weapon System Effectiveness Assessment Based on Operation Loop[D]. Changsha: National University of Defense Technology, 2013.

[11] Guo X C, Chen G M, Chang L L,et al.Construction of Missile Early-warning and Counter-attack System and Effectiveness Evaluation[J]. Journal of Equipment Academy 2016, 27(6): 75-81.

[12] Wu Zh L, Zhao Zh Sh. A Damage Assessment Model Based on Adaptive Neuro-fuzzy Inference System[J]. ACTA ARMAMENTAR II 2012, 33(11): 1356-1357.

[13] Fan Y P, Guo Q Sh,Wang J L. Task-oriented requirement satisfactory degree analysis method for combat capability of equipment system of systems[J]. Systems Engineering and Electronic,2016, 38(8): 1826-1832.

[14] Guo X C, Chen G M, Chang L L,et al. DoDAF and RIMER Based Effectiveness Evaluation of Early-warning and Counterattack Combat System of Missile Systems[J]. Electronics Option & Control. 2017, 24(6): 28-33.

[15] DoD Architecture Framework Group. DoD Architecture Framework Version2.02[R]. USA: Department of Defense, 2011.

[16] Das S, Suganthan, P N. Differential Evolution: A Survey of the State-of-the-art [J].IEEE Transactions on Evolutionary Computation, 2012, 15(1): 4-31.

[17] Wang M L, Li Y. Analysis of ballistic missile penetration effectiveness [M]. Beijing: National Defense Industry Press,2010.