Research on the construction of evaluation index system for equipment maintenance support capability based on AHP

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Abstract. Under the two-level maintenance mode, in order to scientifically evaluate the maintenance support ability of synthetic brigade under the new system, it is an urgent problem to establish a reasonable evaluation index system. First of all, the mission, organizational structure and equipment characteristics of synthetic brigade under the new situation are analyzed. Then, according to the principle and method of establishing index system, the evaluation index is put forward. Finally, AHP is used to determine the index weight, so as to establish the evaluation index system of actual combat training of equipment maintenance support capability of synthetic brigade under the new system.

1 Introduction

As an important component of the army's strategic purpose of "mobile operation, three-dimensional attack and defense", the Synthetic Brigade is composed of integrated and modular units, which has the characteristics of full firepower, quick response and strong independent combat ability. It is the main assault force for the army to carry out operations [1]. As a representative of the army's new combat forces, the brigade has the characteristics of many kinds of weapons and equipment and high requirements for operational support. Under the two-level maintenance system, the Synthetic Brigade puts forward higher requirements for its maintenance and support work. It is urgent to establish a set of scientific and standardized evaluation index system of equipment maintenance support ability, test the level of equipment maintenance support ability, find out the weak links in the construction of equipment maintenance support ability, improve the equipment intact rate, and promote the improvement of combat effectiveness [2].

2 Construction of evaluation index system for actual combat drill of equipment maintenance support capability

2.1 Index system construction method

According to the principle of constructing the evaluation index system, through the analysis of equipment composition, establishment tasks and structural characteristics of the Synthetic Brigade, and through expert consultation and literature review, the evaluation

indicators are strictly selected. The equipment maintenance support capability of the Synthetic Brigade includes organization planning capability, equipment maintenance capability, equipment support capability and data support capability [3-5]. According to the three levels of "ability - evaluation elements - standard requirements", it is decomposed and refined [6]. Each level can form its own system for single or comprehensive evaluation, and it is also an integral part of the overall comprehensive evaluation.

The first level index is the initial decomposition of the capability of equipment maintenance support system. Generally, it can not be directly evaluated. It only plays a normative role in determining the next level index.

The second level index is the refinement and decomposition of the first level index, which can not be directly evaluated, but only plays a normative role in the next level evaluation index. Due to the complexity of the maintenance support system, the secondary indicators can be differentiated differently.

The third level index is the further decomposition of the second level index, which can be directly quantified, namely "evaluation point". Evaluation points are usually quantified by a certain scoring method.

2.2 Index system construction

Through the decomposition and hierarchical analysis of equipment support and maintenance capability of Synthetic Brigade, the index system framework of exercise evaluation of support capability can be constructed abstractly, as follows:

Equipment maintenance support capability of Synthetic Brigade.

$$E = \sum_{i=1}^4 E_i w_{E_i} (i = 1, 2, 3, 4) \quad (1)$$

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$$E_i = \sum_{j=1}^{n_i} E_{ij} w_{E_{ij}} (i = 1, 2, 3, 4; j = 1, 2, \dots, n_i) \quad (2)$$

E_i, E_{ij} ----- They are the first level index and the second level index of equipment maintenance support

capability;

$w_{E_i}, w_{E_{ij}}$ ----- They are the weight of the first level index and the second level index respectively;

n_i ----- The number of secondary indicators of the I first level index.

Figure 1. Index system.

2.3 Quantitative method of evaluation points of evaluation system

The "evaluation point" in the evaluation system, that is, the three-level index, mainly adopts five quantitative methods, namely, two-level system, four-level system, percentage system, income type and cost type, to obtain and process data. The whole calculation model, through normalization calculation, the full score of each layer is 100 points, and the full score of unit total score is 100 points. Finally, the maintenance support capability is quantified into data, and then the equipment maintenance support system capability of the unit is evaluated by the corresponding algorithm, combined with the scoring system and hierarchical calculation.

3 Weight analysis of evaluation index

The research and analysis of weight, in essence, is to determine the importance of each index, is an important part of quantitative evaluation. Different evaluation angles, the environment of the assessment object, the task

undertaken and the different evaluation methods will lead to different weight values. Therefore, the weight is established under certain conditions and the evaluation object and evaluation team have little objection to the weight value, which can not be used in all troops [7]. This paper mainly introduces the construction of index weight by analytic hierarchy process.

① Establish hierarchical structure model

It includes four abilities: organization and planning capability, equipment maintenance capability, equipment support capability and data support capability. Taking these four aspects of ability as influencing factors, the model is constructed.

② Form judgment matrix

In this paper, the data in the judgment matrix are given by experts on the basis of usual experience.

Table 1. judgment matrix.

E	A	B	C	D
A	1	1	2	3
B	1	1	1	3
C	1/2	1/2	1	2
D	1/3	1/3	1/2	1

③ Determining the weight of hierarchical single ranking

According to the formula

$$M_i = \prod_{j=1}^n a_{ij} (i = 1, 2, \dots, n) \quad (1)$$

Calculated $M_1 = 6$, $M_2 = 6$, $M_3 = 0.5$, $M_4 = 0.05556$

Calculated again $\bar{W}_i$

$$\bar{W}_i = \sqrt[n]{M_i} \quad (2)$$

Get $\bar{W}_1 = 1.56508$, $\bar{W}_2 = 1.56508$,

$\bar{W}_3 = 0.8409$, $\bar{W}_4 = 0.4855$

Normalized $\bar{W}_i$

$$W_i = \bar{W}_i / \sum_{j=1}^n \bar{W}_j \quad (3)$$

$$\sum_{j=1}^n \bar{W}_j = 4.45656, \quad w_1 = 0.351, \quad w_2 = 0.351,$$

Table 2. First level index Weight.

Index code	A	B	C	D
Weight	0.35	0.35	0.19	0.11

Similarly, the weight of secondary indicators can be obtained.

Table 3. Secondary index weight.

Index code	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇
Weight	0.20	0.15	0.15	0.10	0.15	0.15	0.05
Index code	A ₈	B ₁	B ₂	B ₃	B ₄	C ₁	C ₂
Weight	0.05	0.10	0.25	0.10	0.55	0.35	0.25
Index code	C ₃	C ₄	C ₅	D ₁	D ₂	D ₃	
Weight	0.25	0.09	0.06	0.30	0.30	0.40	

4 Conclusion

As a representative of the army's new combat forces, Synthetic Brigade has the characteristics of integration and modularization. This paper focuses on the analysis of index system construction and weight establishment method, and proposes a set of easy to operate and strong guidance evaluation index system, which lays the foundation for the Synthetic Brigade to carry out

$$w_3 = 0.189, \quad w_4 = 0.109$$

$$W = (w_1, w_2, w_3, w_4)^T = (0.35119, 0.35119, 0.18869, 0.10894)^T$$

④ Consistency test

After calculating the weight of each ability, the consistency test should be carried out in order to prove the rationality of the weight.

Firstly, the maximum eigenvalue of the matrix is judged, for the equipment maintenance support capability of Synthetic Brigade E, there are:

$$AW = \begin{bmatrix} 1 & 1 & 2 & 3 \\ 1 & 1 & 2 & 3 \\ 2 & 2 & 1 & 2 \\ 3 & 3 & 2 & 1 \end{bmatrix} \begin{bmatrix} 0.351 \\ 0.351 \\ 0.189 \\ 0.109 \end{bmatrix} = \begin{bmatrix} 1.407 \\ 1.407 \\ 0.758 \\ 0.438 \end{bmatrix} \quad (4)$$

$$\lambda_{\max} = \sum_{i=1}^n \frac{(AW)_i}{nW_i} = \frac{1.407}{4 \times 0.351} + \frac{1.407}{4 \times 0.351} + \frac{0.758}{4 \times 0.189} + \frac{0.438}{4 \times 0.109} = 4.011 \quad (5)$$

$$CI = \frac{\lambda_{\max} - n}{n - 1} = \frac{4.011 - 4}{4 - 1} = 0.004 \quad (6)$$

Check list, when $n = 4$, $RI = 0.90$, therefore

$$CR = \frac{CI}{RI} = \frac{0.004}{0.90} = 0.0044 < 0.10 \quad (7)$$

It can be seen that the judgment matrix has satisfactory consistency. We can think that the weight of each ability calculated by hierarchical single ranking is reasonable, and the result of weight calculation is as follows.

inspection and evaluation, and provides theoretical guidance for the army force maintenance support system capacity building and evaluation work.

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