

Research on the Reliability of Evaluating the Efficiency of Commanding Information System

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Abstract—When evaluating the efficiency of the commanding information system, the results are always questioned because of the fluctuation of the data used. The article introduced a method which is suitable to measure the reliability of the evaluation efficiency of the commanding information system as per its own characteristic. Finally, according to the calculation of a sample, it is proved that this method of measuring the reliability of the evaluation efficiency performs very well and it is practicable and workable in reality.

Keywords—Commanding information system; Evaluating efficiency; Measuring reliability.

I. INTRODUCTION

The new joint battle mainly based on information warfare, as the command and control platform, the Commanding Information System (Hereafter called “CIS”) becomes more and more important in armies of all countries. The main objective of CIS is to enhance the overall warfare efficiency of all units by improving their capabilities of commanding battle, control of weapons, reconnaissance and exploration, rapid response, and apperceiving situation. Evaluating the efficiency of CIS is an important topic to determine whether or not it could meet the information commanding and controlling demand in warfare. Through scientifically and reasonably evaluating the efficiency of CIS, the commanders can easily figure out the weakness in CIS so as to improve the performance of CIS in wartime or peacetime, which is helpful to improve their commanding abilities, and it has significant influence of the development of CIS and improve the overall efficiency. Today, there are a lot of articles introduced evaluation of the efficiencies of various information systems, but most of them did not consider the fluctuation of data in evaluation^[1-4], only few articles touched the topic of the reliabilities of the evaluation efficiency of information systems. In general, the efficiency of CIS is measured by various performance indexes comprehensively. So, this article first introduces a method to evaluate the efficiency of CIS from the view of synthetic evaluation. Then, the reliability of the evaluation efficiency of CIS is studied through simulative calculation. The method introduced in this article considers the fluctuation of data in evaluating CIS, which is more reliable and could determine the evaluation efficiency more objectively and reliably.

II. THE METHOD OF EVALUATING THE EFFICIENCY OF CIS

A. The Index Structure

According to the demand of modern warfare and the principles of generality, availability and stability, the index architectonic structure of evaluating the efficiency of CIS can be established as shown as table 1^[4].

TABLE 1. THE INDEX ARCHITECTONIC STRUCTURE OF EVALUATING THE EFFICIENCY OF THE CIS

The first level index	The second level index
U_1 —the capability of command and control	U_{11} —the command delay time; U_{12} —the quality of command personnel; U_{13} —the scope of control battle; U_{14} —the skill of assistant decision-making.
U_2 —the capability of communications	U_{21} —the signal covering scope; U_{22} —the communications capacity; U_{23} —the integrative intercommunication; U_{24} —the reliability.
U_3 —the capability of reconnaissance and exploration	U_{31} —the scope of reconnaissance and exploration; U_{32} —the advanced technique means; U_{33} —the probability of detecting objective; U_{34} —the probability of void alert.
U_4 —the mobile capability	U_{41} —the movement ability; U_{42} —the competence of rapid regrouping; U_{43} —the orientation competence.
U_5 —the capability of information support	U_{51} —the ratio of sharing resources; U_{52} —the competence of acquiring information; U_{53} —the speed of renovating information.

B. The Evaluating Model

When the efficiency of CIS is evaluated, the comment set of fuzzy language should be first determined, and the benchmark values of all second level indexes that aim at each comment are subsequently determined. Then, the performances of CIS are tested, and some experts utilize the gained data to give the scores of all second level indexes according to the grading standard shown in table 2. Finally, the elementary evaluation result is made upon the basis of

calculating the weighted difference value between the scores given by the experts and the benchmark values.

TABLE 2. THE GRADING STANDARD

Judgment value	Graded interval
extreme good	[90,100]
very good	[80,90)
good	[70,80)
comparatively good	[60,70)
moderate	[40,60)
comparatively poor	[30,40)
poor	[20,30)
very poor	[10,20)
extreme poor	[0,10)

Given that w_i is the weight of U_i , w_i should be determined by the commander ($i=1,2,\dots,5$). Let $V=\{v_1, v_2, \dots, v_L\}$ stand for the comment set determined in advance, the comments in V rank decreasingly, namely $v_1 \succ v_2 \succ \dots \succ v_L$. Aiming at $v_k \in V$, the determined benchmark value of U_{ij} is denoted as b_{ij}^k ($k=1,2,\dots,L$; $i=1,2,\dots,5$; $j=1,2,\dots,i_k$). Given that e_{ij} ($i=1,2,\dots,5$; $j=1,2,\dots,i_k$) is the score of U_{ij} , which is determined by the evaluation experts according to the situation of testing the CIS. If $q \in \{1,\dots,L\}$ meets

$$\sum_{i=1}^5 \sum_{j=1}^{i_k} w_i (e_{ij} - b_{ij}^{q-1}) < 0 \leq \sum_{i=1}^5 \sum_{j=1}^{i_k} w_i (e_{ij} - b_{ij}^q) \quad (1)$$

then the efficiency of CIS achieves the standard of v_q as a whole, v_q is accepted to be the elementary evaluation result.

III. THE RELIABILITY OF EVALUATING THE EFFICIENCY OF CIS

Because there are possibly some warps in the tested data and the experts' judgments, It is hard to avoid definite fluctuation in determining the score of each second level index. Consequently, It is necessary that the commander organize other experts to measure the reliability of v_q . So, e_{ij} should be surveyed by these experts ($i=1,2,\dots,5$; $j=1,2,\dots,i_k$), and e_{ij} is classified according to the standard included in {"lesser warp", "obvious warp", "biggish warp"}.

A. Measuring the Reliability of v_q

In order to measure the reliability of v_q , it is demanded to make a good deal of simulative tests. As shown in [5], it is resultful to rely on the even design, in which a even distributing point e'_{ij} that is nearby e_{ij} is used

to substitute for e_{ij} . If e_{ij} is considered to be precise by the experts, then let $e'_{ij} = e_{ij}$. According to table 2, if e_{ij} is considered to be lesser warp, let $e'_{ij} = e_{ij} - 1 + 2 \times \xi_{ij}$ when e_{ij} is considered to be fluctuant, let $e'_{ij} = e_{ij} + \xi_{ij}$ when e_{ij} is considered to be up floating, let $e'_{ij} = e_{ij} - \xi_{ij}$ when e_{ij} is considered to be down floating, where ξ_{ij} is a random number obeying 0-1 uniformity distribution. Analogously, if e_{ij} is considered to be obvious warp, let $e'_{ij} = e_{ij} - 2 + 4 \times \xi_{ij}$ when e_{ij} is considered to be fluctuant, let $e'_{ij} = e_{ij} + 2 \times \xi_{ij}$ when e_{ij} is considered to be up floating, let $e'_{ij} = e_{ij} - 2 \times \xi_{ij}$ when e_{ij} is considered to be down floating. Similarly, if e_{ij} is considered to be biggish warp, let $e'_{ij} = e_{ij} - 3 + 6 \times \xi_{ij}$ when e_{ij} is considered to be fluctuant, let $e'_{ij} = e_{ij} + 3 \times \xi_{ij}$ when e_{ij} is considered to be up floating, let $e'_{ij} = e_{ij} - 3 \times \xi_{ij}$ when e_{ij} is considered to be down floating. Making a simulative calculation by substituting e'_{ij} for e_{ij} in the both sides of formula (1), if formula (1) comes into existence, then this simulative calculation supports v_q , otherwise, it does not support v_q . Suppose each round contains N simulative calculations and M rounds have been made. Given that N_i denotes the times of simulative calculations supporting v_q in i th round. As a result, the reliability of v_q in i th round can be defined as follows:

$$C_i = \frac{N_i}{N} \quad (i=1,2,\dots,M) \quad (2)$$

Therefor, the reliability of v_q derived from the simulative calculations in M rounds can be considered as follows:

$$C^q = \min\{C_1, C_2, \dots, C_M\} \quad (3)$$

B. A Calculative Example

Given that $V=\{"very good", "good", "Comparatively good", "Moderate", "Comparatively poor", "poor", "Very poor"\}$ is the comment set determined in advance for evaluating the efficiency of one CIS, the weight vector of the first level index determined by the commander is $W=(0.2821, 0.0753, 0.1133, 0.2325, 0.2968)$, the benchmark value of each second level index that corresponds to each comment in V is the middle value of the corresponding graded interval shown in table 2. Suppose that the scores of all second level index given by the

evaluating experts are : $e_{11}=82$, $e_{12}=75$, $e_{13}=85$, $e_{14}=90$, $e_{21}=75$, $e_{22}=85$, $e_{23}=90$, $e_{24}=80$, $e_{31}=75$, $e_{32}=70$, $e_{33}=75$, $e_{34}=85$, $e_{41}=78$, $e_{42}=72$, $e_{43}=75$, $e_{51}=78$, $e_{52}=75$, $e_{53}=80$. It is required to evaluate the efficiency of the CIS. Assumed that after having reviewed the scores of all second level index, the inspecting experts consider: e_{21} and e_{23} have biggish warps, the score of e_{23} is on the high side, the score of e_{21} is on the low side. e_{11} , e_{32} and e_{41} have obvious warps, the score of e_{32} is on the low side, the scores of e_{11} and e_{41} are fluctuant. e_{24} and e_{53} have lesser warps, their scores are fluctuant. The other scores are comparatively precise. Let $N=100000$ and $M=10$, It is required to determine the reliability of this evaluation.

Looking at v_1 ="Very good" and v_2 ="good", the benchmark values of U_{ij} derived from the graded interval in table2 are respectively $b_{ij}^1=85$ and $b_{ij}^2=75$ ($i=1,2,\dots,5$;

$j=1,2,\dots,i_k$) . $\therefore \sum_{i=1}^5 \sum_{j=1}^{i_k} w_i(e_{ij}-b_{ij}^1) \approx -20.48 < 0$, but

$\sum_{i=1}^5 \sum_{j=1}^{i_k} w_i(e_{ij}-b_{ij}^2) \approx 14.23 > 0$, \therefore From formula (1), the

efficiency of the CIS achieves the standard of v_2 ="good" as a whole, and the elementary evaluation result is "good".

According to the judgments of the inspecting experts, it is required to generate seven random numbers obeying 0-1 uniformity distribution, namely ξ_{14} , ξ_{23} , ξ_{11} , ξ_{41} , ξ_{21} , ξ_{24} , ξ_{53} . Let $e'_{21} = e_{21} + 3 \times \xi_{21}$, $e'_{23} = e_{23} - 3 \times \xi_{23}$, $e'_{32} = e_{32} + 2 \times \xi_{32}$, $e'_{11} = e_{11} - 2 + 4 \times \xi_{11}$, $e'_{41} = e_{41} - 2 + 4 \times \xi_{41}$, $e'_{24} = e_{24} - 1 + 2 \times \xi_{24}$, $e'_{53} = e_{53} - 1 + 2 \times \xi_{53}$, the rest $e'_{ij} = e_{ij}$. Calculating $K =$

$\sum_{i=1}^5 \sum_{j=1}^{i_k} w_i(e'_{ij}-b_{ij}^2)$, if $K \geq 0$, then the result of this

simulative calculation supports v_2 . By programming to calculate ten rounds that each round includes a million simulative calculations, the reliabilities of this ten rounds are in turn 0.940, 0.963, 0.922, 0.903, 0.873, 0.813 , 0.863, 0.858, 0.943, 0.977.

C. The Confirmation and Revision of the Evaluation Result

To measure the reliability of v_q is helpful for confirmation and revision of v_q . Suppose α is a threshold

given by the commander ($\alpha \geq 0.6$) , if the reliability of v_q satisfies:

$$C^q \geq \alpha \quad (4)$$

then v_q should be confirmed, otherwise the evaluation result should be degraded, namely the evaluation result should be revised as V_{q+1} , the reliability of v_{q+1} needs to be measured again, and v_{q+1} needs to be reconfirmed.

IV. CONCLUSION

According to the characteristics of CIS, this article briefly analyzed the index architectonic structure that evaluates the efficiency of CIS, established the evaluation model from the view of general multi-performance indexes, and then conducted a method of measuring the reliability of evaluating the efficiency. The calculative example shows that the methods introduced in this article can measure the reliability of the evaluation efficiency of CIS easily by combining the operation of CIS and the experts' judgments. Through simulative calculations, the reliability of the evaluation result can be figured out effectively and its flexibility and practicality has been proved. It is worthy of explaining that the evaluation result can be easily revised and confirmed according to the reliability, which is helpful for enhancing the accuracy of this evaluation result and discovering possible hidden problems so as to improve CIS. Moreover, although the methods in this article are to aim at CIS, they can be introduced to common information systems to improve the objectivity of evaluating the efficiency of information systems.

ACKNOWLEDGMENT

This article is supported by the PLA Academy of National Defence Information, the Computer Science and Electronic Technology International Society and the IEEE-CPS.

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