

# The Construction of the Evaluation Index System of Customer-Oriented Software Supportability

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**Abstract.** Information equipment has become the main body of our PLA, and software has become the soul and hub of weaponry, and software maintenance support has become one of the key elements that constrain the formation of equipment operations and support capabilities. Through the analysis of the content, steps and methods of the force software use and maintenance, the factors affecting the software use and support are obtained, including such 4 categories as basic attributes of software, software design features, support resources and support management factors, which can be further divided into 27 items. On this basis, through the initial selection of index system, membership analysis and correlation index steps, the software-oriented evaluation index system for users is finally constructed.

**Keywords:** Software support, Software supportability, Evaluation Index system.

## 1. Introduction

With the deepening of the information construction of PLA equipment, numerous information equipment has been deployed. There are such problems in the current military software as a to various types, difficulties in support, and lack of related support resources. <sup>[1]</sup> These problems directly affected the formation of the troops' capability of equipment support, as well as the equipment readiness. The main reasons for the difficulties in support military software are as follows: firstly, there is little consideration for software support of later stage in the earlier stage of software design, resulting in poor qualities and difficulties in software support; secondly, there is a lack of the evaluation of customer-oriented software supportability and the corresponding verification means for military users. It is difficult for the military users to evaluate the software supportability that will be installed, and then find the weak links and make targeted improvements.

This paper is aimed at the difficulties for the military in pre-judging and discovering the problems existing in software use and supportability. Firstly, it analyzes the main work of the use and supportability of the military software, and the main factors affecting the development of these work, and obtains the main factors based on further analysis. Based on the factors, an evaluation index system of customer-oriented software supportability is constructed to provide a basis for the military to find out the potential problems in the use and support of software in advance, and then provide support for the evaluation of software supportability.

## 2. Analysis of Concept of Software Supportability

There is no uniform definition of the definition of software supportability. Here are a few different definitions. U.S. Army Communications-Electronics Command (CECOM) defines software supportability as: "Software supportability refers to the ability to perform maintenance and improvement, upgrades, or other changes to software. Software supportability is related to the maintainability, adaptability and modifiability of the software, and is related to the software life cycle process, redundant computing power, maintenance and computer supportability resources." [2]. Society of Automotive Engineers (SAE) defines software supportability as: "Software supportability is the design features of the software, as well as the relevant development tools and methods, environmental protection facilities, etc. necessary to complete the software support activities" [3]. GJB 451A Reliability, Maintainability and Support Terms defines software supportability as: "Software supportability refers to the ability of the software to be maintained and easy to be maintained, improved, upgraded or other be changed and supplied." [4]

Despite of the differences in the above definitions of software supportability, the essence of their reflection is consistent. Software supportability is a highly integrated concept, which depends on the relevant design features of the software and the integration of various support elements.

The above concepts consider all the factors affecting software supportability capabilities, especially the capabilities of maintenance, improvement and change of software. Therefore, many current evaluation studies of software supportability tend to pay more attention to the evaluations of software maintenance and change [5-8], but the current work of software change and maintenance of PLA is still completed by the software development units. The software supportability work of PLA exceeds the maintenance and modification of the software source code. Therefore, in the current software support mode, it is of little significance for the improvement of PLA's capability of software support to place too much emphasis placed on improving the capability of maintenance and change of software. The troops are more concerned with the factors that directly affect the use and support of the software. Therefore, the troops-oriented evaluation of software supportability shall first need to determine the elements that affect the use and support of the troops' software. The factors affecting software supportability can be obtained based on the analysis of these elements, which in turn builds an evaluation index system of user-oriented software supportability.

Fig.1 indicates the whole process of the construction of the evaluation index system of customer-oriented software supportability.

### 3. Analysis of the use and Support of the Military Software

At present, the troops mainly undertake software installation, deployment, upgrade, maintenance and uninstallation, software operating environment configuration, data loading, uninstallation and maintenance, software replication and distribution, and software virus during the software use process.

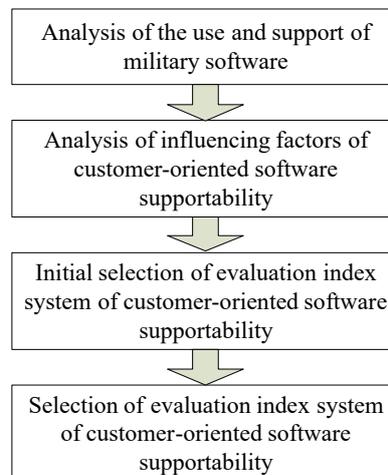


Fig.1 Basic Process of Establishing Software Support Assessment Index System

The whole process of the construction of the evaluation index system of customer-oriented software supportability such as Fig 1.

The elements affecting such tasks as the protection, daily management and problem reporting of software can be obtained through detailed analysis of the steps, methods and methods of the force to carry out these tasks, and then the elements affecting user-oriented software supportability can hereby be determined. See Table 1 for the Analysis of the Use and Support of the Troops' software

**Table 1. Analysis of the Use and Support of the Troops' software**

<b>Serial number</b>	<b>Work items</b>	<b>The main steps</b>	<b>Analysis of main impacts</b>
1	Software installation and deployment	Including such steps as the software infrastructure configuration (installation of operating systems, and business software, etc.), development of software installation package or deployment package, software system installation, etc.	<p>Firstly, it is the design of the software itself, such as its requirements for operating system and database, installation methods and interconnection methods, etc.;</p> <p>Secondly, it is the support recourses of software, such as technical resources, supporting software resources and related equipment and tools;</p> <p>Thirdly, the number and technical level of software support personnel, which directly affect the implementation of software support.</p>
2	Database installation and configuration	Including database installation, configuration and maintenance, etc.	
3	Software operating environment configuration	It is mainly for the environment configuration after successful installation, such as IP configuration, interconnection with other software, etc.	
4	Software configuration change and maintenance	It mainly refers to the addition, deletion, modification, etc. of related software functions in accordance with requirements during software operation.	
5	Data loading, unloading and maintenance	It mainly includes backup, recovery, loading, and uninstallation of business data.	The difficulties in this work are mainly determined by the way data is loaded, unloaded and maintained, which is determined by its own design characteristics.
6	Software copying and distribution	The main work is the replication of the new version of the software and the distribution to each unit.	The main factors affecting software replication are the size of the software and the completeness of the related equipment. The software distribution is mainly related to the size and distribution method of the software. For example, the distribution through network can greatly reduce the workload and time.
7	Software virus protection	The main tasks include daily virus checking and killing and recovery after poisoning.	The influencing factors are mainly whether the resources such as virus killing software are installed and updated regularly.
8	Daily management of software	It mainly includes the daily management of software and its documentation to ensure that the software version is controlled without confusion.	The influencing factors are mainly management tools and means and the rules and regulations on the management of software kit.
9	Remote support for software	It mainly includes software problem reports, remote consultation and support, etc.	Influencing factors include service hot lines, website and other support resources, as well as supporting after-sales policies.

#### **4. Analysis of Influencing Factors of Software Supportability**

Based the above analysis of the main software use and support work of the troops, it can be concluded that the main factors affecting software supportability mainly include 4 major categories:

firstly, it is the basic attributes of the software, which are all attributes that reflect the state of the target software system, indicating the state of the target software in a certain stage during its life cycle from the development to decommissioning, such as the amount of software deployed, the use frequency of software, importance of software, frequency of software maintenance or update, software active time, software programming language and software confidentiality requirements; secondly, it is the software design features, such as software installability, upgradability, simplicity, etc.; thirdly, it is the software support resources, which include related technical materials, tools and equipment, technical level of personnel, etc.; fourthly, it is the management policies and systems of related software kit, such as management system of software versions, reporting system of software problems, and after-sales service system of software. See Table 2 for the analysis of all the influencing factors of software support.

Table 2. Analysis of Influencing Factors of Software Supportability

<b>Type of influence factors</b>	<b>Influencing factors</b>	<b>Note</b>
The basic attributes of software	The amount of software deployed	The amount of software deployed reflects the extent to which the software is deployed in the military. The larger the amount of deployment is, the greater the corresponding workload of support will be.
	Software category	The software category determines the importance of the software to a certain extent, such as the software of weapon systems software is more important than the software of supporting equipment.
	The use frequency of software	The use frequency of software also affects the amount of workload of software support. If a software system is rarely used, the support requirements will naturally be very small.
	The importance of software	The importance of software also directly determines the importance of software support, and the software with high criticality results in higher support requirements.
	The frequency of software maintenance or update	The frequency of software maintenance or update reflects the stability of the software. If the software maintenance and update is frequent, it needs more maintenance support.
	The active time of software	The longer the active time of the software is, the more difficult its support will be. It will be difficult to meet the requirements for the basic environment of the hardware and software and related personnel.
	Software programming language	The software programming language fundamentally affects the maintenance and support of the software. If the programming language is a language that is less demanding and easy to maintain, the written software will be easy to maintain.
	The requirement for confidentiality of software	There are special requirements for management and support for software with high confidentiality requirements. For example, it cannot be distributed

		through the network. It must undergo strict confidentiality approval procedures to carry out corresponding management and support. All of these bring inconvenience to software management and support.
	Software development workload/Development cycle	Generally, the software development workload also reflects the size of the software. The larger the development workload and the longer the cycle is, the larger the software size and corresponding workload of software management and support will be.
The design feature of software	Software size	The larger the software size is, the longer the installation and deployment time will be. Correspondingly, there will be more hidden defects and faults, and greater maintenance workload.
	Number of software components	The number of software components reflects the size of the software from another aspect. The more components or configuration items are, the more interfaces the system has. Correspondingly, the compatibility and interoperability between the systems will decrease, especially in the case that these components are developed by multiple units. If the corresponding specifications are not complete and the management coordination is not timely, the problem will be more prominent.
	Software installation	The software installation way has a great impact on the software support. If the one-button unattended installation is employed, the workload is the smallest. If there is no auxiliary installation wizard, the installation is the most difficult. In addition, if the system requires the user to customize the installation package in line with its own needs and there is no more detailed installation and deployment guide, the installation will be very difficult.
	Software upgrade path	The software upgrade paths mainly include: on line upgrade, new installation upgrade, incremental upgrade, etc. It is the most undesirable upgrade path to firstly uninstall the old software completely, and then install the new software. It is recommended to employ the incremental upgrade and on-line upgrade. It needs less workload of support and costs less time.
	Operating system requirements	The operating system has a greater impact on the software maintenance support. The software of the commonly used operating system is easier to support.
	Database requirements	Software systems with lower requirements on the database are easier to support. Some software systems need to be installed with a separate database system, which requires more support.

	Hardware requirements	Software systems that do not have strict hardware requirements are easier to support. Too high or low requirements for hardware not conducive to the development of software support. Too low requirements make it difficult to find outdated products from the market. Too high requirements may lead to greater costs of support.
	Software reliability	Software reliability determines the frequency of software maintenance and support, and determines the workload amount of maintenance and support.
	The distribution methods of software	The distribution method of software determines the timeliness of software distribution. If the network or satellite can be employed for distribution, the distribution efficiency will be higher, and the support will be easier.
	System recovery mode	The system recovery mode determines the ability of the software to return to the working state as soon as possible under emergency conditions (such as system crash, attack, etc.). If one-click recovery is available, the system is easy to recover.
Support resources of software	Support equipment	The access of replication and distribution device, and the analysis equipment for software maintenance and support
	Support tools	Auxiliary analysis, diagnostic tools, remote support platform, hot line, etc.
	Support personnel	Number of personnel specialized in software maintenance and their technical level, etc.
	Technical materials	The completeness, correctness and accessibility of technical materials, it is best to have an auxiliary electronic technical manual.
	Basic software	It mainly refers to the basic environment and related business software systems necessary for running the supported software system, such as operating system software, database software, Office Software and related necessary business software, etc., and it also need to pay attention to the version requirements of these software.
Management of software support	Software support Agency	It is the prerequisite for the normal operation of software support to have clear organizations and personnel in charge of software maintenance and support.
	Support system of software	It is the guarantee for the smooth implementation of software support to have clear related regulations, systems and operational procedures for software support.
	Management of software version	Management of software version can avoid confusion in the software versions, which may cause deployment software to fail or conflict due to version inconsistency.

## 5. The Construction of the Evaluation Index System of Software Supportability

Based on the above detailed analysis of the factors affecting software support, it is possible to initially establish an evaluation index system of customer-oriented software support. The index system has three layers. The first layer is the target layer, that is, the software support level; the second layer is the factor layer, which mainly includes four factors: the basic attributes of software, the design feature of software, support resources and management factors; the third layer is the criteria and index layer, which is a specific decomposition of various factors.

The index system is mainly constructed through steps such as primary selection of index system, analysis of membership degree and analysis of correlation of index.

### 5.1 Primary Selection of Index System

Initial evaluation index system of software support is constructed based on influencing factors of software support listed in Table 2. The third layer contains a total of 27 guidelines or indexes. Get the pre-selected index set as  $X^{(0)} = (X_1, X_2, \dots, X_l)$ .

### 5.2 Analysis of Membership Degree

View the evaluation index system  $X^{(0)}$  as a fuzzy set, and each index as an element, and analyze the membership degree of each index. If the membership degree of index  $X_i$  in Fuzzy set  $X^{(0)}$  is large, it indicates that the subordinating degree of index  $X_i$  in Fuzzy set  $X^{(0)}$ , is large. As a result,  $X_i$  is important for the Fuzzy set. There are many methods for fuzzy mathematics to determine the membership degree of elements in fuzzy sets. The most commonly used methods are fuzzy statistics and binary contrast sorting. Artificially determined threshold  $M_l$  ( $0 < M_l < 1$ ), retain the index  $(X_i) > M_l$ , and set the second selected index as  $X^{(1)} = (X_1, X_2, \dots, X_k)$  ( $k < l$ ).

A binary contrast sorting method based on fuzzy set theory is adopted.

① Establish the important matrix of binary comparison

Let the number of indexes included in each subsystem be  $P$ , compare each pair of indexes, a matrix can be obtained as follows:

$$B = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1p} \\ b_{21} & b_{22} & \cdots & b_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ b_{p1} & b_{p2} & \cdots & b_{pp} \end{bmatrix}$$

Based on the relevant principles of the binary contrast sorting method in fuzzy set theory, the scaling relation  $b_{ij}$  of “complementarity” of each elements in matrix  $B$  is as follows:

$$\begin{cases} 0 \leq b_{ij} \leq 1 & i \neq j \\ b_{ij} = 0.5 & i = j \\ b_{ij} + b_{ji} = 1 & i \neq j \end{cases}$$

In the formula:  $b_{ij}$  means the importance of  $x_i$  for  $x_j$  when making a binary comparison,  $b_{ji}$  means the importance of  $x_j$  for  $x_i$  when making a binary comparison. If  $x_i$  is more important than  $x_j$ , then  $b_{ij} > 0.5$ , and  $b_{ji} < 0.5$ . If both are equally important, then  $b_{ij} = b_{ji} = 0.5$ . Especially if  $x_i$  is much more important than  $x_j$ , then  $b_{ij} = 1$ , and  $b_{ji} = 0$ . Because it is as important as oneself, so when  $i = j$ ,  $b_{ij} = b_{ji} = 0.5$ , then the correlation matrix for importance is:

$$a = \begin{bmatrix} 1 & \frac{b_{12}}{b_{21}} \wedge 1 & \cdots & \frac{b_{1p}}{b_{p1}} \wedge 1 \\ \frac{b_{21}}{b_{12}} \wedge 1 & 1 & \cdots & \frac{b_{2p}}{b_{p2}} \wedge 1 \\ \vdots & \vdots & \vdots & \vdots \\ \frac{b_{p1}}{b_{1p}} \wedge 1 & \frac{b_{p2}}{b_{2p}} \wedge 1 & \cdots & 1 \end{bmatrix}$$

② Sorting and normalizing

Take the minimum value for each row of the above matrix to get:

$$\varpi = (\varpi_1, \varpi_2, \dots, \varpi_p)$$

$$= (1 \wedge \frac{b_{12}}{b_{21}} \wedge \cdots \wedge \frac{b_{1p}}{b_{p1}}, \frac{b_{21}}{b_{12}} \wedge 1 \wedge \cdots \wedge \frac{b_{2p}}{b_{p2}}, \dots, \frac{b_{p1}}{b_{1p}} \wedge \frac{b_{p2}}{b_{2p}} \wedge \cdots \wedge 1)$$

Normalize  $\varpi_i$ :  $\varpi_i = \frac{\varpi_i}{\sum_{i=1}^p \varpi_i}$

Then we can get the order of the importance of each index to the upper targets ( $\omega_1, \omega_2, \dots, \omega_p$ ), it can be viewed as the initial weight of an index.

5.3 Index Correlation Analysis

There is a certain degree of correlation between the index variables, which makes the information reflected by the observation data overlap. The index correlation analysis is to eliminate the influence of highly relevant indexes on the evaluation, thereby reducing the number of indexes in the evaluation index system. The specific method is as follows: firstly, the data transformation process is performed. Since the indexes in the evaluation index system can be divided into positive indexes and inverse indexes, the formulas for data transformation are also different.

The positive indexes are:

$$Z_{ij} = \frac{X_{ij} - \min_i \{X_{ij}\}}{\max_i \{X_{ij}\} - \min_i \{X_{ij}\}}$$

The inverse indexes are:

$$Z_{ij} = \frac{\max_i \{X_{ij}\} - X_{ij}}{\max_i \{X_{ij}\} - \min_i \{X_{ij}\}}$$

Secondly, calculate the simple correlation coefficient between the two indexes  $r_{ij}$ , the calculation formula is:

$$r_{ij} = \frac{\sum_{k=1}^n (Z_{ki} - \bar{Z}_i)(Z_{kj} - \bar{Z}_j)}{\sqrt{\sum_{k=1}^n (Z_{ki} - \bar{Z}_i)^2} \sqrt{\sum_{k=1}^n (Z_{kj} - \bar{Z}_j)^2}} \quad \text{where } \bar{Z}_j = \frac{1}{n} \sum_{k=1}^n Z_{kj}$$

In case  $r_{ij} > M_l$ , the indexes  $X_i$  or  $X_j$  can be removed, in case  $r_{ij} < M_l$ , both indexes  $X_i$  and  $X_j$  shall be retained. The indexes retained after comparing constitute the index set after the third selection, let it be  $X^{(2)} = (X_1, X_2, \dots, X_p)$  ( $p < k$ ).

In this paper, five software systems in use are selected, and the evaluation index system which has been selected in this paper is used to score the evaluation, and the analysis of membership degree and index correlation are carried out respectively.

See Table 3 for the finally constructed evaluation index system of software support

Table 3. The Evaluation Index System of Software Supportability

Target layer	Factor layer	Index layer	Initial weight	Weight after selection
Level of software support-ability	Basic attributes of software (P) (0.17)	The amount of software deployed	0.25	0.25
		Software categories	0.05	Remove
		The use frequency of software	0.07	0.1
		The importance of software	0.08	0.1
		The frequency of software maintenance or update	0.15	0.2
		The active time of software	0.1	0.1
		Software programming language	0.15	0.15
		The requirement for confidentiality of software	0.05	Remove
		Software development workload / Development cycle	0.1	0.1
		The design features of software (S)(0.51)	Software size	0.2
	Number of software components		0.1	Remove
	Software installation		0.2	0.2
	Software upgrade path		0.1	Remove
	Operating system requirements		0.05	0.05
	Database requirements		0.12	0.17
	Hardware requirements		0.08	0.08
	Software reliability		0.05	0.07
	The distribution methods of software		0.05	0.08
	Support resources of software (D)(0.20)	System recovery mode	0.05	0.07
		Support equipment	0.3	0.3
		Support tools	0.2	0.2
		Support personnel	0.35	0.35
	Management Factors of Software Support (C) (0.12)	Technical materials	0.15	0.15
		Software support Agency	0.35	0.35
		Support system of software	0.35	0.35
		Management of software vision	0.12	0.12

## 6. Conclusion

This paper analyzes the use and support of the military software and obtains the main influencing factors. On this basis, the initial evaluation index system of software support is constructed. After the

analysis membership degree and correlation, the evaluation index system of software support is finally determined. The built evaluation index system of software support can be applied to all types of software. But for different types of software, the scoring criteria for the indexes and the weights may vary, requiring adaptive adjustments. The index system constructed in this paper can be applied to evaluate the software supportability, then find the weak links and make tailor-made improvement.

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