Research on Computer Aided Innovation Model of Weapon Equipment Requirement Demonstration

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Abstract. Firstly, in order to overcome the shortcoming of using only AD or TRIZ solely，and solve the problems currently existed in weapon equipment requirement demonstration, the paper construct the method system of weapon equipment requirement demonstration combining QFD ,AD,TRIZ,FA . Then, we construct a CAI model frame of weapon equipment requirement demonstration, which include requirement decomposed model, requirement mapping model and requirement plan optimization model. Finally, we construct the computer aided innovation model of weapon equipment requirement demonstration, and developed CAI software of equipment requirement demonstration.

Keywords: Computer aided innovation model, requirement, QFD, TRIZ, FA, AD

1 Preface

Weapon equipment requirement demonstration is the key link of weapon equipment development, the translating process from complicated military affairs requirement to material equipment capability parameter, the important gist to confirm weapon equipment develop project. Requirement traction and technology drive is the motivity and foundation of weapon equipment development. The main problem of weapon Equipment requirement demonstration is how to realize the quantitative mapping from operation task to equipment capability parameter, how to analyze and solve contradictive problems during the process of the demonstration and bring out technique innovation project. By applying advanced method and constructing computer-aided innovation model of equipment requirement demonstration, we can make weapon equipment requirement demonstration quantitative, structured and normative. That could enhance demonstration quality and efficiency of weapon equipment requirement demonstration.

2 Applying Analysis of Demonstration Method

The process of weapon equipment requirement demonstration is a complicated systems engineering, and it is more complicated than the requirement demonstration process of general civilian industry product. AD（Axiomatic Design） and TRIZ （Theory of Inventive Problem Solving） are applied widely on the region of product conceptual design, and both have applying predominance. But, when they are applied solely in weapon equipment requirement demonstration, both have disadvantage.

The aim of AD is to establish an axiomatic system based on scientific axioms and principles for the design activity traditionally based on experience. AD have powerful function to define and analyze system, but it has no practical tool to solve concrete problem. Besides, AD only makes macroscopic guidance with independence axiom and information axiom, it does not normalize the process of demonstration. TRIZ is science about system innovation, its main function is to solve the functional problem of main requirement of a system, but its defect is it can not solve the problem meeting entire system requirements. Moreover, TRIZ may solve concrete innovation problem preferably, but its systematic analysis tool is not so powerful comparatively.

QFD is a structured and systemized tool. Its basic principle is to convert the qualitative requirements of user to concrete and instructive design requirement. QFD is a very structured matrix-driven process; it decomposes user requirements into layer of layer mapping between the four demonstration phases. It has great value with the standardization of weapon equipment requirement demonstration.

FA(Function analysis) is a method term in system engineering used to analyze functional requirements and decompose them into single work or activity. It provides Primary system functions with hierarchical development mode and decomposes it into sub functions thoroughly. FA can decide the function scope and their relationship for functional decomposition and provide support for decomposition of weapon equipment requirement demonstration.

The innovative method of weapon equipment requirement demonstration combining QFD ,AD、TRIZ,FA can fully bring into play the capability of system definition and systematic analysis of AD, the capability of solving concrete problem of TRIZ , functional decomposition capability of FA and the excellence of functional decomposition and the excellence of matrix-driven of QFD . It overcome the shortcoming of using only AD or TRIZ solely，and can solve the problems currently existed in weapon equipment requirement demonstration.

3 CAI Model Frame Of Weapon Equipment Requirement Demonstration Based on AD/QFD/TRIZ/FA

Weapon equipment requirement demonstration can be reduced to three step demonstration process between three demonstration regions. The purpose of weapon equipment demonstration is to realize the quantitative mapping from operation task requirement region to operation capability requirement region and from operation capability requirement region to equipment capability parameter requirement region.

The material demonstration process could be broke into requirement decomposed step, requirement mapping step and requirement plan optimization step. So, we construct a CAI model frame of weapon equipment requirement demonstration, which include requirement decomposed model, requirement mapping model and requirement plan optimization model. It can give full play to the advantage of AD, QFD, TRIZ and FA, and realize quantitative analyses and aided innovation analyses. Figure 1 show the CAI model frame of weapon equipment requirement demonstration.

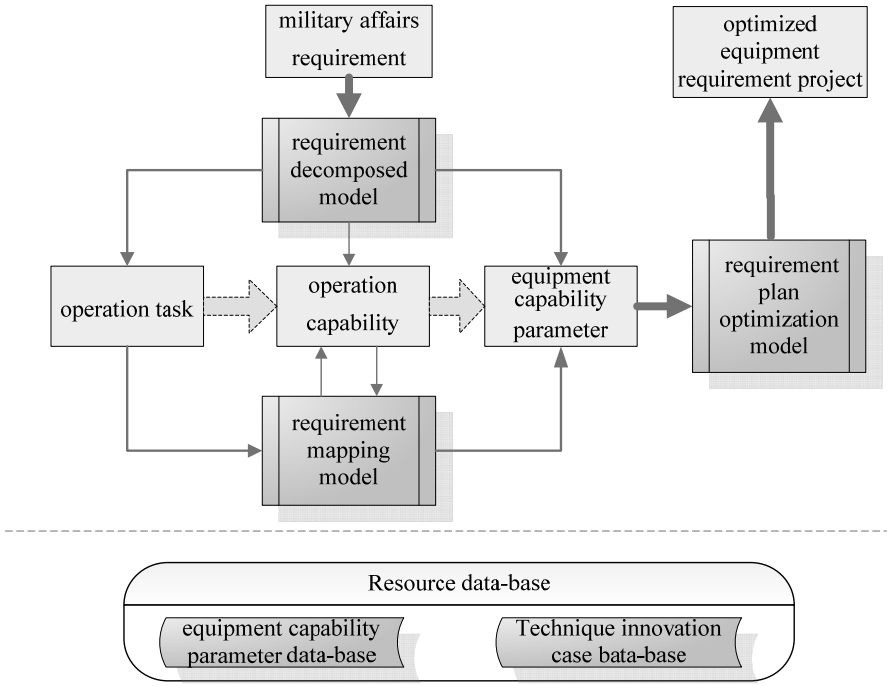

Fig. 1. CAI model frame of weapon equipment requirement demonstration.

Requirement decomposed model uses the functional decomposition frame of FA to decompose the requirements frame in demonstration fields of operation task ,operation capability, equipment capability layer by layer and form requirements decomposition tree; It uses AD to optimize and analyze the structure of decomposition tree and find well-structured and comprehensive decomposition tree to provide us with requirement singleton.

Requirement mapping model adopts QFD to construct HOQ of requirement mapping, it supports the demonstrators by providing importance analysis of requirement index, requirement conformity analysis and aid decision making. It realizes the layer to layer mapping in the three fields of operation task, operation capability, equipment capability for requirement set formed in the first phase in demonstration fields and form primary equipment capability requirement project.

Requirement plan optimization model uses HOQ of QFD to assist deciding technical contradiction in requirement plan and uses TRIZ to carry out innovation analysis for technical contradiction and provides final optimized plan.

4 Construction of Computer Aided Innovation Model of Weapon Equipment Requirement Demonstration

4.1 Requirement Decomposed Model Based on FA and AD

Decomposition of a system may be regarded as an approach to solve the problem "from top to bottom", thus forms a hierarchical tree structure, it decomposes the technical requirement and distributes it to the lowest layer that can meet describable technical requirement according to the structure. FA provide us with the hierarchical tree structure to analyze the function, but in order to ensure the rationality, AD should also be introduced to normalize the process of decomposition mapping.

The independence axiom of AD provide guarantee for the standardization and validity of requirement decomposition, it is required to keep the independence of function requirement. In the process of requirement decomposition, it is necessary to ensure each sub-requirement is independent.

The process of requirement mapping can be described as a eigenvector, and it can be used testing the validity of requirement decomposition. For example，when we realize the requirement mapping from operation capability to equipment capability parameter, the operation capability requirement set decomposed from operation capability can be described as a vector $\{F\}$. At the same time, equipment capability parameter set can be described as a vector $\{\mathrm{C}\}$. So, the relation between the two vector can be described as the expressions.

$$\{F\} = [A]\{C\} \tag{1}$$

$[A]$ is the mapping matrix. When $[A]$ is a diagonal matrix, it is a non-coupling design, and each operation capability can be meet by one corresponding equipment capability parameter. When $[A]$ is a triangular matrix， it means it is a semi-coupling design，only by deciding equipment capability parameter according to the correct order, can we ensure the independence of operation capability. When $[A]$ is a normal matrix，it is a coupling design，and it shows that the equipment capability parameter effect each other and do not meet the requirements of operation capability。The anterior two case show we have a proper process of requirement Decomposition. However，the last cases show we must decomposed the requirement again, and must decomposed the requirement correctly.

$$\begin{vmatrix} X & 0 & 0 \\ 0 & X & 0 \\ 0 & 0 & X \end{vmatrix} \qquad \begin{vmatrix} X & 0 & 0 \\ X & X & 0 \\ X & X & X \end{vmatrix} \qquad \begin{vmatrix} X & X & X \\ X & X & X \\ X & X & X \end{vmatrix}$$

Non-coupling design Semi-coupling design Coupling design

Fig. 2. The three format of mapping matrix

（X represents strong effect each other，0 represents weak effect each other）

4.2 Requirement Mapping Model Based on QFD

The decomposition of demonstration problems using the method of AD and FA also forms the foundation of quantification analysis. Based on this, use HOQ mapping matrix constructed with QFD to quantify and analyze demonstration information. The format of QFD HOQ is as Figure 3: when adopted in the mapping between the fields of weapon equipment requirement demonstration , the meaning of seven parts is used to represent different content. Here we adopt the construction of HOQ of process of the mapping from operation task to operation capability as an example to explain the construction method. （1）represents operation task （2）represents the importance of operation task（3）represents operation capability（4）represents the relationship between operation task and operation capability（5）represents the relationship between operation capabilities,(6) represents evaluation matrix，（7）target value matrix.

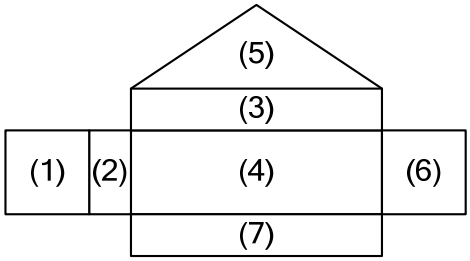

Fig. 3. HOQ

Using mapping analysis matrix provided by HOQ, we can establish the relationship between task requirement and capability requirement, decide the importance of capability requirement for task requirement and provide basis for quantitative analysis of deciding operation capability; analyze satisfaction degree of equipment operation capability for operation task and find the bottleneck factor that effects the whole requirement plan to provide quantitative analysis basis for improving requirement plan.

4.3 Requirement Plan Optimization Model Based on QFD and TRIZ

TRIZ is not only used to solve the problems in the field of mechanism design, it is also widely used in other fields. Introducing TRIZ into weapon equipment requirement demonstration can effectively analyze the design contradiction in requirement plan。Equipment technique innovation analysis based on QFD/TRIZ do the equipment requirement mapping with method based on QFD, use HOQ to confirm the design contradiction in requirement plan, then use TRIZ to solve technical contradiction.

The process of solving the design contradiction of equipment capability parameter in weapon equipment requirement plan :Use QFD to construct coupling analysis matrix for equipment capability parameter, if there is coupling, judge whether it is physical contradiction or technical contradiction .If it is physical contradiction ,use separation principle to renew equipment requirement capability plan ; If it is technical contradiction, use contradiction matrix in TRIZ to carry out innovation plan to provide innovation reference plan for equipment development.

5 Developing Software

A software of equipment requirement demonstration computer-aided innovation was work out, and it greatly enhanced the efficiency and quality of requirement demonstration .

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