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Value Engineering/Value Management Model and Application of Aerospace Projects

Abstract This paper presents a new space model developed by general value engineering/value management model. The authors take the function analysis, function optimization and function realization of the development object as the basic point, to get the final optimization structure by value evaluation, so as to improve the project quality and reduce the project cost. The final case shows that the application of this model can save about 18% of the time and considerable cost of the usually planned projects under the condition of quality assurance.

Keywords: aerospace project, value engineering, value optimization, value stream, design structure matrix

1 Introduction

International space technology has entered a rapid development period. At present, China's space transportation system's big trend is the market development. Historically, aerospace has high risk, high cost and time-consuming features. Value engineering as the management theory and method with the combination of technology and economy, plays an irreplaceable and important role in the development of the space system.

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This thesis proposes a new theoretical model based on the introduction of value engineering/value management (VE/VM) into the space system. The model provides a new idea for the structural optimization of the space system development process and may well improve the function value and the cost management of the project.

2 Theoretical overview

During the Second World War, USA supplied management required projects to be on time, efficient and low cost. Value engineering by Miles, introduces operational research into the field of industrial management, which has become one of that six new management techniques. It is an organized technical and economic thinking method and management technology which focuses on functional analysis (Qiu, 2007). The core content is to research how to ensure the necessary functional reliability (products and work or services, etc.) with the lowest life cycle cost and to achieve the functions and enhance the value of the system, thereby evaluate the effectiveness of the value engineering activity.

Value stream analysis (VSA) is an important management tool for planning continuous process improvement activities and helping an organization to identify and eliminate waste during the process, so that the organization can deliver satisfaction with the products and services to the customer, faster and at a lower cost (Yang & Qiu, 2006). The main technical means used in the process of analysis is the design structure matrix. It is a square matrix with n rows and n columns, which can be used to display the interaction of the elements in the matrix, and it can be used to analyze complex projects (Yang, Lv, & Huang, 2012).

The initial value engineering theory focuses on the space dimension, and the initial value flow theory focus on the time dimension. In view of the complexity of the space system development process, the authors propose a new model which combines the dimensions of time and space. The model provides an effective method for the sequence of activities as to provide an overall description of the whole system and to analyze the information needs of the activity.

3 Functional/value/structure theory model

In the process of the aerospace project development, the functional analysis is the first step, and the basic symbols are shown in Table 1. The essence of value engineering is to carry out the function of project implementation (analysis). It is divided into four steps: functional definition, functional classification, functional finishing and functional evaluation. Of course, because of the complexity of the system, the function (value) optimization is indispensable. The final product function is to be completed during the process, and manufacturing etc.

In this process, the value analysis is the decision-making, identifying and solving the problem, and the structure of the task set. The adjustment of the entire development process is based on the analysis of the function and value analysis. All this must be through the repeated communication to the personnel and with the information.

In order to optimize the resource, this paper constructs the function/value/structure theory model for an aviation development team. The main idea is to study the relationship between the development and the function of the project, and to realize the structure optimization of the space research and development projects with taking the value optimization as the core (Yang & Qiu, 2006). This optimization is usually time and expense of synchronous collaborative optimization.

In the process of functional analysis, first of all, according to the technical dimension of R&D object, the authors take a task which is similar in nature, the relationship is closely linked to the project subsystem, and to assign each subsystem to each sub team; moreover, according to the subsystem in the R&D process possible communication, iteration and feedback of information flow, cluster stator team. On this basis, combining the project time, cost and quality objectives, the authors determine the value of each part of the content of the research so as to determine the link within the team and between the team and evaluate resources, information, and personnel flow. Finally, according to the value stream analysis, the authors determine which team tasks need to be adjusted, combined, which teams need to adjust, merge. After the value optimization of the final research object, the authors determine the structure of the task, the structure of the research and development team and the process structure of the research and development projects. Namely, this is the core of the functional/value/structure theory model proposed in this paper.

Special emphasis: the connotation of the model includes not only interaction between the ring internodes in the process, but also the entire process requires much rework and communication; The team also needs to design the function of these links and evaluate the design results with statistical analysis, and further reveal the opportunity of process improvement based on the functional analysis. According to the data obtained from functional analysis, the value flow of the design process is analyzed, and the key point of the next level of value stream analysis is defined. The further development of a sub process of the value flow is analyzed and the process of design and research with regard to the reduction of waste and opportunities for improvement are identified, developed and guidance system to improve activities is also identified. This is the core idea of value optimization.

In addition, the optimization process is realized by the continuous process of improvement. According to the importance of the function dimension and value dimension of the system design and development, the authors give different weight and optimization of the process integration according to the comprehensive evaluation, so as to improve the speed of R&D projects, reduce the cost of R&D projects and improve the quality of research and development.

Finally, this paper extends the theory of design structure

Table 1

Function/Value/Structure Model with Symbols

Function symbol		Value symbol		Structure symbol	
	Function analysis		The decision procedure		Task start and end
	Function optimization (draw and design)		Need to pay attention to the problem		Task sequence
	Function implementation (process and manufacture)		Information, personnel exchange	––––––	If you have problems returned to the original condition

matrix (DSM). The research and development tasks are divided and combined on the basis of value stream and form a new research task , and mapping for the new R&D team structure. Eventually, the function/value/structure model is presented in this paper.

Anyway, the technological dimension and management dimension as the starting point, function analysis and value analysis as the starting point, value optimization as the core, the authors improve the value of scientific research team of R&D activities, eventually formed the development task structure, program structure and team structure form.

4 Case application

Value engineering can be applied to the manufacturing, assembly process and quality management of spacecrafts, the economic and technical indicators of the aerospace system, the cost of space transportation system, space transportation system control and so on. This paper takes the development of the electronic system of the spacecraft as a case, and elaborates the application and advantages of the theory model of this paper.

In the process of the development of a spacecraft electronic system, according to the physical function analysis and function realization process which includes the necessary procedures, the authors determine the initial research and development process and the project decomposition is decomposed into 26 sub missions, as shown in Table 2.

The authors use the model of this paper to carry out the function /structure /value analysis model on the basis of the above analysis, and to determine the content of task partition, team assignment and the relationship between tasks. In the concept design and overall design, there is a relationship between the first tasks. But overall design control strategies and the overall design load design and calculation part of the information generated will influence the design part of the concept of unit boundary conditions and key parameters of design, has significant dual control, so it is necessary to consider the duality between the control of rework and iterative development process in the analysis of product conceptual design and the overall design. Accordingly, the duality relationship is also the key of the value stream improvement. According to the analysis, the structure of the project is formed as shown in *Figure 1*.

Because there are variety of possibilities in task decomposition and task sequence, the matching between tasks and teams also has many possibilities. To achieve optimal matching and decision, on the basis of the above model and DSM theory, the initial design only consider research object function distribution, decentralized small team structure corresponding to the DSM value matrix. Then, the authors evaluate the various R&D object function between contact and sub teams and evaluate multi class information communication, evaluate the core of task structure and team structure mapping based on 1 to 1 function analysis. By means of contrast, substitution, sorting, and recombination of optimization, the authors obtained a new system optimized matrix according to the function, value and structure of collaborative optimization, as shown in *Figure 2* (Qiu, 2007; Yang & Qiu, 2006).

The core content is to get more detailed information by the four steps of the function definition, function classification, functional finishing and evaluation, so as to allocate the similar functional properties task to each team development. Table 3 gives the team segmentation results.

Compared with the traditional design structure matrix (DSM) which only considers the design object of the information flow, the expanded design structure matrix includes information flow, decision points, problems and

Table 2

The Research Task Instructions and Code

Task code	R1	R2	R3	R4	R5	R6	R7	R8	R9
Task name	Design requirement	Hardware design	DSP core design	Memory design	PLL and DAC design	Peripheral interface circuit design	Circuit layout	Assembly PCB	PCB test
Task code	R10	R11	R12	R13	R14	R15	R16	R17	R18
Task name	Software design	Compressed encoding design	Compressed encoding test	Compression decoding design	Compression decoding design	FPGA platform simulation	FPGA simulation platform before tapeout	Tape out	Main processor driver development
Task code	R19	R20	R21	R22	R23	R24	R25	R26	
Task name	Main processor driver test	Main processor communication program development	Main processor communication program test	Co-processor response program development	Main processor response program test	Integrated design	Integrated test	Test report	

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26
R1	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R2	0.5	0	0.2	0.3	0.4	0.2	0	0	0.7	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R3	0.2	0.3	0	0	0	0.1	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R4	0.2	0.4	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R5	0.2	0.4	0	0	0	0.1	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R6	0.2	0.5	0.2	0	0	0	0	0.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R7	0.3	0.6	0.1	0.1	0.1	0.4	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R8	0.1	0	0.1	0.1	0.1	0.5	0.9	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R9	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R10	0.4	0	0	0	0	0	0	0	0	0	0.2	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0
R11	0.1	0	0	0	0	0	0	0	0	0.5	0	0.5	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0
R12	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R13	0.1	0	0	0	0	0	0	0	0	0.6	0.2	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0
R14	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0
R15	0	0	0	0	0	0	0	0.5	0	0.4	0.2	0.1	0.2	0.1	0	0.5	0	0	0	0	0	0	0	0	0	0
R16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0
R17	0.2	0	0	0	0	0.5	0.7	0.6	0	0.3	0.1	0.1	0.1	0.1	0.5	0.7	0	0	0	0	0	0	0	0	0	0
R18	0.3	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0.5	0.4	0.6	0	0	0	0	0
R19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0
R20	0.2	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0.2	0	0	0.5	0.2	0	0	0	0
R21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0
R22	0.1	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0.5	0	0	0.5	0	0	0
R23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0
R24	0.5	0.7	0.1	0.1	0.1	0.3	0.2	0.1	0	0.4	0	0	0	0	0	0	0	0.3	0	0.4	0	0.2	0	0	0. 4	0
R25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0
R26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0.4	0	0.3	0	0. 7	0

Figure 1. The task of research and development influence matrix.

other types of information, not only the transfer of information between R&D object parameters. Although the form is similar, the content is different. The authors take into account the design and management of content, so in the formation of a team to optimize the decomposition and optimization processes. The functional analysis is not only based on the physical functions of the dimensions of object technology research and development, but also based on the management dimension of R&D team. To a sub team, the number can fully communicated internally to the sub team and at the same time consider the technical dimension of R&D, which can more easily solve the problems. Thereby the model can reduce development time and cost, increase in the quality of research and development. This also reflects the so-called value engineering theory and technology and management thinking.

A comparison of the schemes of the value optimization has been carried out. Original R&D program time is 440 days, but optimized project's time is 360 days, 80 days less than original R&D program time, that is, saving 18.18% of the original planning time. The cost of the original R&D project is 1,103 million CNY, the optimized cost is 867 million CNY, the optimized project saves 235 million CNY, accounted for 21.3% of the planned cost. This shows that the application of the value engineering analysis method can not only reduce the cost of the project, but also can bring about significant savings for the project resource utilization, processing cost and time savings.

5 Conclusions

Since the early 1990s, the authors have been cooperating with space project teams and built a technical and economic analysis model and lifecycle financial management mode, then the CE-1 (the goddess of the moon exploration project) project and other 7 space projects successfully used the VE/VM model, which solved many space project problems, saved funds and improved the project performance. It has proved that the value engineering not only realizes the project quality improvement and cost saving, but also makes the project team management effective and improves the overall project performance. The authors are convinced that the value optimization of

	R1	R10	R2	R4	R5	R3	R6	R7	R8	R9	R13	R11	R14	R12	R15	R16	R17	R20	R21	R22	R23	R18	R19	R24	R25	R26
R1	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R10	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R2	0.5	0.3	0	0.3	0.4	0.2	0.2	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R4	0.2	0	0.4	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R5	0.2	0	0.4	0	0	0	0.1	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R3	0.2	0	0.3	0	0	0	0.1	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R6	0.2	0	0.5	0	0	0.2	0	0	0.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R7	0.3	0	0.6	0.1	0.1	0.1	0.4	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R8	0.1	0	0	0.1	0.1	0.1	0.5	0.9	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R9	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R13	0.1	0.6	0	0	0	0	0	0	0	0	0	0.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0
R11	0.1	0.5	0	0	0	0	0	0	0	0	0.3	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0
R14	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R12	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R15	0	0.4	0	0	0	0	0	0	0.5	0	0.2	0.2	0.1	0.1	0	0.5	0	0	0	0	0	0	0	0	0	0
R16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0
R17	0.2	0.3	0	0	0	0	0.5	0.7	0.6	0	0.1	0.1	0.1	0.1	0.5	0.7	0	0	0	0	0	0	0	0	0	0
R20	0.2	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.2	0	0.2	0	0	0	0
R21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0
R22	0.1	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0.5	0	0	0	0	0
R23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0
R18	0.3	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.6	0	0	0	0.5	0	0	0
R19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0
R24	0.5	0.4	0.7	0.1	0.1	0.1	0.3	0.2	0.1	0	0	0	0	0	0	0	0	0.4	0	0.2	0	0.3	0	0	0. 4	0
R25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0
R26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0.3	0	0.5	0	0. 7	0

Figure 2. The optimized matrix.

Table 3

Function Analysis

Team	Task	Functional classification
Team 1	Design requirements, hardware design, DSP core part design, memory design, PLL and DAC design, peripheral interface circuit design, circuit layout, PCB assembly, PCB test, the overall software design	Research and development
Team 2	Compression coding design, compression test, compression and decoding design, compression test the decoding, FPGA simulation platform, the FPGA simulation platform, Chip	Assembly test
Team 3	Main processor driver program development, the main processor driver testing procedures, main processor communication program development, main processor communication test program, coprocessor response program development, main processor response program test	Drive implementation
Team 4	Integrated design, integration testing, test report	Integrate

aerospace projects will be a useful innovation.

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