

## VALUE ENGINEERING

### An essential tool for the Management of Spatial project

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At CNES, he participated in several major projects as ARIANE, SPOT using VE techniques. As the Administration of the French Association of Value Analysis, he participates in various programs relating to standardization. He is Author of two books :- *Produits et Analyse de la Valeur* (Products and Value Analysis) - CEPADUES Edition and *Conduite et Gestion de projets* (Projects Management and Administration) in collaboration with I. Chvidchenko - CEPADUES Edition.

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#### ABSTRACT

Value Engineering (VE) techniques can contribute significantly to the management of spatial projects. Referring to specific cases for which results exist, this paper will show what VE techniques are most useful and when they should be applied.

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#### INTRODUCTION

In the last few years, all sectors have operated in an extremely competitive environment and under economic constraints. This will probably continue. There are several reasons to explain this new situation. The most important seem to be:

our world is changing: in an era of global competition more and more countries, more and more manufacturers can make good products which were previously only produced by a few manufacturers in a few countries:

The world's political context is changing, the cold war is essentially over, priorities of developed countries are changing:

the western societies need more and more money for more and more sectors, for example, the health sector, care of old people, urban aging infrastructures and inner-city unrest, education, etc...

Consequently, all companies, all organisations, all countries must consider this new situation. In almost all sectors, to keep their positions in the market place, manufacturers have to deal with optimization, quickness, agility, innovation and cost. They must create more new improved products... faster, better with less money. No sector is immune. The automobile industry, defense industry, aeronautic, research and space sectors are concerned. This means that money, time and human capital must be used better and more efficiently.

To win this new challenge, organisations and companies have developed new methods such as Quality Function Deployment(QFD), Concurrent Engineering (CE). They may use VA, VE and Value Management (VM). Other global methods which could be used are Total Quality Management (TQM) or Quality Circle.

Several companies and organisations are integrating these methods in their management, of course, including the space sector. For example, Jet Propulsion Laboratory has developed a TQM

Initiative Plan comprising vision, mission, values and strategic goals. The strategic goals are those of minimizing cost, maximizing customer and employee satisfaction, and implementing small and moderate missions.

At the "Centre National d'Etudes Spatiales" (CNES) - the French space agency - we are using methods such as VE and Functional Analysis. We have been studying parts of the Ariane Launcher and SPOT satellite with VE techniques in spite of negative words such as "...it is not useful for us...". However, the situation is clear. We must now use these methods because we must make as much or more with less money!

My purpose is to describe how methods such as VE, VM and others can be used to improve the management of spatial projects and my objective is to try to explain how.

Firstly, I will describe the main characteristics of scientific and application space projects and the phasing process of the space project.

Secondly, I will describe two space projects which were studied using VE techniques. I will detail how VE techniques can be used to obtain higher efficiency in the management of the project and I will refer to Continuous Acquisition Logistic Support (CALS) and System Engineering.

Thirdly, I will offer my opinion about QFD, CE reengineering and TQM.

## THE FRENCH SPACE AGENCY AND THE SPACE PROJECTS

### The Space projects

CNES is the French space agency whose principal missions are:

- To prepare future space programs.
- To develop both civil and military scientific and application activities. Application programs are those which must offer an operational service at an acceptable cost. Some of these programs are managed jointly with JPL, NASA, Russia and various European countries.

CNES was founded in 1962 and examples of programs we managed and are managing include: Ariane launcher, earth observation with SPOT, location and data collection systems, exploration of

the solar system, atmospheric research and meteorology.

The main characteristics of these programs are:

- high levels of performance;

- frequently, only "one product" or very few products;

- priority of technology, reliability and safety;

- few suppliers have the competence to meet equipment specifications;

- long delays;

- technological risks;

- qualification process.

For application programs such as space radio communication or rescue, we must offer continuing operational services at an acceptable cost.

In this context, there are some factors which weigh against use of VE such as singularity of product, priority of technology and reliability. On the other hand, when we consider that innovation need not be in the system or the technologies themselves but rather in the mission of the projects and the scientific result, then the way one looks at Value Engineering becomes different. At the same time, new economic constraints challenge us to change our behaviour. Thus, we must now use new methods to optimize our management. But before answering how, we must explain our project process.

### The project phasing

. To begin we must define what is a project, what is a program.

. A project groups all work phases to identify and to obtain a target, a system, a definition;

. A program groups project, production, utilisation and withdrawal from service activities.

To minimize technical, schedule and economic risks, the project should be organised using a step by step method to verify that the targeted objective is being achieved. The project phasing is broken down into five phases which are organised around progressive decisions and different reference states.

The five phases are:

- . Assessment Phase (Phase 0) Advanced Studies for NASA. Its outputs are a mission analysis, a first need's requirements (U.R.D.), and a selection of concepts for study in the feasibility phase.

- . Feasibility Phase (Phase A) Preliminary Analysis for NASA.

At the end, we must have and know:

- . A frozen first need's requirements (RD) and a preliminary system's requirements document (SRD):

- . A pre-design of each possible concept with performances, costs, schedules and risks:

The organization of the following phases:

- . Definition Phase (Phase B) Definition Phase for NASA. Its outputs are:

- A frozen system's requirements document (SRD).

- A selected solution to be developed with its performances, costs, schedules, risks, and organization.

- . Development Phase (Phases C/D) Design/Development Phase for NASA.

The system's requirements controls activities at this phase. The outputs are:

- A product definition file;

- A system or a product if that is the case.

### Observation

It should be noted that development of all products ... in automotive, in aeronautics, etc... must follow this phasing process. Of course, this process is not linear and in fact the phases of activities overlap. In each phase, we must think about these activities: for example during the feasibility phase we must take into account how the future system will be used, with whom, etc... for scheduling reasons, some procurements may be launched before the development phase. Eighty percent of the recurrent costs of a product results from the requirements.

### VE AND SPACE PROJECT

It is time now to refer to VE techniques and space projects. To start, I will describe two different space projects where we used VE techniques. Then, I will say a few words about other projects where we are using VE techniques and I'll explain what, when and how VE techniques may be used in space projects.

To finish, I will say a few words about the relationship between CALS (Continuous Acquisition Logistic Support), System Engineering and VE techniques.

### THE COSPAS, SARSAT SYSTEM CASE

It provides satellite aid to search and rescue operations for maritime, aeronautical and terrestrial vehicles anywhere in the world. A constellation of satellites in low altitude (about 1000 km) polar orbit scans the entire surface of the globe several times a day. When a disaster occurs, a distress beacon operating on 121,5 or 406 MHz is activated, and these distress signals are relayed by satellite to ground receiving stations.

The rapid detection and location of an aircraft crash or other disaster site is of paramount importance to the potential survivors and to search and rescue teams. The system development started in 1979 after an agreement was signed between agencies in USSR, USA, Canada and France.

The basic concept is that the signals transmitted by the distress beacon are received by the search and rescue payload installed on a spacecraft. They are relayed to the local user terminals and allow these ground receiving stations to determine the beacon situs.

### The Value Engineering study

The VE study concerned with only the beacon. The situation was: a market study identified a market price and quantity; a prototype was made but its cost was not compatible with the market price. There was a big gap, to resolve this situation, a VE study was undertaken.

A VE team was created with different needed competencies and a VE plan was established. We analysed in detail the need, the constraints (environmental characteristics, wind, rain, temperature; standards ; user characteristics, etc...) and we compared these with the findings of the

market study. We considered possible beacon designs with the user's needs and we selected a target. Then, we analysed the design of each function, each component was identified and we evaluated their contribution to the user's needs. For each technical function, we investigated many technological solutions. To supply energy, which way - battery, which? Lithium, NiCd, or NiH<sub>2</sub>? What are the functions of the chassis ? Which material can be used ?

After this analysis, a proposal was made to management. We proposed:

- user's requirements in accordance with the market study;
- a new design with R & D programs for development of electronic parts: hybrid microelectronics;
- to develop a new OUS;
- to look for other antenna types;
- many modifications for the chassis and a new integration of the different parts;
- and lastly, a production target price.

A supplier accepted our proposal and a new beacon was developed. We can now say that we won our bet.

#### Which Value Engineering techniques were used ?

- Efficiency of the VE team: team members were selected for their competence and expertise.
- Functional analysis to:
  - . describe completely the user related function, user's needs and constraints (environment, relationship between user and product, etc...) during its life ;
  - . describe how the product works, the functional relationship between each element.

With the magic word "function", we think end result possibilities, service, and not product or technology.

- User requirement document proposed to management.
- Cost/function matrix to appreciate the economical

consequence of a need or a constraint.

#### THE DORIS CASE

We know that oceans play a major, but presently poorly understood role in climate evolution. The oceans receive large amounts of heat in the tropics and store it thanks to their large heat capacity. Ocean currents slowly transport the heat pole wards, transferring into the atmosphere at mid - and high latitudes.

It is estimated that indicators of climate anomalies include variations in the oceans circulation and the rise in mean sea level as a result of the combined effect of thermal expansion and melting of the polar ice sheets.

This is why it is so important that we observe the oceans. Only precise, calibrated global satellite altimetry can give oceanographers the repeat observations they need to acquire the whole space/time variation spectrum of ocean circulation. It was the reason why Topex/Poseidon was developed by the French space agency and NASA. Sea surface height is measured every seven km with an accuracy of about six cm. The system uses two onboard radar altimeters to measure the distance between spacecraft and sea surface, and Doris equipment to know exactly the orbit.

This is the present day concept, but it started very differently.

#### The VE study

When we began to study the system, we had problems with the first design. A necessary service requirement - to know exactly the orbit - was very difficult to obtain with the basic concept. This was the reason why a VE study was implemented. The situation was: a first need description was required; a basic concept had to be prescribed. This basic concept had to do with both functions, to measure the distance between spacecraft and the surface and to know the orbit exactly.

The problem was to find acceptable technical solutions. A VE team was created with people from CNES, various companies and scientific laboratories. To start, we had to understand exactly the problem and of course we had to analyse the need and how the system might work. We established a user requirement document in which needs and constraints were explained in functional terms. This was the

problem to resolve. We didn't analyse the basic concept but we decided to try to answer the following question: what are the theoretical ways to exactly measure an orbit? We created a list without imposing any limitations.

To evaluate these different possibilities, we used a comparison matrix taking into account the needs, the constraints, scheduling, cost, political aspects. At the end, the VE team decided to propose another solution based on two systems, with only one measuring the orbit. This solution had several advantages: few consequences on the spacecraft,

provided other services for other applications, and with practically, no technical risk.

So the Doris system was born. It is of course being used for Topex Poseidon missions, but also for two other applications.

Which Value Engineering techniques were used:

This VE program is my favourite study because its obtained outputs exceeded wanted outputs. The technical manager would have liked to see his basic concept utilized.

A team composed of multiple disciplines guarantees objectivity. And it was certainly true in this case. Team members did not have the same culture, few were in scientific laboratories, others were employed by CNES.

Success came also from the functional analysis. With this tool, we understood perfectly the need, the constraint and what was the problem to be solved. We asked the following questions: which system? for which function and for what purpose? These are the fundamental questions to understand a problem.

The functional analysis matrix sets out and compares Product Related Functions and User Related Functions, Need, Constraints and possible solutions.

Systems	Product Related Functions	User Related Functions Need, Constraints
S1		
S2		

What are we doing with VE techniques?

Before answering this question, I must say a few words about other current projects where VE techniques are used.

A look at other current projects

Results of the two above cases and other past applications display the positive effect of VE techniques and we are now using these tools for other projects, particularly for scientific projects for example in the micro gravity area with Mephisto, AGHF equipment, in earth science disciplines with DEMETER for earthquakes.

Very often with these types of projects, scientists want systems or equipment whose performance are very difficult to obtain within the allocated budget.

**Our problem**

We need:

- . to explain the user's need and to establish the user requirement document;
- . to match the user's need and system capabilities and to establish compatibility between the two;
- . to better prepare the desired initial outputs of the assessment phase and outputs of the feasibility phase;
- . to be sure that the system will have the capability to satisfy the mission;
- . to pilot research and development programs in the technical field. This is applicable for components such batteries, microelectronic, etc... as well as for processes.

Lessons Learned

These are the reasons why more and more project managers ask for VE techniques. This trend is likely to expand if we consider the new economic context, eventhough some prejudices against VE techniques continue to exist.

As you have seen, we don't use all VE tools. For example, the traditional cost/function matrix hasn't been used systematically and if it is used, it is more to search another technical solution than to analyze the cost of each service function. For us, its interest is in the increased creativity that it offers.

Since as early as the MacNamara report (under the Kennedy administration), we know that cost overruns on many projects come from excessive design and/or requirement changes. The reasons for these changes are : wrong need analysis, wrong environment analysis and/or underestimation of technological difficulties.

To avoid these problems and render our projects more reliable, the best way is to develop designs for which the capability to satisfy user requirements has been proven. At the same time it should follow the MAYA principle: "Most Advanced but Yet Acceptable".

Some of the VE techniques that we recommend for our projects are:

- External Functional Analysis to capture and to understand the point of view of the user and the relationship between the product, the user and the environment (temperature, standards, ...). Very often we ask the following questions : "What does the user want ? For what ? Where will the product be used ? What are the environmental characteristics ?

The output of this analysis is a User Requirement Document (URD) or a functional performance specification. This output defines user's wants. Generally, the need, the constraints have to be described with a verb and a noun - "the user shall be able to ...". The first set must be established during the assessment phase and it must be completed during the feasibility phase.

- VE Team. It is the foundation for good performance and for conducting a sound feasibility phase. The VE team is normally multidisciplinary : the user, the manufacturer, technical specialists (thermal, mechanical,...), designers.

- Functional Analysis Matrix. To evaluate different solutions and to measure how each can answer to the URD. We recommend using this tool at the end of the first. It is a good way to explain advantages and disadvantages of your proposal.

- Internal Functional Analysis to understand how the product and the system will work, what are the functions of each item and how they are connected. It is very useful for the simulations we need during the feasibility and definition phases.

- The magic word "function" ... absolutely necessary. We need a function not a tool. It is useful to translate the user's needs into system requirements.

It is also very useful to explore new technological solutions. The function explains the problem to be resolved. The technology is the way to solve it. Definition of function is very important in all phases of the program.

- VA process is often used to define our integration processes because in our field we must know the outcome of each operation of a process in advance. After the launch, there is little or no possibility to alter some thing of the spacecraft.

VE Techniques, RAMS, CALS, and System Engineering

*What about RAMS ?*

For many reasons, reliable operational service must be offered by the space radiocommunication system for example the safety for a launcher. To achieve this we must use RAMS techniques (reliability, availability, maintainability and safety) and now we have integrated RAMS activities in our projects. This requirement intensifies the use of VE techniques. It is impossible to conduct a RAMS study correctly without also conducting functional analysis. How can we appreciate the effect on the service of an item's failure without functional analysis. External and internal functional analyses are absolutely necessary.

*What about CALS ?*

To manage our projects and to optimize the system, we need more and more information or data and such must be shared. In view of the cost of information management, and for other reasons, the DoD developed the CALS concept (Continuous Acquisition Logistic Support).

To manage this concept, we must know who is acquiring the data, who needs them and when, also, our tool, VA process could be a valuable help.

*What about system engineering?*

If we observe the main system engineering activities, such as: definition of user's needs, requirement analysis, functional analysis, and architectural analysis. We can use our tools for:

- . external functional analysis to capture user's needs,
- . functional analysis matrix to match user's needs and requirement,
- . internal functional analysis for the architectural analysis

Before finishing this presentation, a few words on QFD, CE Reengineering and TQM

*What about QFD ?*

Some define QFD as "a structured and disciplined process that provides a means to identify and carry the voice of the customer through each stage of product or service development and implementation".

The objective is to link the different characteristics of the product with the user's needs, the voice of the customer. Links are established with different matrices. To capture the voice of the customer, the following questions "what", "when", "where", "why", and "how" are used.

I think that QFD is very close to VE and if we take some QFD principles, we can increase the efficiency of VE. For example, the use of the questions and the external function analysis can better capture the user's needs, the link between two characteristics (required quality/quality characteristics), and so on.

QFD is more formal than VE and more oriented toward quality. On the other hand, with VE we take into account the cost of each function... Furthermore, VE is a design method and a creative approach.

*What about CE?*

The main characteristics of CE is a multi-disciplinary group the same as that recommended in VE. A CE group has the responsibility for the product until the prototype is manufactured. This is not always the case in VE. VE has more tools than CE.

*What about TQM ?*

The objectives of this technique are well defined but the ways to achieve them are not clear. With TQM, we speak of QFD, SPC, VE and behaviour, philosophy. Company employees must become more dynamic ; we must focus on the customer first.

I recommend the use of these tools but it must be observed that daily behaviour is not as it should be.

*What about reengineering?*

I agree with Henry Mintzberg who writes in *The Rise and Fall of Strategic Planning*. If you observe that the main tool of reengineering is the question "why" and if you know that reengineering is used to reorganize the activities of a company in terms of their objectives, you can consider that reengineering is a new name for our old VA.

CONCLUSION

Most companies are organized for repetitive product's production "2000 cars per day". In these companies and organization, the normal behaviour is individual. This organizational behaviour is no longer tolerable. Now the common objective must be to contribute to organizational efficiency in the new economical context.

These disciplines brought to bear on problems must be organized upon a few principles and tools... user's needs, required functions, team, questions as "what, why, when, how". These disciplines should not be competing against each other but rather complementary to attain the principal objective : develop systems or products that work correctly so we can earn money ! VE techniques constitute a valuable and preponderant approach to achieving this end.