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ESTIMATE RECONCILIATION FOR CAPITAL CONSTRUCTION PROJECTS DURING A VALUE ENGINEERING WORKSHOP

By:

Mr. Chongba L Sherpa, VMA, CCM, LEED AP

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Introduction:

Accuracy of the project cost estimate is imperative for any VE team to providing value analysis. The design estimate should be adequately validated before embarking into all aspects of the JOB plan. This process of going over the independent estimate and design estimate in a controlled environment is called reconciliation. The VE team should be allowed to provide an independent estimate for the project they are embarking on prior to the workshop. It is important to remember there are two groups of distinct teams: VE team estimator and Design team estimator.

Who should be present during the reconciliation: All design estimators involved in the original design estimate, all VE team estimators involved in the independent estimate, design Project manager with access to their design team.

Considerations:

One Important consideration to enable this process is that the VE estimating team should not be allowed to know the value of the construction cost proposed by the Design team. This allows the VE estimating team to maintain the independence on their body of estimating work. The Documents for the Value Engineering should be provided to the Cost Estimating Professionals of the VE team. The estimating team should be provided adequate time to go over the documents to provide an accurate estimate for the benefit of the VE team. There should be a thorough takeoff of the quantities based on the drawings and documents provided to the VE team. The Estimating team should include all discipline of estimating including but not limited to Architectural, Engineering and Infrastructure estimating experts. The VE estimator should provide their estimate in the format provided by the design team. All the unit prices should be provided to reflect the current market condition of the project based on the project location and duration of the project. The VE estimating team should also contact any vendors who are proprietary and any large ticket items should be carefully considered for accuracy. When the estimate is complete it should be delivered to the design team and design estimate should also be exchanged at same time. It is also important to provide adequate time to review both the estimates.

Cost Reconciliation:

The estimating reconciliation should be done during the early stages of in the VE session or prior to the VE session. All markups and quantities should be reconciled during the reconciliation process. It is important to have the Project Manager present during the reconciliation of the markups which can be significantly different depending upon the assumptions made by two separate estimating teams and their techniques used. The quantity reconciliation is very technical and should be accurate. It would be very helpful to bring in all the digital takeoff backups. The reconciliation of the unit prices can be conflicting based on the production considerations by the two teams. Vendor quotes can be shared during the reconciliation process which can prove to be useful to the project. Reconciling markups such as general conditions, insurance and profit could be standard based on the market factors. Escalation and Contingencies can be varied based on the perception of the market by the two estimating teams. Escalation is usually based on the rate of annual escalation rate and mid-point of construction. Design Contingency can be reconciled based on AACE estimating level. Changing design contingencies to satisfy budgets at will by the client without consensus with the estimating professional is ill advised. Design consultant should also monitor the reconciliation process so that, if there is any conflict in the understanding of the scope, it could be resolved by the designer based on design intent. Some differences in the quantities can be based on the methodologies used by the estimator, errors in takeoff could be present, and there could be differences in interpretation of the scope of work.

Sample Reconciliation Estimate:

Design Cost Estimate

SCHEMATIC DESIGN 30% SUBMISSION ESTIMATE
[redacted]
NEW YORK, NEW YORK

4/16/2018

CSI TRADE BREAKDOWN

	DESCRIPTION		AMOUNT
2	EXISTING CONDITIONS		1,997,938
3	CONCRETE		13,423,838
4	MASONRY		6,266,370
5	METALS		32,189,170
6	WOOD AND PLASTIC		949,538
7	THERMAL AND MOISTURE PROTECTION		7,082,081
8	DOORS AND WINDOWS		6,467,330
9	FINISHES		6,276,387
10	SPECIALTIES		953,358
11	EQUIPMENT		2,882,172
12	FURNISHING		0
13	SPECIAL CONSTRUCTION		0
14	CONVEYING SYSTEM		1,400,000
21	FIRE PROTECTION		2,815,305
22	PLUMBING		6,236,126
23	HVAC		13,266,999
26	ELECTRICAL		13,382,459
27	COMMUNICATIONS		864,196
28	ELECTRONIC SAFETY AND SECURITY		1,228,674
31	EARTHWORK		12,007,037
32	EXTERIOR IMPROVEMENTS		5,372,685
33	UTILITIES		2,362,907
	SUB TOTAL - 1		137,424,569
	GENERAL CONDITIONS	10%	13,742,457
	SUB TOTAL - 2		151,167,026
	OVERHEAD AND PROFIT	15%	22,675,054
	SUB TOTAL - 3		173,842,080
	DESIGN CONTINGENCY	10%	17,384,208
	SUB TOTAL - 4		191,226,288
	ESCALATION TO THE MID POINT OF CONSTRUCTION	15.0%	28,683,943
	SUB TOTAL - 5		219,910,231
	INSURANCES	2.5%	5,497,756
	SUB TOTAL - 5		225,407,987
	CONSTRUCTION CONTINGENCY	10.0%	22,540,799
	TOTAL CONSTRUCTION COST		$247,948,785

Reconciled Cost Estimate for VE Workshop

SUBJECT SUMMARY - NEW CONSTRUCTION
PROJECT [redacted]
LOCATION [redacted]
TYPE EST. 30% CONSTRUCTION DOCUMENTS
CLIENT NYC OMB / US COST

JOB NO. 8-0169
EST BY EH
CHKD BY JF
DATE 7/20/2018
REV. DATE 0
GSF 239,378

	DESCRIPTION		AMOUNT	$ / GSF
2	EXISTING CONDITIONS		3,613,296	15
3	CONCRETE		12,712,766	53
4	MASONRY		6,446,290	27
5	METALS		34,572,996	144
6	WOOD AND PLASTIC		840,162	4
7	THERMAL AND MOISTURE PROTECTION		8,117,973	34
8	DOORS AND WINDOWS		5,453,745	23
9	FINISHES		6,608,214	28
10	SPECIALTIES		2,375,568	10
11	EQUIPMENT		2,876,100	12
12	FURNISHING		0	0
13	SPECIAL CONSTRUCTION		0	0
14	CONVEYING SYSTEM		1,275,000	5
21	FIRE PROTECTION		2,901,261	12
22	PLUMBING		5,606,152	23
23	HVAC		13,253,804	55
26	ELECTRICAL		13,802,478	58
27	COMMUNICATIONS		718,134	3
28	ELECTRONIC SAFETY AND SECURITY		1,795,335	8
31	EARTHWORK		12,103,239	51
32	EXTERIOR IMPROVEMENTS		6,573,519	27
33	UTILITIES		2,138,390	9
	SUB TOTAL - 1		143,784,422	601
	GENERAL CONDITIONS	10%	14,378,442	
	SUB TOTAL - 2		158,162,864	
	OVERHEAD AND PROFIT	15%	23,724,430	
	SUB TOTAL - 3		181,887,294	
	DESIGN CONTINGENCY	10%	18,188,729	
	SUB TOTAL - 4		200,076,023	
	ESCALATION TO THE MID POINT OF CONSTRUCTION	15%	30,011,403	
	SUB TOTAL - 5		230,087,427	
	INSURANCES	2.5%	5,752,186	
	SUB TOTAL - 6		*235,839,612*	*985*
	CONSTRUCTION CONTINGENCY	10.0%	23,583,961	
	TOTAL PROJECT COST		$259,423,574	$1,083.74

Exchange of Information:

With close to two decades of experience, we have found that reconciliation not only serves as getting the scope correct and price right but also a means to exchange information the design team has acquired over

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the periods they have been engaged in the project.

- The design team gets to convey their impression of the job to the VE team.
- The Design estimator is engaged in the process, so they know where the design process is and the evolving nature of the project
- The Design team does not have to start cold when the design changes are proposed for the upcoming design stage.
- Vendor quotes are exchanged between both parties.
- The Design team and the client get to see the second opinion of the cost.
- A solid foundation of the VE Methodology starts to take root and builds up for all involved.
- The VE team takes ownership of the reconciled estimate for use in the VE process.
- There is a very quick trust build up between the VE experts with the estimating team having been through the reconciliation process.
- The VE estimating expert now can also become somewhat of an information channel for the other experts engaged in the project.

Implementation by Government Agencies:

We have extensive experience with Government Agencies who are using this method and others who are not using the method. One reason for the Agencies not using this method could be the lack of adequate funding for the VE workshop. In the overall preconstruction project lifecycle, it is actually cost saving mechanism within that environment due to validation work performed at the time of the VE exercise. If the project were to be separately validated through a third party, it would cost more time and effort to perform the work for the same result as a VE estimator would provide during the VE workshop interface. NYC OMB has been successfully implementing this methodology over decades and, as a cost estimating expert also in involved in numerous VE Studies, I find this a very wholesome experience. This method is not a one-way communication so, it engages both VE team and the design team. Due to this effort there is an inherent trust build up between the VE team and the design team over the cost estimates and the following process of review and implementation go smoothly and expeditiously. VE workshop is not always the technical aspect of wrong and right but also a nuance information exchange of what are best practices in the engineering, constructability and bidding environment at the time the project is conceived and implemented. All such aspects of the project could be reconciled between the two parties who are interested in providing best value for the project under review. When VE exercises are performed with the bare minimum of the Job Plan adherence and lack of control over the value of the project; over several project experiences the confidence of the client, the design professionals, and estimating experts involved in such practice start to erode in the VE Methodology itself. When the experts who are engaged in such practice lack confidence, it is a self-fulfilling cycle of cynicism and diminishing return on the practice.

Advantages of implementing Reconciliation

- VE team estimator will be in full control of the overall value of the project.
- Better interpretation and documentation of individual ideas for future use.
- Certainty of actual savings while the ideas are implemented in design.
- Full confidence of the VE team with the VE team estimator.
- Building bridges between the VE team and Design and client team.
- More productive time for all the experts due to steady guidance of where the cost is headed.

Disadvantages of not implementing Reconciliation

- If the design estimate is adopted the VE team estimator cannot validate the estimate.
- Ideas might be generated for the wrong reasons.
- Waste of valuable time during the session if the VE estimator conflicts with the design estimate.
- Some aspect of the project might be left out due to the capture in the wrong bucket of cost.

Conclusion:

One of the basic needs of the VE Methodology is accurate assessment of cost. The only way to provide the confidence of accuracy by a seasoned professional is to get engaged in the costing process by their own team. The only way to get two teams to come to a compromise cost of the project is reconciliation. There is a significant need to provide reconciliation before the VE workshop begins. This is the bridge between the design team, which designed the construction project over several months directly getting input from the site and the desires of their clients and public demand; and the VE team which is engaged most likely only once over the design life of the project to suggest and recommend optimum value. Reconciliation provides confidence in the process and provides a quick balancing act of such vast engagement gap between the two teams to instill some faith in the process. When the reconciliation takes place, it is not only the reconciliation of the cost but also the reconciliation of the quantities so there is no doubt in the design engineers mind the VE team does not understand their scope of work. This process ensures all scope of work is picked up by the VE team to evaluate and does not waste valuable time on entities of the project that does not need much attention. Overall, we recommend having a reconciliation effort during any construction project subject to Value Engineering at any stage of the project. We cannot eliminate or take short cuts on one of the major functions of the VE workshop itself to ensure best result of the process.

References and credits:

- VJ Associates Inc. of Suffolk, New York
- Mayor’s Office of Management & Budget, City of New York
- HDR Inc.
- Ramesh Kalvakaalva, PE, CVS

Development of Template for Outlining Science and Engineering Research Based on Functional Thinking in VE and TRIZ

Kiyohisa NISHIYAMA, Manabu SAWAGUCHI

Abstract

This paper aims to report the verification of a new template that outlines research for research paper, research proposal and other technical reports. The template, which is applicable for various science and engineering fields, is developed based on the theory of VE and TRIZ. In recent years, higher education including master and doctoral programs has become more popular and larger number of students enroll the programs. Universities are currently required to make the students acquire higher skills as well as generating further research achievements. In addition, universities are working on research activities by finely segmentalizing various intellectual domains. Supervising students working in such research generates a situation where the supervisor must supervise students who work on research that are not completely agree with their expertise. In such cases, miscommunication between students and supervisors may waste a lot of time and deteriorate their relationships in the communication. Then, the authors have developed a template that outlines research for research paper, research proposal and other technical reports that may be applied across all science and engineering fields with VE and TRIZ as a solution to the problems. In this study, we examined the effectiveness of the template through tutorials and a workshop. In the tutorials and workshops, the template was introduced involving engineering students to instruct how to write research reports to observe their responses. As the results, many students responded positively to the template and, so, we concluded that the template works as an effective instruction for outlining research.

Biographies

Kiyohisa Nishiyama, Ph.D., VES

Vice Rector, Tashkent State Technical University and Designated lecturer, Nagoya University

Graduated from Waseda University in Science and Engineering in 2003 and completed his doctor's course at Birmingham University (UK) in Mechanical Engineering in 2008. He joined Toyota Industries Corporation and later became lecturer in Engineering at Nagoya University. He is specialized in advanced education (English teaching and education for overseas students) focusing on Engineering field. Now he is a vice rector at Tashkent State Technical University, Uzbekistan.

Manabu Sawaguchi. Ph.D., CVS

Director, Value Innovation Institute Co. Ltd. and Professor, RITSUMEIKAN University

Graduated from KEIO University, Faculty of Technology, Department of Mathematical Engineering and got a position as a researcher at the SANNO Institute of Management in 1985. As a visiting researcher, he visited University of Michigan IOE (Industrial and Operations Engineering) in 1997. After that, he earned a doctoral degree in Engineering at WASEDA University in 2005. He had worked 30 years of experience in practical technology management And, now, he is an advisor of SJVE, a vice Chairman of JTS (Japan TRIZ Society), a director of Value Innovation Institute Co., Ltd., a professor at RITSUMEIKAN University and an invited researcher at WASEDA University.

1. Research background

In recent years, higher education including master and doctoral programs has become more popular and larger number of students enroll the programs. Doctoral career was previously limited to the academic industry. Even in science and engineering, especially in Japan, doctoral students had a smaller number of opportunities to find jobs in companies than bachelor and master students, so, there was even a tendency to refrain from entering the doctoral program.

University doctoral programs are currently required to make the students acquire higher skills as well as generating further research achievements. Many doctoral education programs are under collaborations among organizations both in industry and academia. VITAE in the UK, for example, has developed Researcher Development Framework (RDF), a mapping illustration of skills required by each industry, to ignite a movement to expand the activities of doctoral degree holders by giving them opportunities to think about their own career without limiting it only within academia [1].

In addition, universities are working on research activities by finely segmentalizing various intellectual domains. This trend is caused by the diversifying needs of students and industry in the world globalization. Promotion policies of international joint research programs also recommends interdisciplinary research for innovation and human resource education [2]. The declination in the value of knowledge due to improvements in information technology may be another factor.

Supervising students working in such research generates a situation where the supervisor must supervise students who work on research that are not completely agree with their expertise. Even in the same department, one may not understand the research theme of neighbor laboratories, so should be further difficult to fully grasp the research themes brought by new students from other universities.

In such cases, miscommunication between students and supervisors may waste a lot of time and deteriorate their relationships in the communication [3]. One may observe many cases of doctoral students who have wondered into the situation and spend time on communication to determine the direction of research and research paper writing rather than research activities. The situation where a doctoral student is unable to obtain a degree may be considered as a serious impact on the students' life as well as a damage on social productivity.

Then, the authors have developed a template that outlines research for research paper, research proposal and other technical reports that may be applied across all science and engineering fields with VE [4] and TRIZ [5] as a solution to the problems. The template completes a research outline by defining information elements that should be clearly shared among the members in a research community in the format of question and answer. This method can be applied not only for research report writing, but also for various activities related to research communications including presentation promoting more smooth research activities for higher achievements.

2. Methodology for research

Here, we firstly clarify the items in VE and TRIZ methodologies exploited for the development of the template introduced in this paper. The VE step, "definition of function", where a function is defined by a combination of nouns and verbs, is referred for interdisciplinary communication. The template is designed with the intention to facilitate communication among researchers involved in a project by describing behaviors of systems of research interest with nouns and verbs.

On the other hand, the methodology in TRIZ to define a problem as a conflict is also referred. Here, the conflict means the situation that when improving a parameter, it unavoidably deteriorates another parameter as shown in Fig.1-(a). The situation may be recognized as a system that is designed to generate "Positive State" unavoidably generates "Negative State" as illustrated in Fig.1-(b).

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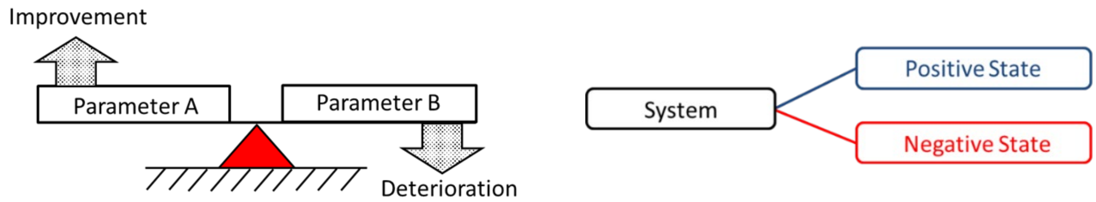

(a) (b)

Figure.1 Conflict defined in TRIZ

In this study, we examined the effectiveness of the template through tutorials and a workshop. In the tutorials and workshops, the template was introduced involving engineering students to instruct how to write research reports to observe their responses. The details of the template are described first in 2.1 below. Section 2.2 describes the contents of instruction conducted using this template.

2.1 Details of Template

The template mainly aims at describing research activity in science and engineering fields clearly and concisely by defining several information items. The template has been developed through interviews conducted by the authors when instructing masters and doctoral students in engineering field. The interview has enabled the authors to notice that research description may be outlined with templates applicable for all scientific and engineering fields by using VE and TRIZ methodologies mentioned above.

The template assumes that all research topics are systems. Here, a system, which is composed by components, generates certain behavior as the result of their interaction. One may recognize that the components in the system are also composed by smaller components. Then, the template uses a rule for describing the interaction among the components in the system, so, a system is expressed by using the rule of definition of function in VE, subject, object (noun) and verb for organizing information.

2.1.1 Template for description of investigation

As daily activities, researchers conduct their research for some purpose. The research activity may be recognized as “observing how something influence something”. In detail, it means that the parameter of the former “something” is controlled and the influence on the parameter of latter “something” is measured. Here, we define the former something as Controlled Component that are described by the following items.

1	Controlled component (Name, etc.)	The name of Controlled Component in the paper
2-1	Controlled Parameter 1	The attribute of Controlled Component is defined by parameters. The parameters should be defined here.
2-2	Controlled Parameter 2	
2-3	Controlled Parameter 3	
:		

Next, we define the latter something as Measured Component that are described by the following items.

3	Measured Component (Name, etc.)	The name of Measured Component in the paper
3-1	Measured Parameter 1	The attribute of Measured Component is defined by parameters. The parameters should be defined here.
3-2	Measured Parameter 2	
3-3	Measured Parameter 3	
:		

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One may clearly and concisely describe the contents of investigation by inserting the information items shown in the above table into the following template.

> This research focused on the relationship between "1: Controlled Component" and "3: Measured Component". Then the authors investigated the influence of "2-1: Controlled Parameter1", "2-2: Controlled Parameter 2", "2-3: Controlled Parameter 3",･･･on "3-1: Measured Parameter 1", "3-2: Measured Parameter 2","3-3: Measured Parameter 3"･･･.

2.1.2 Template for problem definition

The investigation described by the template above should be performed for problem solving. In TRIZ methodology, a problem is defined as a state where a "system" is designed to generate "Positive State" but it inevitably generates "Negative State" as shown in Fig.1-(b). Many students fail to clearly define the "Positive State" from the system on their research when explaining their research work.

"Positive State" is a state where a system generates a behavior, the result of the interaction of the components in the system, that people feel positive, while "Negative State" is a state where a system generates a behavior that people feel negative. Here one should be noted that the feeling of positive and negative depends on how people subjectively feel about the behavior.

Based on the definition of a problem to be solved through research is defined by the following information items:

4	Conventional System (Name, etc.)	A system that has been commonly used
5	Negative State_Conventional	Negative State generated from Conventional System
6	The reason why the "I-2: Negative State_Conventioal" is considered to be"	If it is necessary, the reason why people feel the state negative should be explained
7	Research System (Name, etc.)	A system of interest in research
8	Positive State (Explanation)	Positive State generated from Research System
9	The reason why the "I-5: Positive State" is considered to be "Positive"	If it is necessary, the reason why people feel the state positive should be explained
10	Negative State_Research	Negative State generated from Research System
11	The reason why the "I-7: Negative State_Research " is considered to be "	If it is necessary, the reason why people feel the state negative should be explained

By inserting the items into the following template, one may describe a problem to be solved through research.

> "7: Positive State" is considered to be positive because "9: The reason why the "7: Positive State" is considered to be positive". So far, "4: Conventional System" has been commonly introduced (gained interest) to obtain "8: Positive State". It is, however, recognized as a problem that "4: Conventional System" generates "5: Negative State_Conventional". "5: Negative State_Conventional" is considered to be negative because "6: The reason why the "5: Negative State_Conventioal" is considered to be negative". Currently, then, "7: Research System" is expected to be a solution to the problem. However, it is recognized as a problem that "7: Research System" generates "10: Negative State_Research". "10: Negative State_Research" is considered to be negative because "11: The reason why the "10: Negative State_Research" is considered to be negative".

The following items, which exploits the functional thinking in VE, define the problem in more detail. These tables are equivalent to function analysis on Positive State and Negative State respectively.

12	("I4: Research System") acts on Component or System	Positive State should be described as a function
13-1	Component acts on Component	How the Positive State is generated should be described by a few functions
13-2	Component acts on Component	
13-3	Component acts on Component	
	:	

14	("I-4: Research System") acts on Component or System	Negative State should be described as a function
15-1	Component acts on Component	How the Negative State is generated should be described by a few functions
15-2	Component acts on Component	
15-3	Component acts on Component	
	:	

The template below inserted with the information items completes detailed explanation of the problem. Here, it should be noted that the functional analysis is only for organizing information, so, the explanation regarding this part should be flexibly modified.

> "7: Research System" performs the function of "12:("7: Research System") acts on Component/ System" as its positive state, "8: Positive State". The function of "12:("7: Research System") acts on Component/ System" is composed by the functions: "13-1: Component acts on Component", "13-2: Component acts on Component", "13-3: Component acts on Component"・・・. Meanwhile, "7: Research System" performs the function of "14-1: ("I-4: Research System") acts on Component/ System" as its negative state, "10: Negative State_Research". The function of "14: ("7: Research System") acts on Component/ System" is composed by the functions: "15-1: Component acts on Component", "15-2: Component acts on Component", "15-3: Component acts on Component" ・・・.

2.1.2 Two research types

The authors propose to classify the approaches for solving problems mentioned above are classified into two types, clarifying the generation mechanism of problems and verification of problem solutions. The following sections introduce templates for each of these two research types.

2.1.2.1 Clarifying the generation mechanism of problems

Here, the definition of "Clarifying the generation mechanism of problems" is described here. The situation may be that the existence of a problem is recognized, but no one knows why the problem happens. In such case, one may need to clarify how the problem is generated. Research paper is often intended to report results of investigation for such purpose.

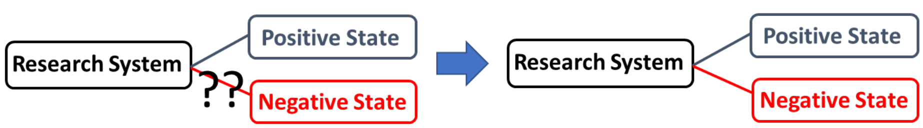

Figure.2 Clarifying the generation mechanism of problems

The template for the first sentence of the abstract is as follows.

> This paper aims to clarify the generation mechanism of "10: Negative State_Research" from "7: Research System".

The claims derived from the results obtained from the above research activities should be as follows.

16-1	Component acts on Component	Functions related to generation mechanism of "10: Negative State_Research " clarified by research
16-2	Component acts on Component	
16-3	Component acts on Component	
:		

These results (from research activity) have shown that "10: Negative State_Research" is riginated from the functions, "16-1: Component acts on Component", "16-2: Component acts on Component", "16-3: Component acts on Component"･･･.

In addition to the description about the problem of interest, functions related to the generation of Negative State that has been pointed out by previous research but has not been confirmed in detail. The necessary information items and templates are shown below. Unclarified functions related to generation mechanism of "10: Negative State_Research

17-1	Component acts on Component	Functions for generating Negative State (items that have been pointed out through previous research but not confirmed)
17-2	Component acts on Component	
17-3	Component acts on Component	
:		

Previous research on the generation mechanism of 10: Negative State_Research" has pointed that the functions: "1-17: Component acts on Component", "17-2: Component acts on Component", "17-3: Component acts on Component",･･･may be the origin of "10: Negative State_Research", but the detail is still unclear.

2.1.2.2 Verifying a problem solution

Research classified as verification of problem solutions is in the situation that the generation mechanism of the problem has already been clarified by previous studies. The purpose of the research type is to verify the solution to the problem that has already been proposed and show its effectiveness.

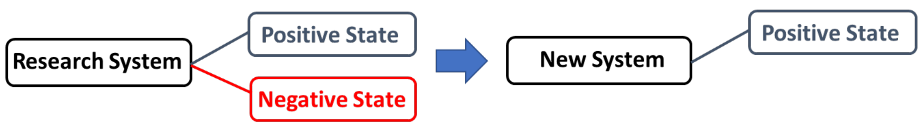

Figure.3 Verifying a problem solution

The template for the first sentence of the abstract is as follows.

18	Verified New System (Name, etc.)	The system that has been verified through the research

This paper aims to introduce the development of "18: Validated New System", a new system that inhibits "10: Negative State_Research" generated from "7: Research System".

The claims derived from the results obtained from the above research activities should be as follows.

These results (obtained through research) have shown that "18: Verified New System" inhibits "10: NegativeState_Research". In addition, the authors discussed on problems caused by "18: Verified New System".

Also, if necessary, other solutions that have been proposed to solve the problem should be described as a part of the research background. The necessary information items and templates are shown below.

19-1	New System 1 (Name, etc.)	The name of systems already proposed to inhibit "10: Negative State_Research
19-2	New System 2 (Name, etc.)	

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19-3-	New System 3 (Name, etc.)	
:		

Previous research has proposed "19-1: New System 1", "19-2: New System 2", "19-3: New System 3" ··· as new methodologies to inhibit "10: Negative State_Research", but they are not yet drastic solutions to the problem. Our research group has, then, proposed "18: Verified New System", a new system that inhibits "10: Negative State_Research" generated from "7: Research System".

2.1.3 Examples of template usage

This section introduces an example of the application of templates. The information items, which are for problem definition, are shown in Table X.

4	Conventional System (Name, etc.)	Mechanical parts made from metals such as iron and aluminum and others
5	Negative State_Conventional	Higher density and difficulty in processing
6	The reason why the "I-2: Negative State_Conventioal" is considered to be"	The state cause difficulties in weight and cost reduction
7	Research System (Name, etc.)	Mechanical parts made from heat-resistant hard resin
8	Positive State (Explanation)	Proper functionality as mechanical parts
9	The reason why the "I-5: Positive State" is considered to be "Positive"	Proper functionality of mechanical parts is required in various situations in our daily life
10	Negative State_Research	Malfunctions that are caused unexpected failure of mechanical parts
11	The reason why the "I-7: Negative State_Research " is considered to be "	Products do not satisfy the requirements as mechanical parts

The information items are inserted into the template to complete the sentences with some revising process. A sample of research abstract developed with the information items is shown below.

This paper aims to clarify the mechanism of failures in mechanical parts made from heat-resistant hard resin.Currently, machine products have many parts made from metals such as iron and aluminum and others. The features of metal parts, higher density and difficulty in processing, cause problems in their weight and cost reduction. Recently, then, mechanical parts made from heat-resistant hard resin with its higher processing accuracy have gained attention. The mechanical parts, however, cannot be fully applied to mechanical products that require higher reliability because they sometime unexpectedly fail causing product malfunction. Heat-resistant hard resin, which has higher strength equivalent to metals, are expected as a replacement for mechanical parts. Previous researches, pointed that the usage environment may deteriorate the strength of the heat-resistant hard resin causing the unexpected failures. However, the detailed mechanism has not been clarified yet. In this research, we examined how particle sizes of oil mist and its temperatures influence on the strength of the heat-resistant hard resin with respect to the fact that the unexpected failures were often observed near machines, such as machine tools, that use lubricant oils. Then, we observed strength reductions at smaller particle sizes of oil mist and at higher temperatures and so, concluded that the particle sizes of oil mist and its temperature may be factors that have caused the unexpected failures.

2.2 Tutorial and workshop

Various activities, so far, have been carried out by using the template described above. This section explains the detail of the tutorials and the workshop.

2.2.1 Tutorials

The author regularly provides individual guidance on research paper writing with engineering students. The students are asked to learn the template methodology through video lecture materials in advance to the tutorial, then, in the tutorial, the support of research paper writing is decided through the discussion with the author. So far, many students have been successfully submitted research paper to international conferences and journals. The communication in the tutorials allowed the authors to collect opinions of students on the template.

2.2.2 Workshop

A workshop aiming at writing research paper or research proposal by using the template was conducted. The participants in this workshop were12 engineering students (master and doctoral students). The workshop provided the instruction for using the template and opportunity to decide the information items for the research of each participant. At the end of the workshop, a questionnaire survey shown in Table X was conducted to observe the students' response.

Q1 Did you understand the contents of the workshop? Q2 Do you want to encourage other people to participate in this workshop? Q3 Do you think the contents of this workshop will be useful for organizing information obtained from research? Q4 Do you think the templates introduced in the workshop are useful for writing research papers? Q5 Do you think the contents of the workshop will help you deepen your understanding of your research? Q6 Do you think the contents of the workshop will be useful when writing papers?

3.Results and discussion

3.1 Observation of students in tutorials

So far, approximately 50 students, who were struggling with writing research papers, have consulted in the tutorials. Majority of the students have completed their research paper following the methodology with the template, so, the use of templates was considered effective in instructing such students.. Many students were also struggling with the writing in English language, but few of them had pure problem of the language. Most of the students had difficulty in communication with other people involved in the research activity.

However, on the other hand, some students, who are mainly from pure scientific field, showed disappointment against the template. They tended to say that their research may be formatted following the template, but it does not agree with conventions of journals to be submitted. As a future research, the authors are planning to develop new templates for such students.

3.2 Questionnaire survey results

The figure below, which indicates that most students thought the contents of the workshop useful, shows the results of the questionnaire survey conducted at the end of the workshop.

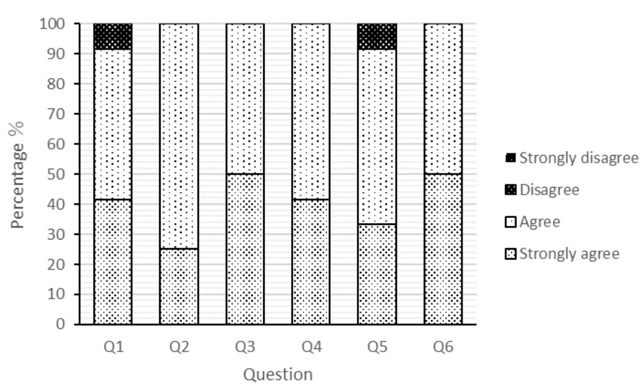

Figure.4 Questionnaire survey results

The authors plan to apply the template for international research communication, since international students highly appreciated this workshop. The participants of this workshop included many international students. In recent years, universities world widely recommend study abroad, and students with various backgrounds join research programs across borders. One may predict that supervisors and students, who use non-native language in research communication, will have more opportunities to conduct research activities across language barriers.

4. Conclusion

This paper has reported the verification of a template for outlining research paper abstract, research proposal and other technical reports. The template, which is applicable for various science and engineering fields, is developed based on the theory of VE and TRIZ as a solution to the miscommunication between students and supervisors. In this study, we examined the effectiveness of the template through consultant meetings and a workshop, where the template was introduced. Both the meetings and the workshop were aiming at writing research paper or research proposal, and then observing student responses. As the results, many students responded positively to the template and, so, we concluded that the template works as an effective instruction for writing research reports.

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NEW METHOD TO APPLY VM TO ANALYZE THE USE FUNCTION AND THE ESTEEM FUNCTION OF *YAKIGURIT*

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Biography

Keiko Ishii is a merchandiser at a leading organic vegetable delivery company in Japan, where she has been working since graduating with a B.S. in biochemistry. Her work consists of developing food products through logistics planning and quality control of farms and food factories, as well as being in charge of multiple aspects of production, from planning and manufacturing, to sales. As a FA-Trainer at Functional Approach Institute Co., Ltd., Tokyo, she conducts VE studies on daily meals and their related things. Her VE articles include 'Study by the VE Application to Quality Control in the Distribution of the Egg' 'A Study of Eating Styles with Spoons, Forks, and Hashi by the Extended Function Diagram and the Extended Function Analysis'.

Abstract

Many of the foods that we eat in our daily life have shells and peels. Among others, those with hard shells cannot be served unless the shells are removed from the edible parts at a certain point of their production procedure. Shelling as *koto* may take place at a factory or kitchen. It may also take place immediately before we eat those foods. Then, a question arises: why do many of us want to shell those foods as *koto*? For example, some fashionable bars serve shelled pistachios or shelled almonds. Indeed, the author's favorite bar serves shelled macadamia nuts. The shells of macadamia nuts are so hard that it requires a special shell cutter to eat them. Another example is nutcrackers that are made to look like a doll. The jaws of the doll is what is used to crack open hard shells. Many people use these dolls as a decoration. These dolls are also famous in a ballet musical. There is an aesthetic appeal other than just eating shelled foods for the different tastes that they provide. In other words, 'esteem' other than that of 'tasting' is hidden in these hard shell foods when we eat them. Not only does 'eating' have a function to 'Satisfy hunger', but also it seems to have other functions totally different from 'Satisfy hunger'. Hence, the author has conducted a VM analysis on the relation between the use function and the esteem function of one such hard shell food *Yakigurit*, a product offered by a food service company that she works for. As a result, she has succeeded in devising a new method to clarify what effect foods generally have on their diners. This paper shares such a method, along with its related techniques.

Keywords: use function, esteem function (koto), *Yakigurit*, Use/Esteem Division FAST, AND/OR Bond of Use/Esteem FAST, Performance Formula

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1. Introduction

Among foods which we eat, many have shells and peels. Some shells and peels are so hard that they prevent us from eating those foods, and thus far we have developed shelling/peeling technologies during the course of our history. Through these developments, many foods, which otherwise would remain inedible, have been made accessible to bring to our dining table. Wheat and rice are no exceptions as they require the threshing process to make them edible.

Such food-processing technologies have altered how we eat hard shell foods. Many such foods create elegant dining scenes when they are served with their hard shells removed in advance. At other times, shelling takes place by their diners' own hands at the final production process, that is, immediately before they eat them.

Even most formal banquets serve shelled foods, whose shells guests strip off edible parts by hand. Escargots and shelled shrimps are examples of these. Cutlery is used to produce elegancy in dining these foods.

Then, how are lobsters and mussels served? Their shelling takes place by chefs before these foods are served on the dining table. It also takes place by diners' own hands on the dining table. Since either way of serving these foods have been kept until now, it would be impossible to consider this 'shelling' process as the only means to enhance their tasting functions.

Many people like to 'eat'. Indeed, the act of 'eating' is filled with 'esteem' (enjoyment/pleasure). Then, what is the relation between the use function and the esteem function of 'eating'? Moreover, is there any method to measure the effect of 'eating'? The author has found out the effect of the theme 'eating' on people, through her VM analysis on the relation between its use function and esteem function.

2. VM ANALYSIS

2.1. Use function and esteem function of 'eating' through VM

When people eat hard shell foods, shelling – the act of removing hard shells from edible parts – is always included in their production procedure. Then, do diners think of the act of shelling itself as 'esteem'?

In the example of lobsters and mussels, to 'Shell lobsters' and to 'Shell mussels' are what their diners do in their final production process. Their *koto* can be considered as 'Enjoy shelling' and 'Esteem shelling'.

The author has found that there was a difference between the use function and the esteem function of 'eating' regarding how each of them affected its entire theme. The basic difference lay in how to view each when defining it. However, it was difficult to understand what each function was. To cope with this, the author defined each function from each different *koto*: 'Making' and 'Enjoy "making"' in their production procedure.

To verify the theme, the author chose *Yakigurit*. It is the name of a food product offered by a food service company that she works for. It is just roasted chestnuts, whose cooking is as simple as roasting and shelling. It is easy to understand *Yakigurit*'s entire production procedure because of its simplicity. It is also important to point out that the chestnut is an inevitable component in Japanese food life.

2.2 Defining the function of Yakigurit

To define the function of 'eating', the author focused on each *koto* function of *Yakigurit* as a component in its each production procedure. At first, she was thinking of the product's physical characteristics as components. By doing so, however, she was afraid of focusing too much on finding the product's attractions in its physical characteristics. This made her difficult to differentiate what its use function or esteem function would be. Therefore, the author differentiated these functions using five senses, not just sight, by focusing on the product's production procedure.

Focus on the product's *koto* function also enabled the author to obtain another *koto* view: 'Enjoy shelling'. *Yakigurit* made her possible to find out that people enjoy certain acts as well as tasting when they eat.

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Then, what other *koto* functions does *Yakigurit* have, as well as ‘Make *Yakigurit*’ and ‘Enjoy “making *Yakigurit*”’? The following is the definition of each function in its each production procedure.

The author defined the following three as the functions of one *koto* component ‘Make *Yakigurit*’: ‘A: Gather chestnuts’, ‘B: Heat chestnuts’ and ‘C: Process chestnuts’ shells’. As the functions of the other *koto* component ‘Enjoy “*making Yakigurit*”’, she defined ‘a: Enjoy gathering chestnuts’, ‘b: Enjoy heating chestnuts’ and ‘c: Enjoy processing chestnuts’ shells’.

When people ‘enjoy’ something, they usually receive ‘enjoyment’ through their five senses such as sight, touch and smell. The author tried hard to use nouns which could be quantified, but nevertheless they contained some qualitative expressions.

Figure 1 shows the definitions of each function gained from the two main components: ‘Make *Yakigurit*’ and ‘Enjoy “making *Yakigurit*”’.

Koto* to make *Yakigurit		***Koto* to enjoy "making *Yakigurit*"**	
A: *Koto* to gather chestnuts	Increase chestnut-number Reduce size-difference Reduce defect	a: *Koto* to enjoy "gathering chestnuts"	Increase chestnut-number Reduce optimal average-weight-difference per chestnut
B: *Koto* to heat chestnuts	Gain heat Help digestion	b: *Koto* to enjoy "heating chestnuts"	Gain heat Gain baked color Enhance flavor Improve taste Strengthen sweetness
C: *Koto* to process chestnuts'	Cover center Help shelling-ease Make crack	c: Koto to enjoy "process chestnuts' shells"	Cover center Help shelling-ease Make crack Peel shell

Figure 1: Definitions of *koto* functions in *Yakigurit*’s production procedure

2.3 Diagraming the function of Yakigurit

The author diagramed functions defined from each component. The high order function of the use function ‘Make *Yakigurit*’ was <<F1: Provide vitality-source>>. Its secondary functions were the following four: <<F11: Satisfy hunger>>, <<F12: Provide nutrition>>, <<F13: Help eating-ease >> and <<F14: Improve quality-stability>>.

In comparison, the high order function of the use function ‘Enjoy “make *Yakigurit*”’ was <<F2: Enhance happiness>>. Its secondary functions were the following three: <<F21: Enhance taste-expectation>>, <<F22: Gain security>> and <<F23: Provide enjoyment>>. Each of the functions was difficult to imagine from the production procedure ‘Make *Yakigurit*’.

Figures 2 and 3 show the FASTs gained through defining *Yakigurit*’s functions.

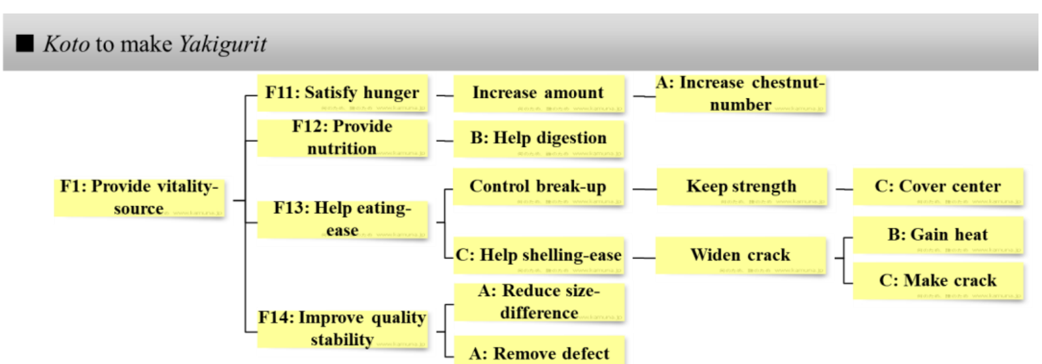

Figure 2: *Koto* FAST of ‘Make *Yakigurit*’

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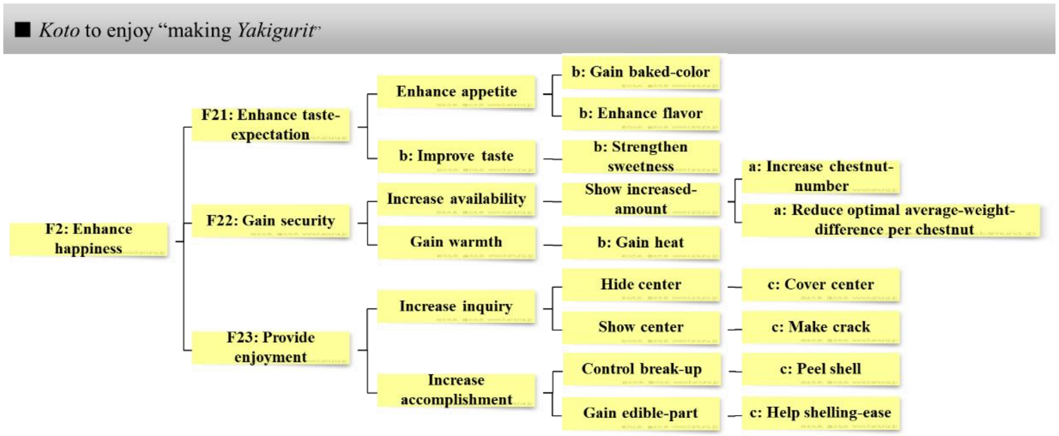

Figure 3: *Koto* FAST of 'Enjoy "making *Yakigurit*"'

By comparing these two FASTs, the author discovered that they had quite different functions. Indeed *Yakigurit* is a 'food', but the FAST of its esteem function shows no function of 'eating'. 'Eating' can be seen only in the use function, such as <<F11: Satisfy hunger>> and <<F12: Provide nutrition>>.

One interesting finding was that people do not even put *Yakigurit* into their mouth when their esteem function and its two low functions are <<F21: Enhance taste-expectation>>, <<Enhance appetite>> and <<Enhance taste>> respectively.

The esteem function of *Yakigurit* had nothing to do with 'eating'. Thus, it followed that the users (makers) of *Yakigurit* who 'Enjoy "making *Yakigurit*"'are not necessarily its 'diners'.

3. NEW TECHNIQUES TO ANALYZE THE USE FUNCTION AND THE ESTEEM FUNCTION

3.1. Use/Esteem Division FAST

The author paused to think of what the highest order functions of both its use and esteem functions would be. As a result, she gained a diagram as shown in Figure 4. She named it "Use/Esteem Division FAST" as it came from each FAST of the use function and the esteem function.

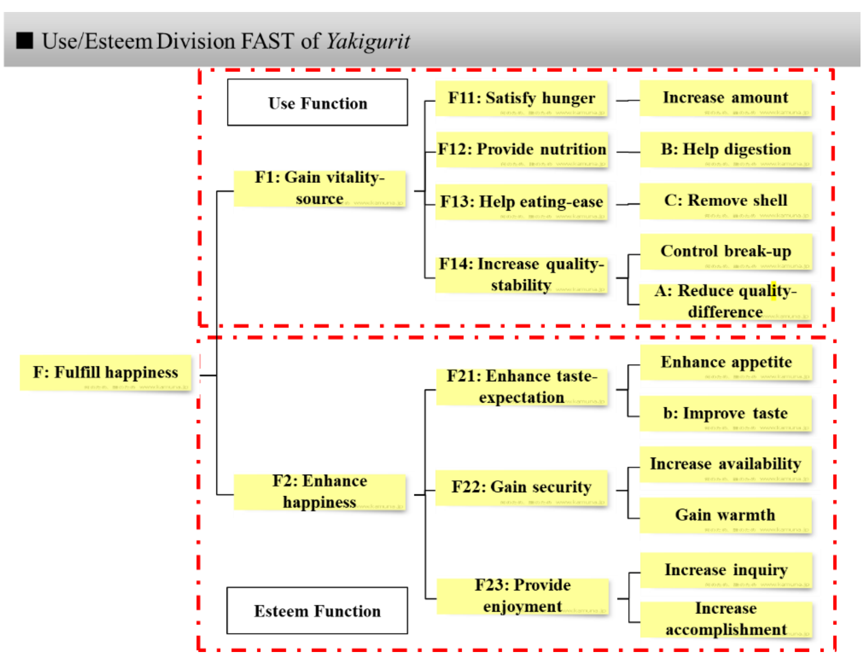

Figure 4: Use/Esteem Division FAST of *Yakigurit*

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The main feature of this functional tree lies in that we can make two FASTs (use function and esteem function) from one theme. Then, we set functions to satisfy each high order function. By doing so, we can gain the highest order function to achieve both the use function and the esteem function.

We should set each component from the production procedure. Then, we diagram functions defined by each component in one FAST. Furthermore, we make another FAST in which functions are defined with the view to 'Enjoy "following work procedure"'. From these two FASTs, we finally gain the highest order function. We can consider it as the function combined with both the use function and the esteem function.

3.2. "AND/OR" bond of FAST

The author felt something strange when making *Yakigurit*'s "Use/Esteem Division FAST", especially in that its high order function was <<F2: Enhance happiness>>, which was not necessarily related to 'eating'. To <<Enhance happiness>> could be satisfied by functions other than those of 'eating'.

In other words, while in the use function, all of its low functions must be achieved, not all of those in the esteem function are necessary. Even one should be enough to achieve its high order function.

From these observations, the author realized that for the achievement of its high order function, the use function needs all its low function (for example, A, B and C) to be achieved ("AND" bond); Meanwhile, the high order function of the esteem function can be achieved even when any one of its low order functions (for example, a, b or c) is achieved ("OR" bond). This led to a new FAST as shown in Figure 5. The author named it "AND/OR Bond of Use/Esteem FAST".

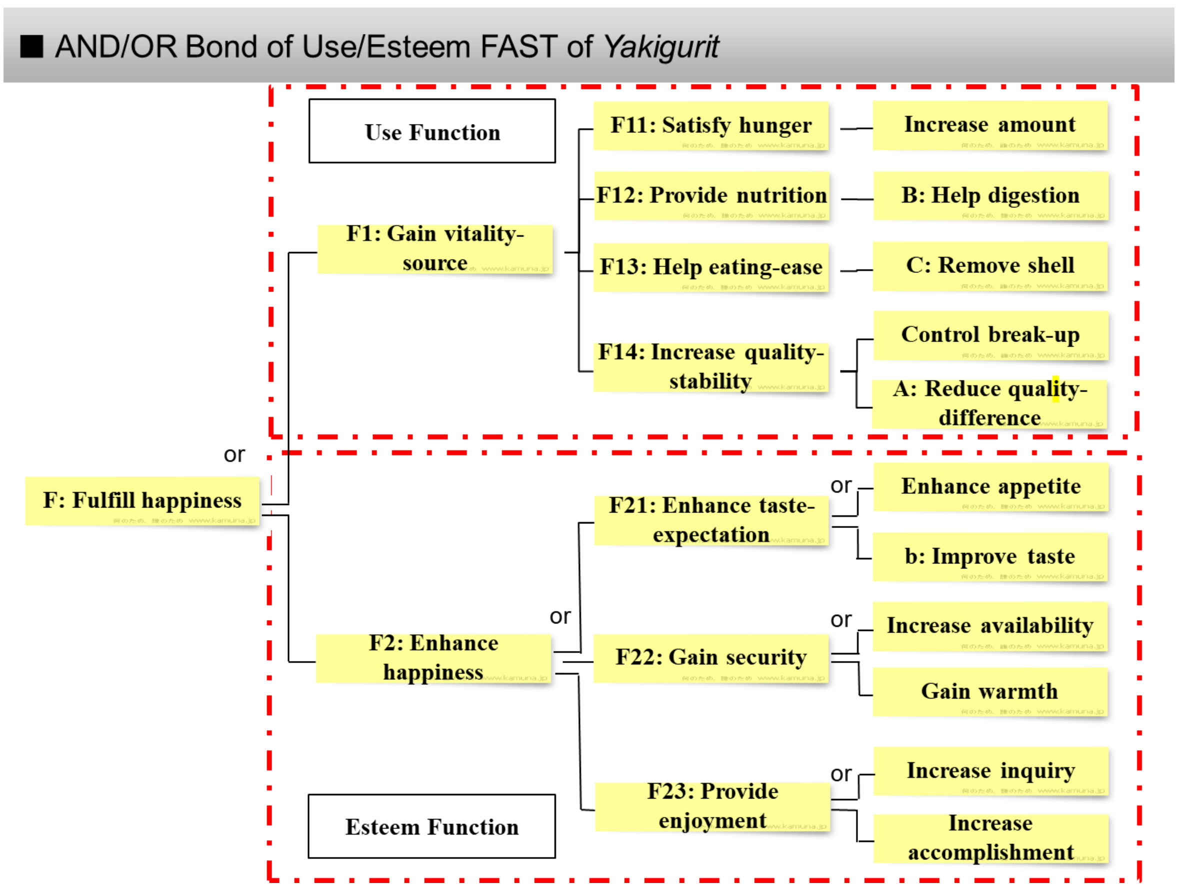

Figure 5: AND/OR Bond of Use/Esteem FAST of *Yakigurit*

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3.3. Performance Formula

The author noticed that there should be a difference in achievement of the high/low order function between the use function and the esteem function.

Both functions are becoming more abstract as their order goes higher, but the esteem function is more abstract than the use function. All the more, the achievement of each independent function of the former affects its entire theme. Each function can be achieved together with others. It can also be achieved on its own. Moreover, each function does not require others for its achievement.

In the use function, the achievement of its high order function becomes ‘zero (0%)’ when that of its low order functions goes below the acceptable value. It never goes beyond 100% even if its low order functions satisfy the acceptable value. Similarly, in the use function, the achievement of its high order function becomes ‘zero (0%)’ when that of its low order functions is ‘zero (0%)’. However, their upper limits never exist. Figure 6 shows these.

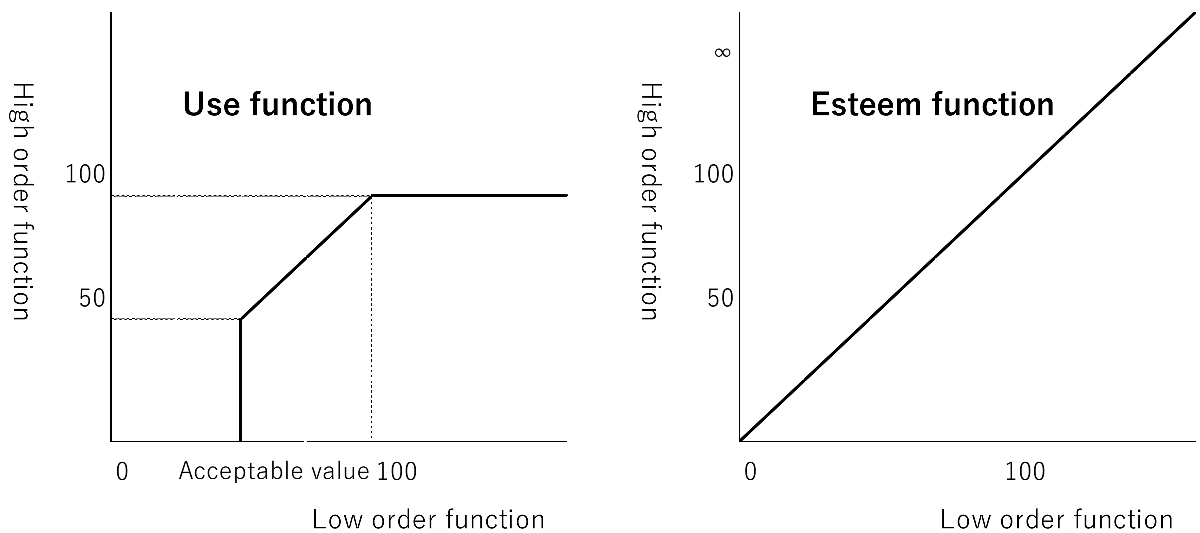

Figure 6: Two-axis analysis of the use function and the esteem function

Based on the “Use/Esteem Division FAST”, the author discovered differences in how the combined secondary functions are achieved: ‘Multiplication Type’ and ‘Addition Type’. These types differ in the limit of each low order function and the achievement of each high order function.

In ‘Multiplication Type’, any of the low order functions – F11, F12, F13 and F14 – needs to be more than ‘zero (0%)’ to achieve their high order function. The range of their achievement lies between 0% and 100%.

Meanwhile, in ‘Addition Type’, even if all of the low order functions – F21, F22 and F23 – are ‘zero (0%), their high order function can be achieved. Its upper limit is infinite. The author named these “Performance Formula” as below.

Multiplication Type: $F = F11 \times F12 \times F13 \times F14$

Limits of low order functions: $F11,\ F12,\ F13,\ F14 > 0$

Achievement of high order function: $0 < F \leq 100$

Addition Type: $F = F21 + F22 + F23$

Limits of low order functions: $F21, F22, F23 \geq 0$

Achievement of high order function: $0 \leq F \leq \infty$

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3.4. Radar chart analysis of the esteem function

In the use function, the achievement of its primary function becomes higher as that of its secondary functions goes up. Wherein, that of its each secondary function should be beyond the acceptable value; Even if any one of them is below that value, its primary function cannot be achieved.

For example, when the achievement of <<F11: Satisfy hunger>> is 100% but that of <<F14: Improve quality-stability>> is below the acceptable value (for example, there are several decayed chestnuts), <<F1: Provide vitality-source>> cannot be achieved.

Then, how about the esteem function? To analyze its achievement, the author visualized it in a radar chart. To differentiate its secondary functions more concretely, she used its six tertiary functions – <<Enhance appetite>>, <<Improve taste>>, <<Increase availability>>, <<Gain warmth>>, <<Increase inquiry>> and <<Increase accomplishment>>.

People differ in what they find attractive or how attractive they feel it is. Assume that the average value of 'attractiveness' is '3'. Some people may feel something attractive when all of its six tertiary functions are '3'. Some may feel it attractive when some of the functions are above the average even though the others are below the average. Others may feel it attractive when one function excels while the other five are not attractive, either '1' or '0'. Even in the last case, the entire secondary level may be highly achieved, bringing in higher achievement of the highest order function.

Even when any of the secondary functions is achieved below the acceptable value, it does not hinder the achievement of the highest order function. It is difficult to say that any of the above patterns may produce the highest performance, but it can be achieved if only one of the secondary functions over-excels. Figures 7 and 8 show these

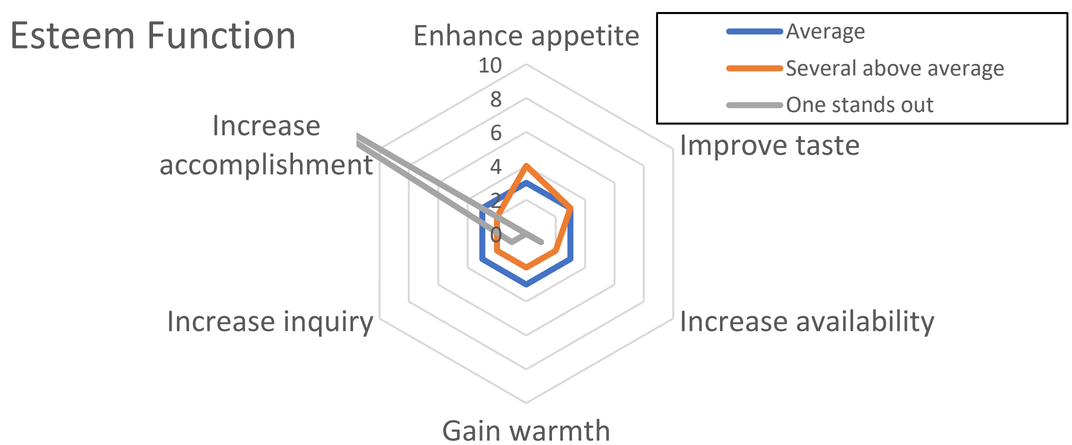

Figure 7: Radar chart analysis of the esteem function

Esteem Function	Enhance appetite	Improve taste	Increase availability	Gain warmth	Increase inquiry	Increase accomplishment	Total
Average	3	3	3	3	3	3	18
Several above	4	3	2	2	2	2	15
One stands out	0	0	1	0	1	20	22

Figure 8: Addition-type calculation of the esteem function

Figure 7 shows that 'only one over-excels' has an extremely distorted shape. Five of the six tertiary functions are under-achieved at either '0' or '1', but one function <<Increase accomplishment>> has an extremely

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high value of ‘20’. Figure 8 shows them by ‘addition type’. Ironically, the esteem function with ‘only one over-excels’ shows the highest achievement.

Similarly, viewed from its highest order function <<Fulfill happiness>>, the esteem function has nothing to do with the achievement of the use function. For example, if something is so rare that people cannot obtain easily, it cannot <<F1: Provide vitality-source>> but can over-achieve <<Increase accomplishment>> when they obtain it. In this case, it can <<F: Fulfill happiness>> far more than anything that can be found everywhere. Therefore, the achievement of the esteem function alone can control that of the highest order function of both use function and esteem function. It can be calculated by ‘addition type’.

4. STUDY RESULTS

Through her study on *Yakigurit*, the author has gained the following three results with regards to the relation between the use function and the esteem function:

- Use/Esteem Division FAST: The use function and the esteem function affect the entire theme differently. To gain their common highest order function, each FAST of the two functions should be made separately in advance.
- AND/OR Bond of Use/Esteem FAST: The relation between the high order function and the low order function is either ‘AND bond’ or ‘OR bond’. The former requires that all of the low order functions should be achieved in order to achieve the high order function (use function). The latter does not always require that to do so (esteem function).
- Performance Formula: The achievement of the high order function can be gained through calculating the effect of the low order functions. In many cases, the achievement of the use function can be gained by ‘multiplication type’, and that of the esteem function can be gained by ‘addition type’.

From these results, it can be said that influence of the esteem function on the entire theme is infinite, while that of the use function is much smaller.

Yakigurit creates scenes full of enjoyment before they are eaten. Its taste may become the only focal point, but it actually offers customers tricks, which drive them to shell the food by hand or drive them to touch it even though it is hot. It even offers customers an event ‘chestnut-gathering’, which drives them to gather chestnuts.

Customers want to eat *Yakigurit* all the more by using their five senses. Their desire to eat it can be enhanced by various tricks from its actual thing or its photos to its written information. Its written information may not be about its taste, but it can be anecdotes of its producer from his/her struggle and commitment to his/her character. Such information can stimulate customers’ appetite and <<Provide enjoyment>>. The producer’s tricks may enhance some functions of customers.

The esteem function can create scenes in which people can enjoy themselves and enhance pounding or exciting feelings. It can make people’s ‘good memory’. There is no one way to <<Fulfill happiness>>. When combined, multiple functions may generate a new significant function. It is possible that one person’s happiness be greater than that of another. Its achievement is infinite.

5. CONCLUSION

Through this study, the author has devised the following techniques:

- Use/Esteem Division FAST
- AND/OR Bond of FAST
- Performance Formula

In the food industry, mixed together with the use function and the esteem function, these analysis techniques enable us to clarify what the nature of ‘eating’ is. Thus, the author has found that this new VM

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method with these three techniques should be applied widely to the food industry.

The esteem function of ‘eating’ goes as far as its tableware. Japan has food culture called *ohsara-mori* (platter). People share assorted foods on a big plate, which is 30 cm in diameter, and is placed in the center of the dining table. A Japanese local cuisine called *sarahachi-ryori* (big platter). It uses an even bigger plate that is as large as 50 cm in diameter. Another feature of *sarahachi-ryori* is that it is an expensive plate with a painting on it. It is full of assorted foods, its painting is completely hidden. As people eat the food, more empty space appears on the plate. People become amazed when they eventually see a gorgeous painting. Its esteem function is an aesthetically beautiful feature for people to enjoy and celebrate on a special occasion.

In addition, Japan has culture called *nabe-houkou*/*yaki-houkou*. These terms refer to people in charge of hot-pot/hot-plate cooking whom give detailed instructions, such as the order of ingredients, the right heat, cooking, and presentation of the dish. They love to ‘manage’ cooking rather than ‘cooking’ itself. Barbecue exemplifies this. These are the esteem function too.

How about other fields other than food? Crossword puzzles or plastic models have a function to <<Fulfill happiness>> through completing all the process for those activities as well. Rarely offered items such as auctions and rare tickets may make people excited through those types of processes as well. For example, it was big news in Japan that at the first auction of January 5th, 2019 at Toyosu Fish Market in Tokyo, a company bought a tuna for 333.60 million yen, the highest price ever bid.

Some products may have its use function of ‘0’. Originally high in their use function, it may turn ‘0’ as soon as its use is over. For others, their users may make their use function ‘0’ although it is still above the acceptable value. Nevertheless, people prioritize their products’ esteem function. Vintage items such as commemorative coins/stamps, antique furniture and vintage clothes exemplify these.

Through this study, the author felt the depth of VM as to how concretely it can achieve each of the use/esteem function of products/services. ‘Eating’ is an act which we conduct every day. It is mysterious all the more for this reason. The author wishes to continue her VM study on functions in the food-related field.

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IMPLEMENTATION OF VALUE ENGINEERING PROPOSAL IN SEWER SYSTEM IN THE KINGDOM OF SAUDI ARABIA.

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ABSTRACT

Yanbu Industrial City (YIC) is known as a new, modern, and heavy industrial urbanization. For that reason, the need for new urban water sustainability is probably more evident than in other cities. Water sustainability has become a top policy discussion to maintain or enhance all natural and urban elements' growth without compromising the future. Fortunately, Royal Commission Leaders have responded to the challenge by making urban water sustainability development a high priority [3].

Thus the objective of this paper is to determine the most appropriate waste water network solution, using the Value Engineering concepts, which is used for comparing the different alternatives for lift station system instead of gravity in sewer deep system which where:

Option-1: Wastewater Network with maximum depth of 6.0m and Lift stations,
Option-2: Wastewater Network with maximum depth of 8.0m and Lift stations,
Option-3: Wastewater Network with maximum depth of 10.0m and Lift stations,
Option-4: Wastewater Network with maximum depth of 30m (Deep Sewer).

Value Engineering (VE) is a total management approach to improve the quality of construction projects. It increases the efficiency and performance of the projects to gain the best integrated benefits. The VE focuses on function analysis of the researched subjects and strives to achieve the required function reliably at the lowest Life Cycle Cost (LCC).

The potential use of the Value Engineering (VE) process can be used effectively in developing the optimum solution which use lift station system instead of gravity in sewer deep system finding that the appropriate alternative was waste water network with maximum depth of 10.0m and Lift stations is more economical and efficient than the traditional system which achieve cost saving about 23%.

Keywords: Value Engineering, Drainage, Life cycle cost.

1. General

1.1. Objectives

• To understand the implementation of value engineering in waste water network.
• To identify certain parameters by using this methodology how time, cost, and quality can be optimized.

1.2. Aim

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This study aims to understand the application of value engineering in waste water network to optimize cost, time and quality.

2. LITERATURE STUDY

2.1. Value Engineering Concept

Value Engineering Concept Value Engineering Concepts is the emphasis on the cost of products or services by involving the principles of Engineering. This technique seeks to achieve the same minimal quality as planned with minimal cost. The planning process undertaken in the implementation of Value Engineering is always based on the required functions and the value obtained [1].

2.2. VALUE ENGINEERING

Value engineering is an organized, creative, cost search technique for analyzing the function of a product with the purpose of value enhancement without compromising with its quality, performance and efficiency. It is a systematic process that seeks to achieve value for money at the lowest cost possible, consistent with required level of quality and performance. The main focus of Value Engineering is on improving the function, reducing the cost of the product, or both by the way of product evaluation and analysis.

Value = Function (desired performance)/Cost.

Value engineering not only involves lowering the cost of processes and methods but also analysis of the function of a product. VE is a systematic approach directed towards purpose of analyzing system, equipment, facilities, staff and services for the purpose of achieving their desired functions low cost with required quality. Implementation of VE on any project leads to increased performance, quality and efficiency. The success of existing value engineering programs indicates that the same application to interior projects can be an opportunity for saving costs and better performance.in today's time of reduced budgets, cost cuts and staffing problems we can no longer afford untimely delays in projects and increased costs.

When a project costs more than what was initially planned decision makers are forced to take tough decision with regards to the projects [2].

2.3. VALUE ENGINEERING HISTORY

The practice of VE has flourished for almost an era [1], with its roots in general electric during World War 2, when invention was needed due to resource scarcity. It was hard to procure some essential materials and several substitutions had to be made. The vice president, Harry Erlicker, noted that these improvements have resulted in lower prices and better goods several times. This inspired him to look for an approach to deliberately maximize the value of a commodity. He assigned the job of discovering a more proficient way to improve value of product to Lawrence d. Miles, an engineer [8].

In 1947, a method called value analysis (VA) was developed by miles and his team to measure the cost of the product and work to minimize unnecessary expense. The new methodology was enhanced, analyzed, and confirmed to be highly successful as a consequence of considerable investment. In 1952, VA started its industry-wide production.

2.4. VE DEFINITIONS AND FEATURES

The numerous specialists and practitioners of this method have a multitude of interpretations, and few are mentioned below:

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• [3] “a discipline action system, attuned to one specific need: accomplishing the functions that the customer needs and wants at the lowest cost”.
• [4] “a validated management strategy using a structured approach to find the best practical balance between the expense, efficiency and quality of the project,”.
• Connaught.on.and.green (1996) “a systematic approach to delivering the required functions at lowest cost without detriment to quality, performance and reliability”.
• Hayles.and.simister (2000) “proactive, creative, team approach to problem-solving in construction projects to provide the best value for money”.
• [5] VE can be characterized as a coordinated, systemic, comprehensive approach to problem-solving basically focused on evaluating role of processes, machinery, amenities, resources, and materials for the need to perform their vital roles with the necessary efficiency, durability, quality, and safety at the lowest life-cycle capital expenditure.
• [6], described VE as it is an innovative and well-organized mechanism that aims at providing the user with consistent chance to save costs without damaging key functions or results.

2.5. Value Engineering Methodology

Value Methodology Standards, SAVE International. 2007
The value methodology is a systematic process that follows the Job Plan. A value methodology is applied by a multidisciplinary team to improve the value of a project through the analysis of functions.
The job plan consists of the following sequential phases, as shown in Fig. (1).

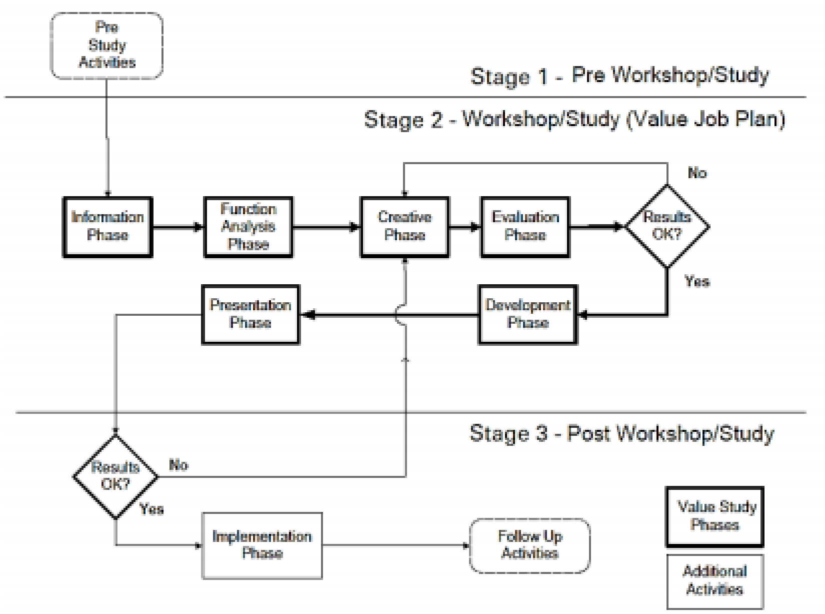

Figure (1): Value Study Process Flow Diagram [SAVE International Standard 2007]

2.5.1. Pre-Workshop Phase (Pre-analysis):

Preparation tasks involve six areas: Collecting/defining client wants and needs, gathering a complete data file of the project, determining evaluation factors, scoping the specific study, building appropriate models, and determining the team composition (Alyousefi, 2011).

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2.5.2. Workshop Phase (Value analysis):

Value engineering is every so often done by systematically following a multi-stage job plan (Council, 2001). The early original system of VE was a six-step technique which was called the "value analysis job plan." Then later others have speckled the job plan to fit their constraints.

VE is carried out every so often by consistently executing a multi-stage work schedule. The initial VE method was a six-step methodology known as "value analysis job plan" which was further developed and molded with the framework of the projects that used the job plan in their execution.

The six stages job plan (information phase, function analysis phase, creative phase, evaluation phase, development phase, and presentation phase) is considered and explained briefly.

- Information gathering:

This asks what the requirements and preferences are for the object. Function analysis, an important technique in value engineering, is usually done in this initial stage. It attempts to determine what functions or performance features are significant. This stage should be saturated with as much information as possible. It asks questions like; what does the object do? What must it do? What should it do? What could it do? What must not it do?

- Function analysis phase:

Function analysis is a key issue in VE. For this purpose, Function Analysis System Technique (FAST) is used to picture all the functions of a component's subsystem (process, etc.) showing their specific relationships to each other and clearly showing what the subsystem does.

- Creative phase:

In this stage value engineering team asks; what are the various alternative ways of meeting requirements? What else performs the desired function?

- Evaluation phase:

In this stage, all the alternatives are assessed by evaluating how well they meet the required functions and how effective the cost savings are.

- Presentation phase:

In the final stage, the optimum alternative is selected and offered to the client for a final decision.

2.5.3. Post- Workshop Phase (Post-analysis):

The objective during Post-Study activities is to assure the implementation of the approved value study change recommendations. Assignments are made either to individuals within the VE study team or by management to other individuals, to complete the tasks associated with the approved implementation plan.

While the VE Team Leader may track the progress of implementation, in all cases the design professional is responsible for the implementation. Each alternative must be independently designed and confirmed, including contractual changes if required, before its implementation into the product, project, process, or procedure. Further, it is recommended that appropriate financial departments (accounting, auditing, etc.) conduct a post-audit to verify to management the full benefits resulting from the value methodology study.

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2.6. VALUE ENGINEERING ADVANTAGES

1) Job analysis distinctive way (function analysis).
2) A significant number of good ideas that are relevant are nominated.
3) An action plan that consists of multiple consecutive steps of a logical chain in place.
4) A multi-disciplinary unit working on common values research.
5) Ensure cooperation with the respective project authorities.

3.0 CASE STUDY:

Project Name: T12 ACCESS ROAD (4KM) & BYPASS 1 EXPRESSWAY INTERCHANGE (65Ha)

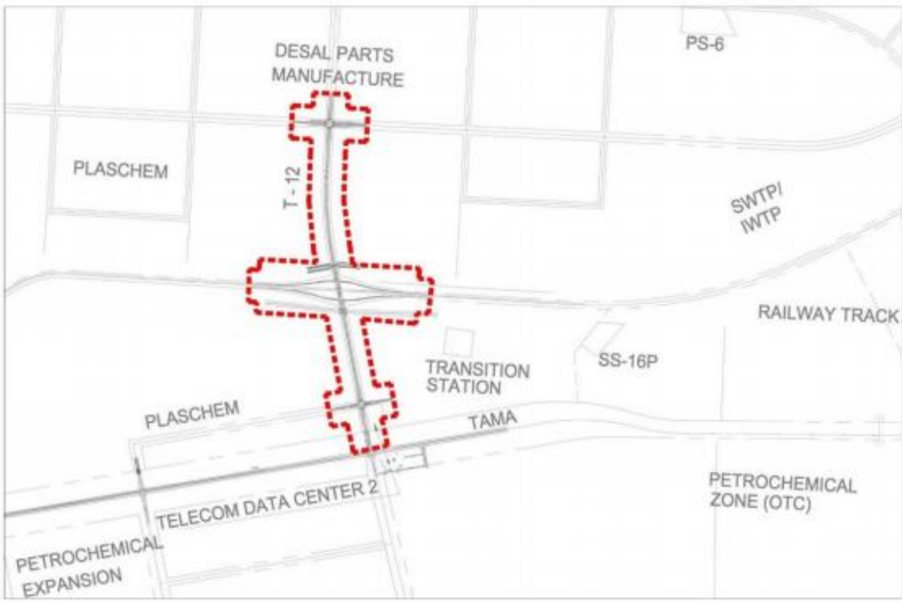

Figure (2): Layout of The Project.

This Value Engineering (VE) study was conducted at 30% design stage for T12 Access Road (4km) & Bypass 1 Expressway Interchange (65ha), Contract No. PIC R-T-7529, Yanbu Industrial City, Expansion Area, from April 1 to 5, 2018 at Leadership Development Center of Royal Commission in Yanbu, Saudi Arabia. The project was designed by SAUDCONSULT, Saudi Arabia, and the total cost of this project was estimated at SAR 312 million. This Value Engineering (VE) Study provided an overview of the project, key findings, recommendations and the ideas developed by the VE Team. Detailed documentation, analysis and recommendations of the study were provided in this VE Study Report.

❖ The primary objectives of the VE team were to:

- Apply the principles and practices of the VE Job Plan.
- Conduct a thorough review and analysis of the project.
- Brainstorm and evaluate possible improvement opportunities.
- Search for innovative approaches.
- Identify potential value added and cost saving opportunities.
- Confirm required performance and functional requirements.
- Optimize the design by refining all systems.
- Enhance project value and quality.

The study was to define functions of the project and other facilities to generate alternatives, multiple ideas and recommendations to avoid unnecessary costs and optimize the project total Life Cycle Cost (LCC).

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Following are salient features of the project:

- The Road T12 consists of 3 lanes in each direction with 9.0m raised median with double arm lighting pole at the center.
- The standard lane width is 3.75m.
- Two side open ditches were provided within the 90 m ROW
- ROW for Road T12 is 90m.
- Road T12 is 4 km long.

3.1. VE JOB PLAN

The VE Team employed the SAVE International® VE Job Plan, which consists of the following
stages and phases:

3.1.1. INFORMATION PHASE:

The objective of this phase was to obtain a thorough understanding of the project by reviewing the project's drawings, specifications and BOQ, which were available at the time of study.
The VE Team Facilitator prepared the cost model from the cost estimate of the baseline. The model is organized to identify major construction elements. The cost model clearly showed the cost drivers for the project and was used to guide the VE Team during the study.
The VE team found that (based on the cost model) the WASTE WATER SYSTEM item is the largest cost among the other items in the project as its cost is equivalent to 41.70% of the total project cost .. Therefore, it will be focused on in this research.

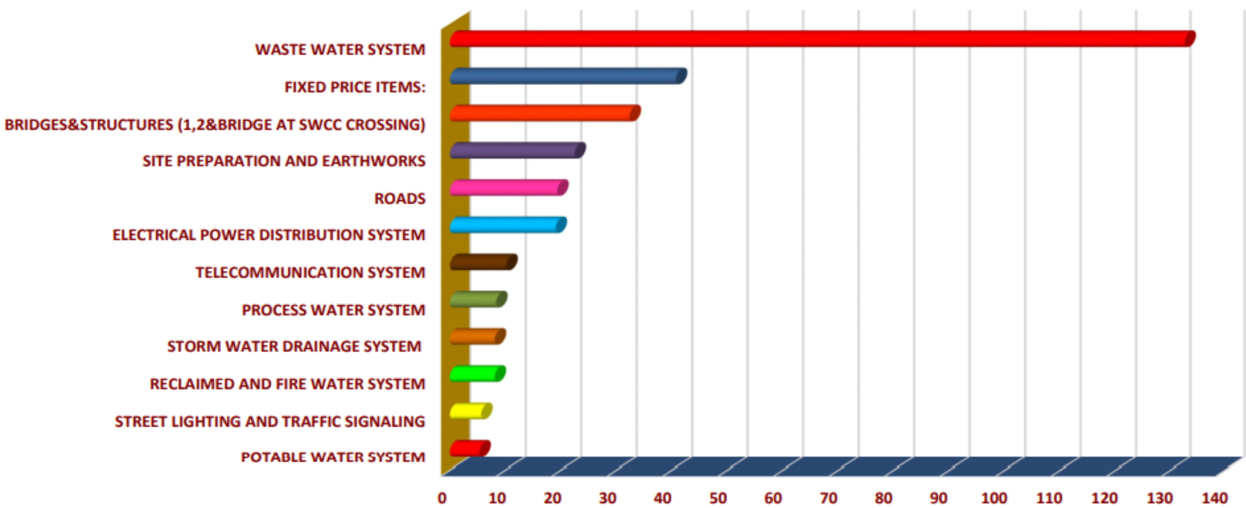

Figure (3): The Cost Model of the Project.

3.1.2. FUNCTION ANALYSIS PHASE:

The VE Team analyzed the project using the VE Job Plan and associated tools. Using function analysis and Function Analysis System Technique (FAST) diagram, the team defined the basic function of this project with various criteria. The team discussed all

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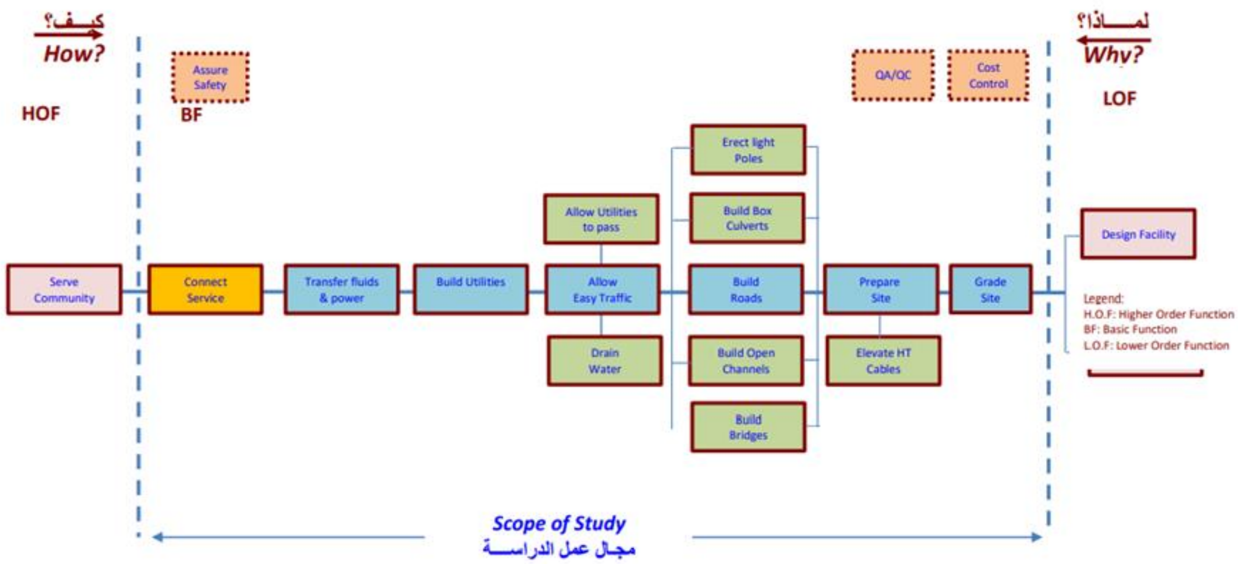
functions to be performed by project components/items and prepared the following FAST Diagram.

Table (1): Function Wording.

WORK FUNCTIONS			
Verbs	**Nouns**	**Verbs**	**Nouns**
Connect	Lines	Allow	Passage
Transfer	Liquid	Contain	Water
Receive	Liquid	Protect	Damages

Figure (4): FAST Diagram.



3.1.3. CREATIVE PHASE - IDEA GENERATION

During this phase, the VE Team employed creative techniques such as team brainstorming to develop a number of alternative concepts that satisfy the project's various functions. This phase generated many ideas that were moved into the Evaluation Phase. Finally, following four options have been studied for the waste water system (Use lift station system instead of gravity in sewer deep system):

Table (2): The Alternatives of Waste Water Network.

Idea no.	Idea
C	CIVIL
C-01	Wastewater Network with maximum depth of 6.0m and Lift stations
C-02	Wastewater Network with maximum depth of 8.0m and Lift stations
C-03	Wastewater Network with maximum depth of 10.0m and Lift stations
C-04	Wastewater Network with maximum depth of 30m (Deep Sewer)

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3.1.4. EVALUATION PHASE

The purpose of this phase was to evaluate the alternative concepts developed by the VE Team during the brainstorming session. The team used a number of tools to determine the qualitative and quantitative merits of each concept.

After listing all ideas, the team started the evaluation phase through the following steps:

1. Comparing all the remaining ideas against the five criteria using the Criteria Evaluation Form.
2. Using advantages/disadvantages forms.
3. Running the matrix, if needed.

Table (3): The Criteria Evaluation Form

N	Criteria	Rank
A	Constructability	1
B	Ease of maintenance	2
D	Need for specialist contractor	4
E	The availability of raw materials	5
C	Time of implementation	3

Table (4): Advantages/Disadvantages Form.

EVALUATION			
Proposal No.	Idea	Advantages	Disadvantages
C	CIVIL		
C-01	Wastewater Network with maximum depth of 6.0m and Lift stations	Easy to construct, Pipes and Manholes are readily available in the KSA market, Maintenance/repair is easy, Low cost of pipe installation.	Lot of Lift Stations are needed, High operational cost of Lift Stations.
C-02	Wastewater Network with maximum depth of 8.0m and Lift stations	Easy to construct, Pipes and Manholes are readily available in the KSA market, Maintenance/repair is easy, Low cost of pipe installation.	Many Lift Stations are needed but less than that of option-1, Little High operational cost of Lift Stations.
C-03	Wastewater Network with maximum depth	Hard to construct as open cut but still workable, Pipes	Few Lift Stations are needed, Low operational

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	of 10.0m and Lift stations	and Manholes are readily available in the KSA market, Maintenance/repair is moderate, Medium cost of pipe installation.	costs as less number of Lift stations are required.
C-04	Wastewater Network with maximum depth of 30m (Deep Sewer)	No Lift Station is needed, Very Low operational cost.	Hard to construct as special Equipment (TBM Machines) required, Pipes and Manholes are not readily available in the market for deep sewer, It needs customized Pipes and Manholes for the project, Special equipment are needed for Maintenance / repair / inspection, The cost of pipe installation is extremely high.

Table (5): Wastewater Network Cost Breakdown for Options

OPTION	Pipeline Costs	Lift Stations & (O&M) Costs	Contingency Cost	Grand Total Cost
Option 1	33424188.16	61625846.92	9400552.92	104450588
Option 2	40083957.81	53445277.08	9250144.11	102779379
Option 3	62341682	29159819	9049599	100551100
Option 4	193395139.2	---	19126991.79	212522131

In value index matrix for Criteria

- How Important

1- Major Important = 2
2- Minor Important = 1
3- letter/letter = one point for each other

Table (6): value index matrix

(A) Constructability	A							
(B) Ease of maintenance	a/b	B						
(C) Time of implementation	a/1	b/1	C					
(D) Need for specialist contractor	a/1	b/1	c/d	D				
(E) The availability of raw materials	a/2	b/2	c/1	d/1	E			
Weight	6	6	3	3	1	**Q**	**C** (Million SAR)	**Vi = Q/C**
% of the total	31.6	31.6	15.8	15.8	5.3			

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Wastewater Network with maximum depth of 6.0m and Lift stations	5	5	3.5	5	4.5			
	158	158	55.3	79	23.85	474.2	104.45	4.54
Wastewater Network with maximum depth of 8.0m and Lift stations	5	5	4	5	5			
	158	158	63.2	79	26.5	484.7	102.79	4.72
Wastewater Network with maximum depth of 10.0m and Lift stations	5	5	4.5	5	5			
	158	158	71.1	79	26.5	492.6	100.55	**4.90**
Wastewater Network with maximum depth of 30m (Deep Sewer)	2	2	3	2	2			
	63.2	63.2	47.4	31.6	10.6	216	212.52	1.02

The value index matrix shows that the Wastewater Network with maximum depth of 10.0m and Lift stations have the larger value index.

3.1.5. Development phase:

This phase of the process was to take the concepts or ideas that ranked the highest from the Evaluation Phase and further develop them into full VE recommendations. In many cases, it was possible that one or more ideas can be combined to form an overall recommendation, which were evaluated further by the VE Team.

Table (7): Development phase.

DEVELOPMENT PHASE After Review & Approved by RCY				
Idea No.	**Idea**	**Saving (SAR)**		**REMARKS**
C	**CIVIL**			
C-01	Use lift station system instead of gravity in sewer deep system	77,347,000 (Without operation & maintenance cost)		
C-01	Use lift station system instead of gravity in sewer deep system		24,847,000 (With operation & maintenance cost)	

Table (8): Development phase.

DEVELOPMENT PHASE After Review & Approved by RCY				
Contract :	PIC R-T-7529			
Project :	T12 ACCESS ROAD (4km) & BYPASS 1 EXPY. INTERCHANGE (65ha)			
Location :	MADINAT YANBU AL-SINAIYAH (MYAS)			
Item No.	**Value Engineering Proposal**	**Total Saving / Justified Additional Cost (Estimate by VE Consultant)**		
C	**CIVIL**	**ECC**	**LCC**	**TOTAL**

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C-01	Use lift station system instead of gravity in sewer deep system	77,347,000	24,847,000	100,551,100

3.1.6. Presentation phase:

The VE Team presented their findings in the form of an oral presentation on the final day of the study.

4.0 CONCLUSIONS

Based on the value engineering study of lift station system instead of gravity in sewer deep system at varying depths with four options (6, 8, 10 and 30 meters) with corresponding required number of Lift Stations for the Master Plan area over 4 km long,

following conclusions are made for consideration and decision making to carry on further work on the design and preparing RFPs for implementation with the objectives of minimum costs (capital and recurring Operation and Maintenance) of the pipeline, lift stations, pumps and odor control equipment, etc.

it can be readily concluded that Option -3 is least cost whereas Option -4 is most expensive. Advantages of Option -3 are ease of construction and maintenance, readily availability of pipes and manholes, but has disadvantage of requirement of some lift stations involving O & M costs.

Since this proposal will be applied to over nine applicable similar projects the saving of around SR 400 Million in Sewer System in the Kingdom of Saudi Arabia will be achieved.

The results shown in changing the above materials has a relative impact on the overall cost of the project. So, if value engineering is applied in projects, it can make more benefits in terms of saving cost, time and increasing or maintaining the same quality.

Table (9): Project Budget

Project Description	The Cost	% The percentage
Waste Water Network	130,000,000 million	41.70%
Other Items	182,000,000 million	58.30%
Total Budget of The Project	312,000,000 million	

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PAPER TITLE: A RANGE SCALE / MATRIX OF VALUE ENGINEERING STUDY IMPLEMENTATION STRATEGIES

AUTHOR NAME: JAMES MCCUISH AND CHARLES JENNINGS

Abstract:

Over many years of conducting value engineering studies, and other project improvement engagements, we have found there is a broad range of client expectations, and a significant range of client commitment to allocation of resources and funding for Value Engineering engagements.

In many cases, these variations are not apparent in a Request for Proposal document which has been prepared by the client or in some cases the client engineering contractor. As a result, value engineering practitioners may find they are responding to a request for bid with a professional opinion as to what the client needs to improve their projects. However, for a variety of reasons actual client expectations may be significantly different. The range of client expectations will be influenced by cost of workshops, schedule of workshops, actual commitment to conduct the value engineering results sought for and in some cases, a significant lack of understanding with respect to the value methodology.

In almost 3 decades, the authors have experienced a broad range of such variations in client commitment and have developed an initial working scale to aid in discussion with clients as to what their real expectations We suggest such conversations are extremely important, if not mandatory. This is particularly the case when the client requests a fixed sum or lump sum bid.

This paper shares a new 1-7 scale / matrix which is under development and which is being tested with a broad spectrum of clients and practitioners. It is in ongoing review and will be improved over the months, as it is tested and edited. However, in current form we are finding the approach to be currently very useful.

Introduction

While conducting value engineering studies, and other project improvement engagements, we have found there is a broad range of client expectations, and client commitment to allocation of resources and funding for Value Engineering engagements.

Often, this spectra of expectations and commitment is not apparent in the initial client discussions. And in many cases the client expectation and commitment is misaligned with the value engineering practitioner or consultant assumptions as to the precise client focus. In many cases the experienced value engineering practitioner only takes a very short time to understand the level of commitment which should be necessary to make a major impact on the return of investment for the project. However, over the years in far too many cases, due to variations in the client commitment of resources practitioners deliver “acceptable” results, which could have been superlative results with incrementally more client commitment.

In many cases, these variations are not apparent in a request for proposal document which has been prepared by the client or in some cases the client engineering contractor. As a result, value engineering practitioners may find they are responding to a request for bid with a professional opinion as to what the client needs to improve their projects. However, for a variety of reasons client expectations may be significantly different. The range of client expectations will be influenced by cost of workshops, schedule of workshops, actual commitment to conduct the value engineering and in some cases, a significant lack of understanding with respect to the value methodology.

In almost 3 decades, the authors have experienced a broad range of such client commitment and have now developed a working scale to aid in discussion with clients as to what their real expectations are. In some cases, these may be uncomfortable conversations with the clients, however, we suggest such conversations are extremely important, if not mandatory, when the client requests a fixed sum or lump sum bid. And definitely prior to bid submittal and/or contract execution.

Discussion

Over the decades, we have found value implementation strategies ranging from "complete focus on minimizing the cost of the value engineering engagement" up to a "full understanding of the power of the value engineering methodology and a commitment to derive as much as possible from the effort."

> "Everyone wants a magical solution for their problem, and everyone refuses to believe in magic"
>
> Jefferson

The following graphic depicts the development of a reference scale / matrix, which we are using / testing at the time of this publication. In the current form this scale provokes interesting & requisite discussions.

VE Implementation Strategy	Description	Characterized by Focus	Results Targeted	Pre-work	Consultant Proposes
1. Absolute Minimum VE Cost	Absolute Minimum VE Cost to check a box in their Internal Project Process regardless of effectiveness. (Regardless of what may or may not be recommended in the Client's internal project VE requirements)	**Focus on VE Cost exclusively**	Lowest Cost of VE to "Check Boxes"	**"Very little to none!" Just show up and run a meeting – and call it VE**	Show up "cold" and run minimum Workshop hours. Expectations of results - Low
2. Fixed total VE Budget	Make informed decisions about which VE can be done on a "fixed total VE budget." (Regardless of what may or may not align with the Client's internal project VE requirements)	**Seek Guidance to Prioritize VE to select higher value VE**	**Just Perform a limited number of VE, which are done well**	**Willing to conduct only minimum pre-work**	Provide guidance to manage budget resources for selected VE (cost, hours).
3. Minimize Time of Staff Engagement	Design VE efforts that minimize staff time away from their duties attending workshops. (Efforts may or may not align with the Client's internal project VE requirements)	**All about Minimum staff time away from operations**	**Reduced staff activities - maybe not consider LCCA**	**Use pre-work alternatives as required to minimize time for staff in workshops**	Identify pre-work tasks that reduce workshop duration and resulting reports min. WS hours
4. Control Project Resource Committed	Project wishes to implement VE but needs to minimize resources used (Capex) due to project budget constraints, regardless of VE benefits (Opex or ROI impacts).	**Target the right VE and invest in them**	**Improve selected project KRAs (Capex, Schedule) May not pursue LCCA analysis**	**Use pre-work to understand Function vs Cost for Capex & Construction Cost and selected KRA improvement**	Capex focused Pre-work, includes Cost Analysis and long workshop hours
5. Serious about VE Utilization	Project understands VE methodology impact and is serious about using VE to improve project outcomes. Wishes guidance on VE.	**Flexible on VE resources dedicated**	**Focused on value improvement results, with full cycle ROI & LCCA**	**Significant pre-work recognized as pivotal and conducted to achieve value improvements**	Full VE classic pre-workshop tasks and preparation, including long workshop hours
6. Committed to Invest in VE	Project understands that VE can reduce the project cost by at least 3% - 5 % (often 10% to 15%). Project will invest resources to capture potential value improvements.	**Spend time and resources required to explore value improvements**	**Focused on full cycle ROI results**	**Significant pre-work recognized as pivotal and conducted to achieve value improvements**	Full VE classic pre-workshop tasks and preparation, including long workshop hours
7. Significant Investment in VE implementation	Project understands that VE will improve project value by at least 3% - 5 % (often 10% - 15%), Project is also interested to deliver the product to the market sooner than the existing schedule, to improve ROI. Project will proactively invest resources necessary to capture a potential prize.	**Spend time and resources required to capture value improvements**	**Focused on guaranteed project value results (ROI)**	**Significant pre-work recognized as pivotal and conducted to achieve value improvements.**	Full VE classic pre-workshop tasks and preparation, including long workshop hours

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In the following pages we discuss each in turn in light of our experience which has engaged clients at all levels of the scale.

1. Absolute Minimum VE Cost

Absolute Minimum VE Cost to check a box in their Internal Project Process regardless of effectiveness. (Regardless of what may or may not be recommended in the Client's internal project VE requirements)

Focus	**Results Targeted**	**Pre-work**	**Consultant Proposes**
Focus on VE Cost exclusively	**Lowest Cost of VE to "Check Boxes"**	**"Very little to none!" Just show up and run a meeting – and call it VE**	Show up "cold" and run minimum Workshop hours. Expectations of results - Low

This strategy is often characterized by a request for proposal with the phrase similar to "please provide a price for a two day value engineering workshop." In some cases the request for proposal will specify the respondent may only communicate with a single contract specialist (in the contracts/admin. Department) and may not communicate with the project team. The specified time it may be three or a maximum of four days.

The client expectation is a lump sum figure will be provided, essentially, with no other discussion. The client may have no expectation of prework requirements or necessity. The project team and our engineering contractor, architect or designer may be totally unfamiliar with value engineering, however, the client internal project management procedures may require a value engineering study to be conducted. In some cases, we have found we are extremely familiar with the internal corporate guidelines for value engineering and other value improving practices which have been promulgated by the clients' internal Project Management Office (PMO). However, the project team does not wish to follow these procedures.

However, many project management teams look upon these internal guidelines as simply suggestions and are looking for a way to "check the box" with an absolute minimum of effort or commitment of resources in cost and schedule. Since much of the value engineering work on major projects is conducted in the front-end loading Stages 2 and Stage 3, often the design engineering contractor, construction contractor may be working on their own lump sum bid.

These client contractors feel significant tension since in most cases they have provided a lump sum quotation to the client which does not include time, or cost allocation, in the schedule or resources in their personnel cost for the work of preparing for conducting and conducting the pre-work analysis, workshop and following a value engineering engagement.

In other cases, the design contractor has advised the client that value engineering is simply something they do as their general and normal work process. So, when the client project management office insists the major project team conduct the value engineering and/or other value improving practices as appropriate standalone and separate workshops, the contractor and client project team may push back on time and resources. However, they may be unwilling initially to share their real focus is to simply be able to check a "Value Engineering Report" box for minimum time and cost.

The value engineering practitioner is now faced with a client who essentially wishes a qualified facilitator to show up "cold" on the first morning, with no funded pre-work, and take the team through a process, often limited to six hours per day, and produce something they can call a Value Engineering

Report for the file.

Unfortunately, many teams who follow this path actually benefit minimally from a skilled practitioner guiding them in how to think for a few hours. Therefore, the tiny improvement becomes the enemy of the superb improvement that value engineering is capable of delivering. The sought after "VE Report" is delivered, the appropriate box is checked, and the downward spiral of value engineering effectiveness is initiated in the project team, and potentially other projects in the client project portfolio. The "way to check VE box" proliferates throughout the client project management community to the deterimant of the methodology and the other projects.

We have found that sometimes clients are somewhat uncomfortable when presented with the scale of value engineering implementation strategy, and asked these questions directly. Are you at number one? And a follow-up discussion addressing if you really are at number one. Then it is probably unreasonable to expect a 10 to 15% positive impact on capital expense on a major project. So let us just be honest with each other about your expectations and requirements.

At the next level we may look at a client who has a "fixed budget" approach.

2. Fixed total VE Budget

Make informed decisions about which VE can be done on a "fixed total VE budget."
(Regardless of what may or may not align with the Client's internal project VE requirements)

Focus	**Results Targeted**	**Pre-work**	**Consultant Proposes**
Seek Guidance to Prioritize VE/VIPs to select higher value VIPs	**Just Perform a limited number of VIPs, which are done well**	**Willing to conduct only minimum pre-work**	Provide guidance to manage budget resources for selected VE/VIPs (cost, hours).

This strategy may initially be similarly categorized in the request for proposal as the absolute minimum VE Cost strategy. However, when the client is presented with the scale they may feel more comfortable with providing guidance to the value engineering practitioner that while they are not in number one, they do have a hard limited budget for the engagement.

With this clarity the practitioner may then be able to provide guidance on how to manage that budget such that the client and the client engineering contractor with some guidance can perform prework. And additionally, the practitioner may be able to provide options with respect to development, evaluation and presentation strategies. Since the "jewel in the crown" of value engineering is effective function analysis and developing options for delivering those functions. The skilled practitioner may find ways to optimize the core of the value engineering methodology within the client fixed budget.

In some cases, as this discussion progresses the client may become more familiar with the value engineering methodology and may choose to challenge their management with an expansion of the allotted budget.

As we move to a third level, which has a nuanced difference from level 2, in that personnel resources are limited, however, that limitation is a result of ongoing operational activities rather than simply value engineering budget constraints.

3. Minimize Time of Staff Engagement

Design VE efforts that minimize staff time away from their duties attending workshops.
(Efforts may or may not align with the Client's internal project VE requirements)

Focus	Results Targeted	Pre-work	Consultant Proposes
All about Minimum staff time away from operations	**Reduced staff activities - maybe not consider LCCA**	**Use pre-work alternatives as required to minimize time for staff in workshops**	Identify pre-work tasks that reduce workshop duration and resulting reports min. WS hours

This client strategy tends to emerge associated with projects at existing sites such as chemical plant projects refinery projects, manufacturing facilities, and existing working buildings / offices etc. The driving force for reducing the staff activities is associated with the obligations of the required value engineering workshop participants that they continue to run ongoing operations. In many cases the majority of the staff who must be present at the value engineering workshop, are unable to commit several full days of work away from their ongoing operations, obligations.

In such cases the skilled practitioner will develop pre-work activities and frontload the preparation for the workshop with information phase and function analysis and targeted areas prior to assembling the team.

In the current new environment of heavy reliance on videoconferencing and other online activities. It is actually much easier to accommodate the participants obligations. The value engineering job plan may be followed as prescribed, albeit staged. However, there may be interspersed analysis and report preparation activities, which may be done between the formal online workshop process. It can be particularly useful if the value engineering practitioner is somewhat familiar with the technology and industry targeted for the workshop.

Since the focus of the client in this case is in fact to minimize the work disruption so as to preserve revenue generation, rather than the consulting cost of the practitioner team, it can actually contribute well to improving the overall results of the value engineering study. Part of the reason for this improvement is the team actually has more time to conduct appropriate idea analysis in the development phase. Additionally, with online video conferencing and analysis there is little reason to meet in one place for limited consecutive days.

We have found this works particularly well with participants who are globally diversely located.

So while the client stipulation of minimizing resource time away from operations may initially be regarded as a difficulty, with effective planning and scheduling it can actually contribute to a more superior set of analysis and results from the value engineering study. As a "by-product" of the online VE facilitation the client is able to engage the best services without the cost of travel time for the team and the limitations of limited 4-5 day workshops.

4. Control Project Resource Committed

Project wishes to implement VE but needs to minimize resources used (Capex) due to project budget constraints, regardless of VE benefits (Opex or ROI impacts).

Focus	Results Targeted	Pre-work	Consultant Proposes
Target the right VE and invest in them	**Improve selected project KRAs (Capex, Schedule) May not pursue LCCA analysis**	**Use pre-work to understand Function vs Cost for Capex & Construction Cost and selected KRA improvement**	Capex focused Pre-work, includes Cost Analysis and long workshop hours

A somewhat nuanced, but different strategy than 3 is one of resource constraints in which the client recognizes the power of value engineering, however, is also capital constrained. In this case, the practitioner may work with the client to develop the prework and function analysis essentially from the expertise and experience of the practitioner. Other alternatives would include the level of analysis which can be conducted in the client's budget in the development phase. And potentially handing over the output of the development phase to the client who then assumes responsibility for presentation phase and development of a value engineering report.

The main point about such a potential approach to delivery of value engineering is that open and candid discussions with the client as to what can be achieved within their budget is a cornerstone of the engagement.

5. Serious about VE Utilization

Project understands VE methodology impact and is serious about using VE to improve project outcomes. Wishes guidance on VE.

Focus	**Results Targeted**	**Pre-work**	**Consultant Proposes**
Flexible on VE resources dedicated	**Focused on value improvement results, with full cycle ROI & LCCA**	**Significant pre-work recognized as pivotal and conducted to achieve value improvements**	Full VE classic pre-workshop tasks and preparation, including long workshop hours

By the fifth level we start to move to working with clients who have probably has significant experience in value engineering and have commitment to assigning appropriate resources in cost and schedule. In such cases, clients will normally rely upon the analysis templates and return on investment analysis provided by the practitioners

This is often the case when major projects are deemed to be "in trouble" and the client project manager or director has previous good experience with application of Value Engineering and other Value Improving Practices. However, in many such cases the design contractor, construction contractor or architect may not have such experience and if working under a lump sum contract may experience significant tension in assignment their of resources.

6. Committed to Invest in VE

Project understands that VE can reduce the project cost by at least 3% - 5 % (often 10% to 15%). Project will invest resources to capture potential value improvements.

Focus	**Results Targeted**	**Pre-work**	**Consultant Proposes**
Spend time and resources required to explore value improvements	**Focused on full cycle ROI results**	**Significant pre-work recognized as pivotal and conducted to achieve value improvements**	Full VE classic pre-workshop tasks and preparation, including long workshop hours

At a level 6 we start to see real focus on tangible, significant results, the client will most probably have had excellent experience with value engineering previously. The client will also already be well aware the success of value engineering is significantly dependent upon the prework, logistics, effective function analysis, and other preparation prior to the creativity stage of value engineering. This preparation and commitment becomes significantly important if some long workshop hours are anticipated. Design and construction contractors will need to have warning for preparation well ahead of the value engineering workshop, such that they can plan for all of the time, and the appropriate additional overtime payment, for the professional design and construction contractor staff.

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7. Significant Investment in VE implementation

Project understands that VE will improve project value by at least 3% - 5 % (often 10% - 15%), Project is also interested to deliver the product to the market sooner than the existing schedule, to improve ROI. Project will proactively invest resources necessary to capture a potential significant prize.

Focus	Results Targeted	Pre-work	Consultant Proposes
Spend time and resources required to capture value improvements	**Focused on guaranteed project value results (ROI)**	**Significant pre-work recognized as pivotal and conducted to achieve value improvements.**	Full VE classic pre-workshop tasks and preparation, including long workshop hours

At this top level of client engagement in the value engineering methodology, the client plans for the value engineering work to be done many weeks ahead of the formal value engineering workshop. It is not unusual to significantly engage all participants and stakeholders in the prework. Additionally, the structure of the analysis to be applied in the development phase is clear to everyone.

Further, the input calculation parameters, measures, and values associated with capital expense, operating expense, potential impact on revenue stream and lifecycle cost analysis considerations are all agreed to with clarity well ahead of the workshop. Such that idea development calculations may be based upon full-cycle Return on Investment (Incremental NPV and %IRR) rather than simply Capital Cost reduction.

8. Include Project Risk identification and Analyses

Any of 5), 6) or 7) above plus risks identification and analyses based on VE recommendations.

Focus	Results Targeted	Pre-work	Consultant Proposes
Spend time and resources required to improve project risk management plan	**Align project team integration to interactively manage risks**	**Significant pre-work and workshop planning to achieve best possible value improvements and risk management.**	Full VE classic pre-workshop tasks and preparation, including long workshop hours and additional efforts and workshops to address risks.

This number eight level is really an "addition" to the working seven levels of engagement discussed previously. Rather than a further level, it identifies the potential option for some teams to incorporate risk analysis into the value engineering idea development calculation and analysis. This tends to be the case when clients are looking at several different strategic options for selection of Operationally compatible value engineering ideas or proposals.

This risk analysis addresses the likelihood of actually achieving return on investment improvements and is generally characterized by development of cumulative probability curves for Net Present Value and percentage Internal Rate of Return.

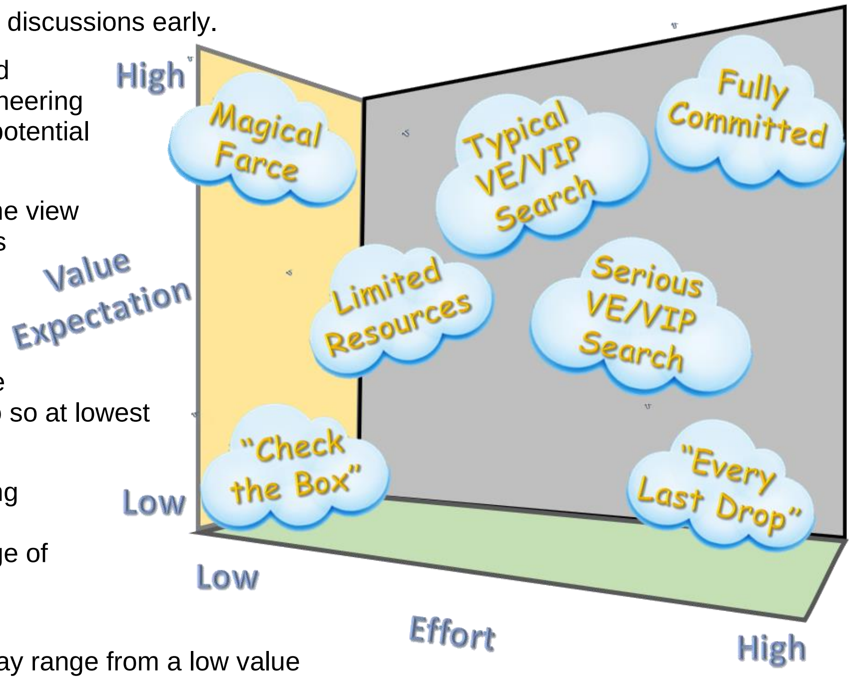
In our experience, few project teams conduct this analysis as part of their value engineering work. However, they may conduct it as part of their full value improving practices focus, and integrate this risk analysis into their decision support packages to continue funding the project as it progresses through the FEL Stage-Gate process.

Conclusion

We can summarize the concepts presented in the figure shown

So, we can recognize that while there are several levels of client engagement in Value Engineering:

It is often helpful to target these discussions early.



- Many teams have had good experience with value engineering and are excited about the potential results
- Not all teams have the same view of value engineering and its effectiveness.
- Often teams are required by internal process guidelines to perform Value Engineering and wish to do so at lowest cost regardless of results.
- Often, project staff preparing requests for proposals are unaware of a potential range of project expectations and/or commitment

Potential Team Commitment may range from a low value expectation and low effort, essentially a "check the box" motivation from the project team. … to a project team that is fully committed to a Value Engineering study with high expectations and recognition of the commitment of time and resources to achieve significant results.

On some occasions, the team recognizes there may not be much improvement available from a value analysis and this may be confirmed in the pre-event and information phases.. However, they are motivated to get the very last drop out of the potential improvement in Capital Expense and Operating expense for Return on Investment. This may be the case with marginal projects and certainly is occasionally the case with safety or environmental projects which must be performed to preserve a license to operate

On the other end of the scale would be a team that only wishes low effort and has very high expectations. In such cases it may be the chore of the professional value engineer to explain and temper the expectations of what may, or may not, be possible with very little effort on the part of the project team.

Bounded within these bookends is a potential for a limited resources VE/VIPs, typical VE/VIPs search and a more serious VE/VIPs search

is probably more important for us to recognize that these various potential project team commitments do in fact exist.

In many cases these are not fully explained, or verbalized, in the initial request for proposal.

We have found as practitioners is very useful to explain this recognition of the spectra of client expectations and have an open discussion with the client as to where they see their position on the scale. We are then able to customize and target their value engineering experience more exclusively.

While it would indeed be useful if all project teams, and investment teams, were to fully realize the power of the value engineering work. Please do not disturb me and talking right.

We should recognize these realities and be prepared to respond to them

In conclusion, we have found that while project teams may not agree exactly with the level of value engineering engagement characterizations as developed so far in the scale presented, the discussion generated by working with the scale helps to provide significant clarity between client and practitioner.

The discussion with clients tends to be somewhat like “So, is your team somewhat close to a 1 or 2? Or are you in fact closer to a 5 or 6?

It is not really important to settle on a single number. Rather, it is more important for both client and practitioner to share that minimum effort and commitment will not result in superlative outcomes. And further, if superlative outcomes are required to preserve the project’s viability for further investment, then the commitment of resources has been shown over decades to have such superlative outcomes from value engineering

The current scale depicting Value Engineering Implementation Strategy as presented is being further developed and tested with clients and practitioners and will be an ongoing living document which will be improved over time.

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VE IN THE SUPPLY AND DEMAND OF SYSTEMS

Abstract

We often fail to anticipate the entire series of cause-and-effect relationships that follow from a particular decision. Systems Engineering can overcome this challenge by helping us view our actions in the context of a larger system. One such approach is to overlay a **supply/demand structure** to a system in which an ability to **supply** a good or service is being balanced with the **demand**, utilization, or consumption of that product or service. (Goodman & Lannon)

All stakeholders of a system belong to either the demand sub-system or the supply sub-system and seek benefit from it. Based on causal relationships these sub-systems drive a system towards balance. Curating a system that serves the needs and desires of its stakeholders requires proactive decision making and a comprehensive understanding of these systems.

The ability of systems thinking to provide a third person perspective of an entire system enables it to be a practical stakeholder-inclusive decision-making tool. To add to this, this paper has attempted to improve systems thinking by,

- Splitting a system into Supply and Demand sub-systems
- Employing FAST Diagrams to structure these sub-systems as the functions of Supply and Demand

The authors believe that this approach can be used across various systems and would drive effective decision making within these systems.

AUTHORS: ANITA LUKOSE; ABRAHAM LUKOSE

Introduction

Systems Engineering is a transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods. (INCOSE)

We often fail to anticipate the entire series of cause-and-effect relationships that follow from a particular decision. Systems Engineering can overcome this challenge by helping us view our actions in the context of a larger system. One such approach is to overlay a **supply/demand structure** to a system in which an ability to **supply** a good or service is being balanced with the **demand**, utilization, or consumption of that product or service. (Goodman & Lannon)

Supply and Demand Sub-systems

When looking at systems through the generic lens of Supply and Demand, the stakeholders of the system belong either to the supply or to the demand sub-system.

These sub-systems behave as two types of feedback loops, a reinforcing loop and a balancing loop.

The reinforcing feedback loop (R), which means that a change in a node flows around the closed loop and will change the same node in the same direction, eventually generating behavior of exponential growth. The second is a balancing or negative feedback loop (B), which means that the feedback flows of the elements in the system structure will bring the current state of the system into its goal and maintain stability (Aminah & Minato, December, 2019).

The relationship between Supply and Demand sub-systems are synonymous to the reinforcing and balancing loop. This relationship is visualized in Figure 1 as a causal loop diagram.

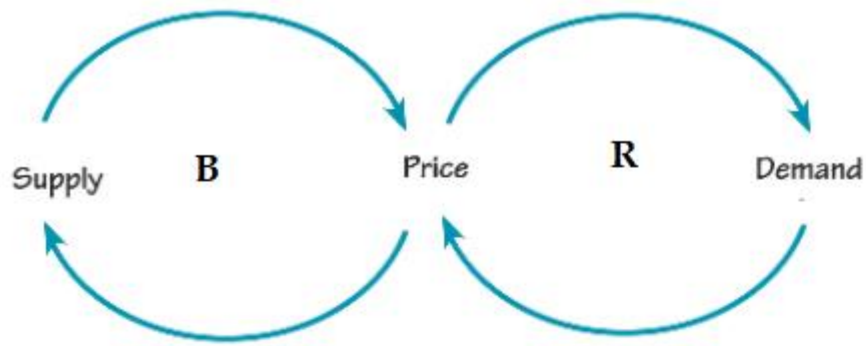

Figure 1: Supply and Demand feedback loops in systems

All stakeholders of a system belong to either the demand sub-system or the supply sub-system and seek benefit from it. Based on causal relationships these sub-systems drive a system towards balance. Curating a system that serves the needs and desires of its stakeholders requires proactive decision making and a comprehensive understanding of these systems.

Why?

The potential of thinking of a system as a balancing act between Supply and Demand are (INCOSE),

- Establishing, balancing and integrating stakeholders' goals, customer needs.
- Generating and evaluating alternative solution concepts and architectures
- Performing design synthesis and system verification and validation;
- While considering both the problem and solution domains, taking into account necessary enabling systems and services, identifying the role that the parts and the relationships between the parts play with respect to the overall behavior and performance of the system, and determining how to balance all of these factors to achieve a satisfactory outcome.

Additionally, this approach has the potential to improve the value that can be derived from the Value Methodology.

Supply and Demand Sub-systems

In the pursuit of understanding the larger system it is necessary to detail the following aspects of its sub-systems,

1. **Demand sub-system**
   - The logic of the demand sub-system
   - The stakeholders of the demand sub-system
2. **Supply sub-system**
   - The logic of the supply sub-system
   - The stakeholders of the supply sub-system

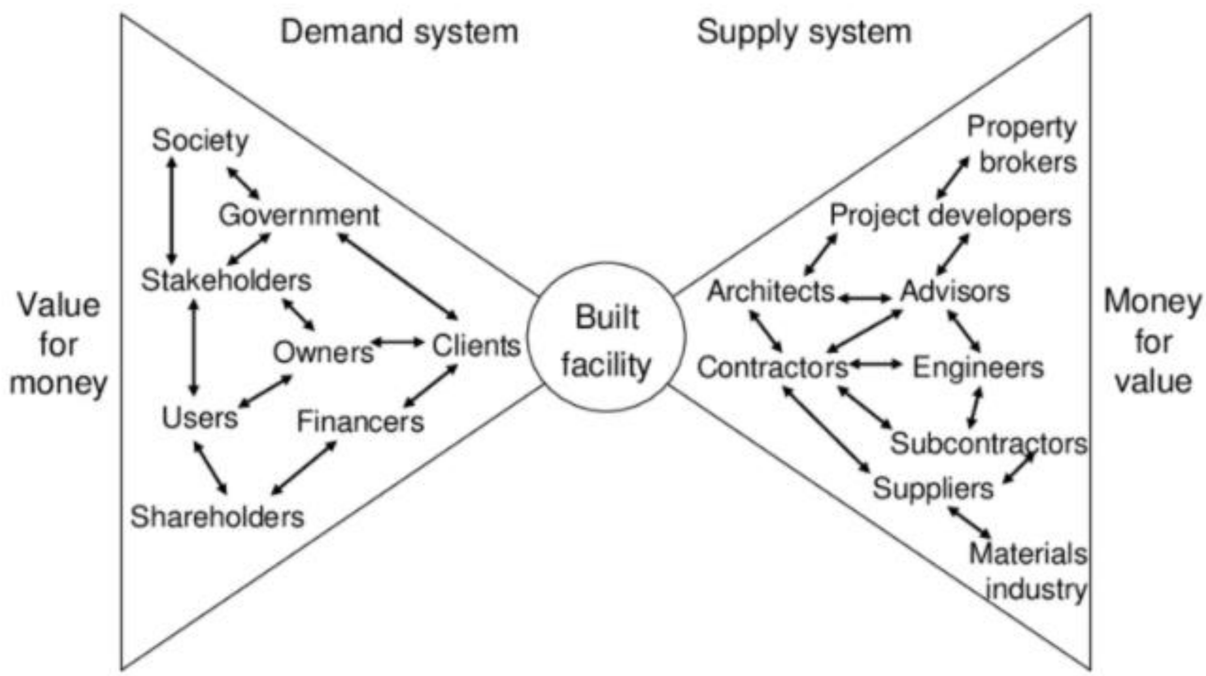

Figure 2: An example of supply and demand stakeholders in a Construction system (Bossink & Vrijhoef, May 2008)

Thus far, this paper has explained the motivation to divide a system into its two components of supply and demand. From here, the paper will attempt to explain how the principles of Value Engineering as propagated by SAVE, International can be used to understand supply and demand sub-systems.
This paper calls for the use of Customer-oriented and Technical FAST diagrams to develop a comprehensive understanding of supply and demand sub-systems.
The authors of this paper believe both Customer-oriented and Technical FAST Diagrams are indispensable tools that can work together to provide context of the users and a better understanding of the logic of any system. To this end, 4 types FAST diagrams need to be created for any system:

1. Demand-side Customer-oriented FAST
   - This captures the perspective of the stakeholders of the demand sub-system.
   - These stakeholders will be the users of the product/process/project.
2. Demand-side Technical FAST
   - This captures the logic of the product/process/project that is to be provided to customers.

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- This FAST can be used to validate and improve the offering of the organization.

3. Supply-side Customer-oriented FAST
   - It intends to capture the perspective of stakeholders within the supply subsystem.
   - The stakeholders will be employees/service provider/ product provider needed to provide the service/product/project.
4. Supply-side Technical FAST
   - This captures the logic of how a product/process/project will be provided to the customers.
   - This FAST can be used to validate and improve the mode of delivery of product/process/project.

Case Study – The procurement of a residential house

To study the creation of these 4 types of FAST Diagrams, we will use the Construction Industry system as an example.
In this case, a family would like to procure a house that can accommodate them and their requirements.
The construction of this house will bring together the following stakeholders:

- Contractor
- Clients
- Government
- Shareholders
- Project manager
- Engineers
- Architects
- Property brokers
- Advisors
- Owner
- User
- Financers
- Suppliers

The customer FAST Diagrams can be created from the perspective of any of these stakeholders using interviews and/or questionnaires. This can be considered as requirements gathering or stakeholder analysis for the project.
It is the opinion of the authors that Customer-oriented FAST Diagrams for the supply and demand side can be captured as is conventionally practiced. This would be involve capturing their needs, wants and desires into a Customer-oriented FAST Diagram. The creation of these 2 FAST Diagrams would assist in the creation of better Technical FAST Diagrams.
The Technical FAST Diagrams can be used to understand the logic behind the Supply and Demand Sub-systems. The FAST for the Supply sub-system will capture functions related to the delivery of a product/service to the customer. The FAST for the Demand sub-system will capture functions related to the user.
The functions of the stakeholders in the construction industry are detailed in the table below. These stakeholders will have an impact on either the Supply or the Demand or both sub-systems. As such, their functions can belong to the Supply or the Demand sub-systems.
In Table 1, a '(S)' is used to highlight the Supply sub-system functions, while a '(D)' is used to indicate Demand sub-system functions.

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Stakeholder	Function(s)	
Contractor	Make Product	(S)
Client	Perform Transaction	(S)
	Procure Offering	(D)
	Identify Requirement	(D)
Owner	Assign Manpower	(S)
	Identify Opportunity	(S)
Government	Adhere Regulations	(S)
Shareholders	Create Policy	(S)
	Sustain Business	(S)
Project manager	Manage Budget	(S)
	Monitor Offering	(S)
	Satisfy Stakeholders	(S)
	Manage Timeline	(S)
Architects	Fulfill Requirement	(D)
	Create Offering	(S)
	Identify Requirement	(D)
Property brokers	Explore Options	(D)
	Sell Product	(S)
	Attract Customer	(S)
Engineers	Create Offering	(S)
User	Follow Principles	(D)
	Improve Quality (of Life)	(D)
	Address need	(D)
	Understand opportunity	(D)
	Identify requirement	(D)
Suppliers	Source resources	(S)
Advisors	Improve system	(S)

Table 1: Function listing

The intention with these functions were to identify functions that would be generic and applicable across systems so as to understand the concept being outlined in this paper.

- **Supply sub-system - FAST Diagram**

The supply sub-system works towards the function 'Make Profit' with the objective 'Sustain Business' (or the more generic function 'Sustain System'). The basic function of this system is to 'Perform Transaction' between client and owner. To perform a transaction, the system requires that both the functions 'Make Product' and 'Sell Product' are satisfied. The product, in this case, a residential house is sold by a property broker who works to 'Attract Customer'. And the product is made by 'Source Resources' from the Suppliers. The kind of resources that are to be sourced and the customers that are to be attracted are motivated by the kind of offering that is created by the engineers and the architect (represented by the function 'Create Offering'). The kind of offering to be created is motivated by the opportunity that the owner identifies ('represented as the function 'Identify Opportunity').

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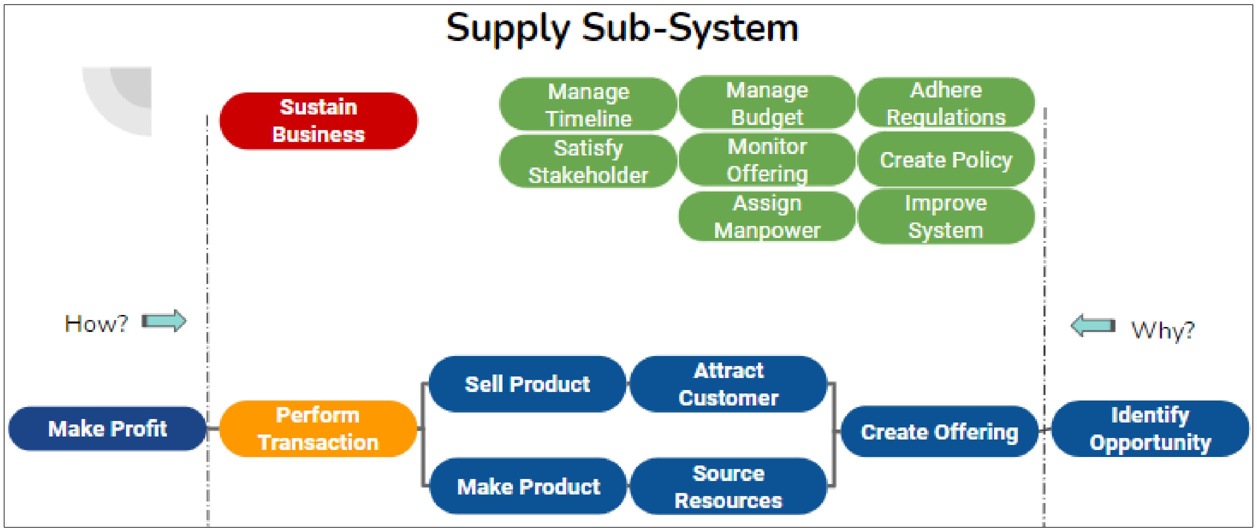

Figure 3: FAST DIagram of the SUpply sub-system

- **Demand sub-system - FAST Diagram**

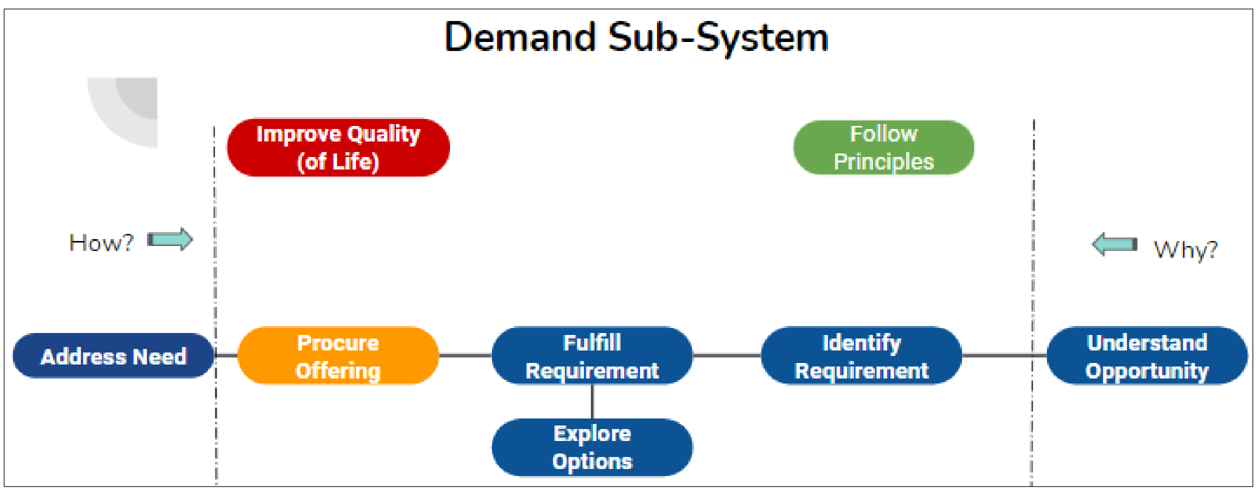

Figure 4:FAST Diagram of the Demand sub-system

The Demand sub-system is motivated by the want by a user to 'Address Need' with the objective to 'Improve Quality of Life'. The basic function of this sub-system is to 'Procure Offering'. This offering is expected to address a need of the user/client. In this case, the offering is expected to address a need for accommodation and other corresponding requirements. An offering will be procured when it fulfills the requirements of the user (represented by the function 'Fulfill Requirement'). In this system, the responsibility for this function falls on the shoulders of the architect. To identify the correct offering the user may explore different options that will fulfill requirements (represented by the function 'Explore Options'). To be able to fulfill the requirements of the user, the architect and the user will need to be on the same page about the requirements of the user (represented by the function 'Identify Requirements'). And for a user to understand their requirements it is necessary to outline the opportunities that would arise from having a product/process/project (represented by the function 'Understand Opportunity'). In this case, it is paramount for the user to understand the opportunities that come with buying a house to actually procure the house.

Other Examples:

These are some other examples of systems that can be broken down to their supply and demand sub-systems.

- **Hospital Supply and Demand** (Aminah & Minato, December, 2019)
    1. Supply-side Customer-oriented FAST
       Medical physicians and other stakeholders of the hospital
    2. Supply-side Technical FAST
       Healthcare financing
    3. Demand-side Customer-oriented FAST
       Patient pathways and other users of the hospital
    4. Demand-side Technical FAST
       Hospital capacity
- **Public transport organization – Bus network Supply and Demand**
    1. Supply-side Customer-oriented FAST
       Drivers, conductors and employees
    2. Supply-side Technical FAST
       Organization structure and financing
    3. Demand-side Customer-oriented FAST
       PT User experience
    4. Demand-side Technical FAST
       Provision of transport service to users

Conclusion

Different stakeholders impact a system differently. Some may have no impact on the user while some may want nothing to do with the offering. It is important to make this distinction to make effective decisions for the system.

An architect may be able to churn out an unbelievable number of designs which is amazing on its own. However, unless we understand that as a stakeholder, an architect is expected to understand and act on user requirements, we may never understand why users are not responding with as much fervor.

The ability of systems thinking to provide a third person perspective of an entire system enables it to be a practical stakeholder-inclusive decision-making tool. To add to this, this paper has attempted to improve systems thinking by,

- Splitting a system into Supply and Demand sub-systems
- Employing FAST Diagrams to structure these sub-systems as the functions of Supply and Demand

This approach has the potential to improve the value that can be created from the Value methodology and can be used across various systems to drive effective decision making within these systems and thereby derive more value from these systems. To this end, we hope to see more studies done along this line of thought and gladly invite any feedback.

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PAPER TITLE: COST INTELLIGENCE THROUGH TEARDOWN AND BENCHMARKING- VE APPROACH

AUTHOR NAME: BHASKAR M. PADALKAR - (JOHN DEERE, INDIA)

Abstract:

With the latest focus on high end technology we can see products are equipped with highly engineered components. The contribution of spend on purchasing this type of parts is more than ~ 50% of the total spend. To control cost of these type of parts as a core competency every Product Manufacturing company is analyzing & estimating supplier design parts used on the specific products/ Machines with available cost analysis and cost management tools. This is developed by referring teardown data of these parts and business insights of the component vendors.

This paper throws more light on steps to follow benchmarking with Value Methodology to understand what industry is using on products/machines for given applications. For improved accuracy in estimating the costs various inputs gets validated step by step in terms of available data. Additionally, we can plug in insights by tear down and benchmarking of the specific components. **This paper aims to** scaling up current cost management tools to improve the accuracy on cost control methods with additional insights by benchmarking to enhance the core competency. This paper highlights the improvements in current methods of benchmarking and cost analysis with Value Methodology and lastly establish how this approach of recommendations of alternative designs and offerings available in market with best in class cost structure will ***yield up to 30% cost reduction opportunities to propel the cost improvement drive across the industry.***

Introduction

Cost is critical and important factor in all industry. The cost of the alternative action-The action not taken- is referred as opportunity cost. Management is always looking for comparative solutions with opportunity cost that were not tried in past. This can be done by predicting the cost. For predicting the cost, it is essential to have Cost control methods and tools in place with continuous refinements to improve the accuracy level by which one can predict the cost of a given product, Assembly or Components.

Cost Management

Definition: Cost management is the process of effectively planning and controlling the costs involved in a business. It is considered one of the more challenging tasks in business management.

Generally, the costs or the expenses in a business are recorded by a team of experts using expense forms. The process involves various activities such as collecting, analyzing, evaluating and reporting cost statistics for budgeting. By implementing an effective cost management system, a company's overall budgeting can be brought under control.

Cost management is employed by many businesses as an integral part of business management. When cost management is applied to a specific project, the expected costs in the business are analyzed in the beginning phase of the planning period. The project manager then approves the predicted expenses in purchasing the materials required for the project. The costs and expenses are recorded and monitored during the project execution period to ensure that the cost is in line with the actual cost management plan. Once the project is complete, the actual costs are compared with the predicted costs, which will help in predicting future expenses.

Some of the advantages of cost management include:

- The ability to predict a project's future expenses and costs
- The maintenance of a central record of all predicted expenses
- The ability to ensure that costs are approved before purchases are made
- The ability to control a project's expenses

Cost Intelligence:

As a part of cost Management every manufacturing company purchasing components from vendor have their internal processes to control on the cost. These processes include the Cost analysis and cost prediction with various tools & software to verify and negotiate the prices provided by vendors in their quotations before the long-term purchases are made. There are various inputs in the form of commodity prices, manufacturing costs, Labor costs etc. in particular region of country of manufacturing. This cost control process and tools put together forms a Cost intelligence.

VE Methodology:
Value Engineering is a systematic step by step approach by a Multidisciplinary team intended to achieve the functions (desired by the customer) of a product, process, system or service at an overall minimum cost, without affecting/ while improving quality, performance, reliability, delivery, safety or environment.

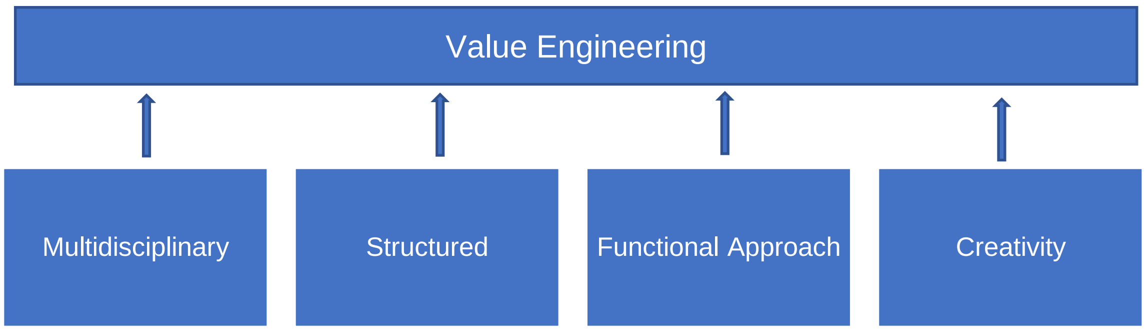


Figure 1. Four Pillars of Value Engineering

There are 8 steps in VE job plan

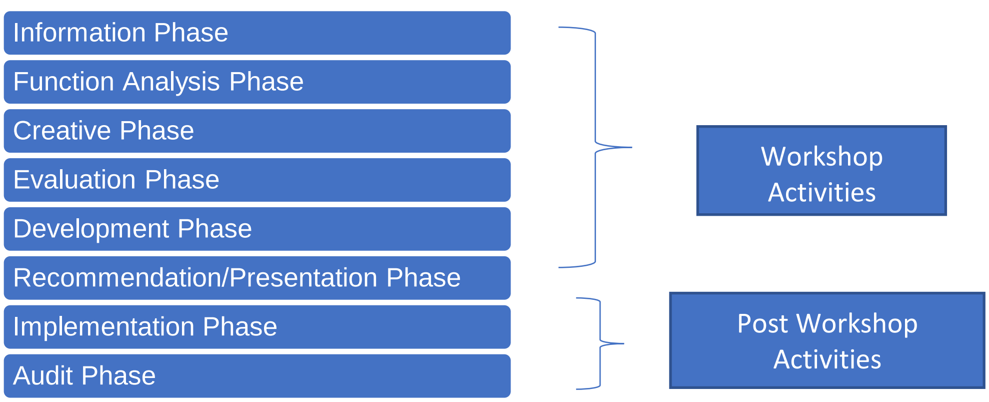


Figure 2. VE Job plan

Benchmarking: It is the process to learn the best in class standards for Products, Process & Services, and make necessary changes as continuous improvement to meet these standards.

“Why re-invent the wheel if I can learn from someone who has already done it?” Jackson Grayson Jr, chairman of the Houston-based American Productivity and Quality Center, which offers training in benchmarking and consulting services, reports an incredible amount of interest in benchmarking (Ross, 1995, p. 235)

Reasons and perceived benefits of benchmarking:

Increasing productivity and individual design:
Companies are benchmarking for a variety of reasons. The reasons can be broad, such as increasing productivity, or they can be specific, such as improving an individual design. By simply looking outside itself, a company can identify breakthroughs in thinking. A similar process used in a different way can shed light on new opportunities to use the original process (Muschter,1997).

Enhance learning:
Another reason to benchmark is overcoming disbelief and enhancing learning. For example, selling or hearing about another company’s processes and how they are working will help employees to believe that there may be a better way to compete (Brookhart, 1997).

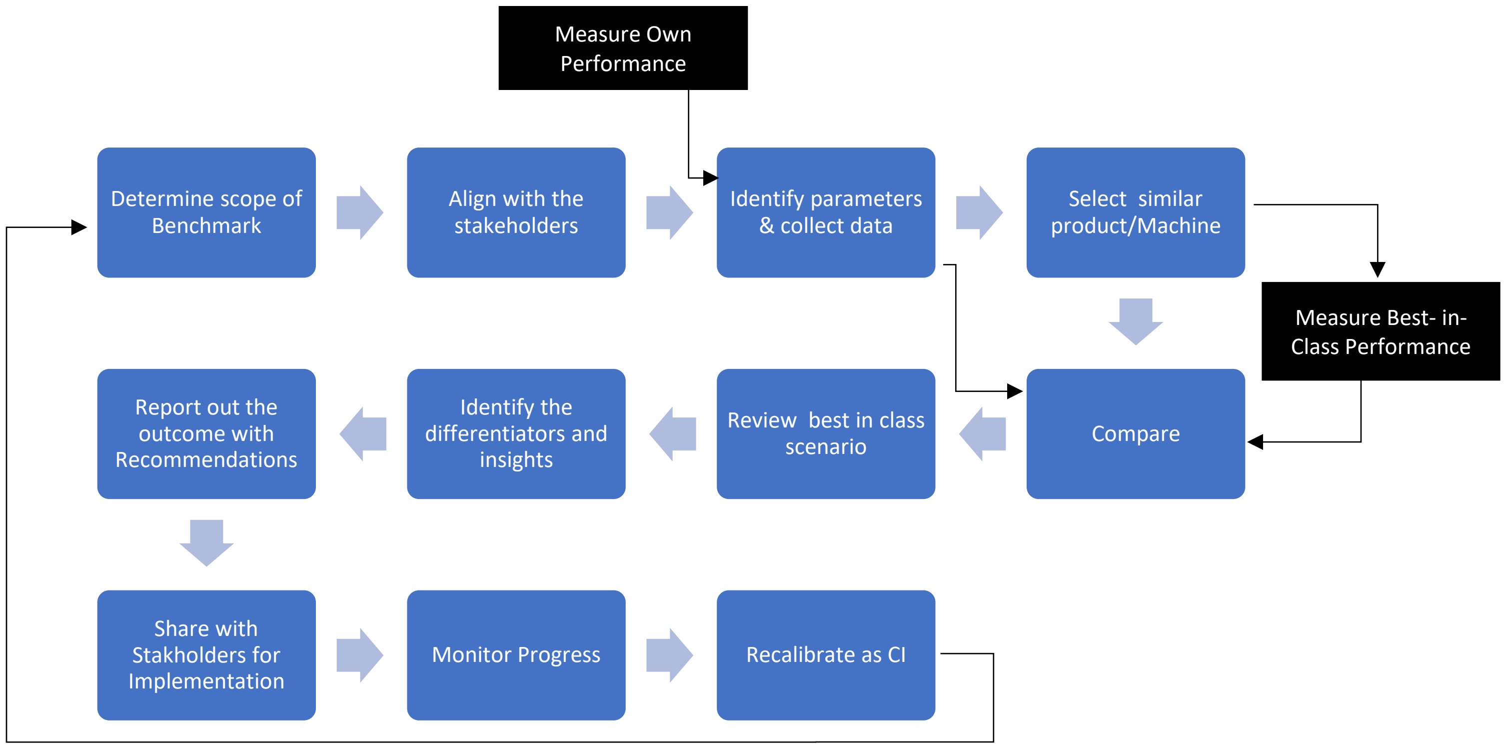
Each company should carefully evaluate its own perspective in what benchmarking is and how they wish to use this process. The company needs to determine whether their focus is on financial results or on meeting customer requirements. This is the only effective way to begin the benchmarking process.

Benchmarking Process:
According to The Nuts and Bolts of Benchmarking, written by Margaret Matters and Anne Evans (1997), there are five stages included in the benchmarking process:

1) **Planning the exercise**: this step involves identifying the strategic intent of the business or process to be benchmarked. Many times, this information can be obtained by looking at the company’s mission statement which summarizes its main purposes. Then selection of the actual processes to be benchmarked must be chosen. This consists of identifying various products produced by the benchmarked company and asking your own company if using this process will create positive results in the organization. Then the customer’s expectations must be identified. Finally, the critical success factors have to be determined to benchmark. These factors are links to successful business results.

2) **Form the Benchmarking team**: the first step is to select overall team members. These members should be chosen from various areas of the organization. All members should cooperate and communicate with one another to get the best results out of the benchmarking process. There are three main teams comprising the overall group. The lead team is responsible for maintaining commitment to the process throughout the organization. The preparation team is responsible for carrying out detailed analysis, and the visit team must carry out the benchmarking visit.

The benchmarking Process Map:



Source: Adapted from Bateman (1989, p.6)

Figure 3. The Benchmarking Process

3) **Collect the data**: this step involves gathering information on best practice companies and their performances. Before a company identifies best practice companies, they should first identify their own processes, products, and services. This step will allow a company to fully realize the extent of improvements available. Site visits are also an important factor in collecting data because they allow for a more in-depth understanding of the processes.

4) **Analyze the data for gaps:** this step involves determining how your company relates to the benchmarked company. It allows identification of performance gaps and their possible causes

5) **Take Action:** this step involves determining what needs to be done in order to match the best practice for the process. Not only should determination of changes be made, but they also should be implemented (Matters and Evans, 1997)

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Covid 19- Triggers for benchmarking:

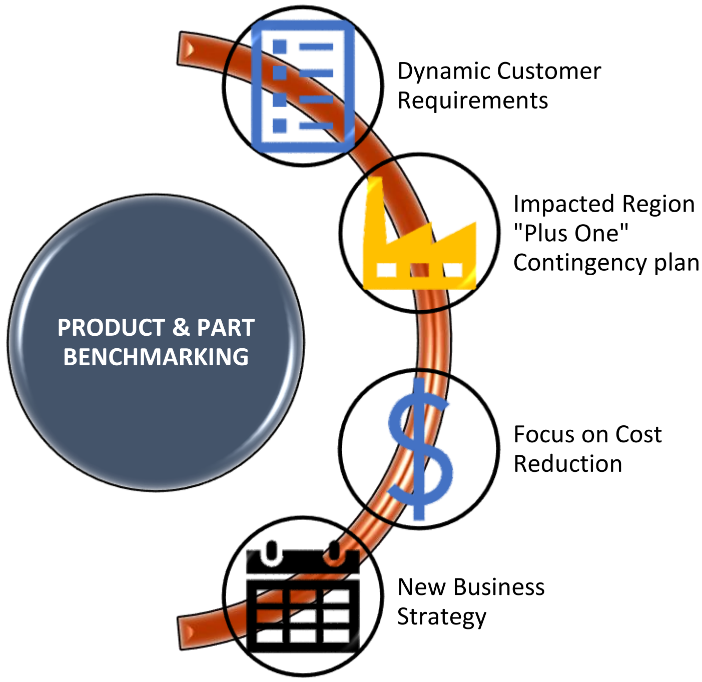

Figure 4. Triggers for Benchmarking

Cost Benchmarking: This can be done by following methods:

1) Zero based costing
2) Directional Costing
3) Analogical Costs
4) Cost Regression Analysis
5) Teardown & Benchmarking

VE approach in Cost Intelligence & Benchmarking:

Lets now understand how we can adopt Value methodology in Cost Intelligence through step by step approach in each stage.

Traditionally for VI we have two approaches

A. Engineering- VE Opportunities
B. Commercial- Cost Negotiation Opportunities.

With both these approaches component level benchmarking can identify value Improvement opportunities with Function based Value Methodology.

1) **Orientation Phase**: Identify Project, Benchmarking Schedule, align resources, review methodology and gather initial data.

2) **Information Phase**: With reference to Figure 3 collect the information of scope of activity and Measure own current state parameters & identify Objective of the study

3) **Function Analysis Phase**:
    a. Define & categorize functions of both the components under review
    b. Develop FAST diagram
    c. Allocate Function Cost
    d. Check Value Gap and focus on areas (e.g. Specifications/Design Criteria)

4) **Creative Phase**: Brainstorm to determine alternate ways to accomplish the Functions and design philosophy on key differentiators that can be considered as best in class offerings in the market

5) **Evaluation Phase**: Identify and review best combinations with Decision matrix

6) **Development Phase:** Validate the outcome of Evaluation and create Business proposal for Value Improvement, Develop Implementation plan, Review with stakeholders & Leadership, Fine tune the proposal

7) **Recommendation Phase**: Report out with Pilot project and review with Management to obtain concurrence for implementation.

8) **Implementation follow-up & Audit**: Pilot proposal implementation either Design change or negotiation with Existing supplier, review and recalibrate the insights as Continuous Improvements.

Conclusion:

With the disruptive technologies pouring in new products, processes industry is changing more dynamically. Companies are exploring digital and high-end technology components for making their products future ready and of course with optimum cost. With the challenges put by Covid-19 pandemic there would be more focus on Value Improvements. This paper has introduced a new method in cost intelligence with proven Value Methodology and establishes a step by step approach connecting Cost Intelligence with benchmarking. The paper also highlights the differentiating fact about identifying the value improvement opportunities with the best in class offerings by exploring alternatives can yield up to ~30% cost improvement. **VE in conjunction with Cost intelligence can play a vital role in cost improvements in current products as well as early integration in new product development**.

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Value improvement approaches in manufacturing

A Study of Manufacturing losses through VE approach

Eliminate manufacturing Loss to improve Cost by focusing the functions involve in manufacturing losses.

A VE approach to add value

1.Determining the cost of the losses through (LOSS-COST MATRIX)

2. Prioritize the loss to be focused for elimination or reduction.

3. Find out the functions involve in loss making process.

4. Put the functions in logical way. (FAST DIAGRAM)

5. Identify non-value-added functions.

6. Establish alternate functions to reduce time loss.

7. Calculate cost benefit achieved by reducing time.

ABSTRACT

In manufacturing process, we come across various losses which restrict the business to become effective. Organization need to fully understand all the manufacturing losses and their costs associated to bring about the focused improvement activities and to improve value in the manufacturing process.

Manufacturing is getting more and more challenging and complex due to shorter product life cycle, high mixed with low volume production situation, low equipment performance and volatile customer demand. There-fore productivity becomes the key factor for company to become competitive so that the organization faces least threats and able to translate business effectively.

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A perfect utilization of God hour i.e. 24x7 hours improves the availability of equipment if the losses are well captured and addressed scientifically. The instant actions and controls enables the manufacturer to become fast, flexible and agile to respond customer volatile demand.

Down time of machine in manufacturing process is any point of time when machine is not available for production. This downtime time categorized as different type of losses. Every loss can be converted into cost associated with to calculate the amount of opportunity loss business has suffered. Thereby it is possible to focus on improvements required to increase value in the manufacturing if it is made clear to understand the process and its effectiveness.

Value Engineering (VE) concepts can be applied to business and its process to get results-oriented decisions. It is a fantastic process that enable us to have complete understanding of the system, process in terms of value, alternate solutions, alternate material, manufacturing process

VE functional approach to bring about the value improvement in the process is very effective tool. Understanding the functions involve in the production and services gives a clear idea about the nonvalue added activities and the activities that requires focus to improve value in the process. This also set the goals to proceed in logical way. It is also possible to link the functional cost of all the losses related to manufacturing using FAST diagram.

As we understand

VALUE = FUNCTION / COST

So, improvement in function with reduced cost can bring value in the process of manufacturing where losses can be minimized or eliminated. This paper here is to brief the idea of linking the losses with functional approach to solve and bring changes in cost associated with the losses.

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INTRODUCTION

In today's competitive market, the companies facing one of the biggest challenge to deliver the product at shortest possible time. The flexibility of the Companies to cater the shorter demand and new product demand is the need of hour. The company capable of producing a wide range of products for high demand is always on the high rise. Customers with high demand, look for manufacturers that have the production capabilities to satisfy their needs. Companies with this production power are in constant struggle to compete for more customers. One most important threat to the companies is to produce quality products at competitive prices and it has become one of the highest challenges for production and manufacturing processes. More and more companies trying to adopt manufacturing loss elimination process by changing manufacturing methods and processes to create a system of delivering product at competitive price.

In this paper, it is being tried to be explained how company can link the manufacturing loss elimination process adopting VE approach to reduce cost and improve function considering one example of loss. One of the method that company can adapt is to learn the functions involve in each of the loss-making process and cost associated with it through Loss-cost matrix. Study of the functions that leads to more manufacturing loss and placing them logically into FAST diagram of VE methodology can be helpful to add value to the process by improving functions and functions which leads to non-value addition to the process needs to be eliminated.

The loss must be converted into cost associated and computed accordingly to know the present monetary loss cost. The functions that leads to high cost involvement needs to be taken in creative phase of VE to seek alternate solutions.

The 4M conditions (Man-Machine-Material and Method) to the manufacturing process if it is non-complied will lead to losses. Method of computing loss varies from company to company and their system of accountability.

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VE functional approach

VE functional approach for study of manufacturing loss elimination is very powerful technique enable to think differently about the process improvement and the cost reduction focused approach on the functions enable company to remain competitive always.

There are 16-type of loses that involved in the manufacturing system. These are as follows

TYPE OF LOSSES

1. Break-down loss.

2. Set-up loss.

3. Tool change loss.

4. Shut down loss.

5. Adjustment loss

6. Minor stoppage and idling loss

7. Speed loss

8. Defect and rework loss

9. Management loss

10. Line-organization loss

11. Start-up loss

12. Motion loss

13. Distribution loss

14. Yield loss

15. Energy loss

16. Die, jigs and tool loss

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A tool widely used in manufacturing is the loss cost matrix. Loss cost matrix is a matrix where Losses are linked with various cost associated in a tabular form to understand the implication. To create the matrix the list of 16 losses (Loss structure) are put down the left-hand side of the table and the top of table the various cost (Cost structure) are mentioned.

The manufacturing cost has two parts it consists of Production cost and general or administrative cost.

Further Production cost has two parts i.e. one is Fixed cost and another is variable cost.

A sample of Loss – cost chart (In manufacturing industry)

Cost Structure		Production Cost								General cost			Total Loss In Rs.
		Variable cost				Fixed cost							
Loss Structure		Raw material cost	Fuel cost	Power cost	Consumable cost	Direct Labour cost	Indirect labour cost	Maintenance & Repair	Tools & die cost	Interest charges	Administrative cost	Logistic cost	
Availability Loss	Shut Down loss					●							1500
	Break down loss					●		●					3000
	Start up loss					●							400
	Set up loss	0				●							3500
	Adjustment loss	0	0	0		●							750
	Tool change loss				0	●							200
Performance Loss	Minor stoppage & Idling loss			0		●		0					200
	Speed loss			0		●							400
Quality loss	Rework	●	0	0	0	●							200
	Scap	●	0	0	0	●							600
Management loss	Waitings					0	●			0	0	0	1700
	Motion loss					●							200
	Line balancing loss					●							300
	Logistic loss					●						0	700
Resource Effectiveness	Yield loss		0	0	0	0	0	0	0				300
	Energy loss		●	●									150
	Jigs and Tools loss				●				0				300
												Total loss in Rs.	14400

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The black colored circles show the direct and blank circles shows the indirect cost associated with the losses on the various costs.

On the derived matrix, the improvement team can easily select the loss which has the biggest cost involved and focused improvement activity can be undertaken to reduce or eliminate the cost associated. It is easy for the team to see the tangential and measurable financial benefits.

Prioritizing the loss which constitutes major cost elements should be addressed where value addition is possible eliminating non-value-added activities and minimum time spent. Also, it is imperative to understand from the data how to effectively use productive time by eliminating or reducing the non- value-added activities, or clubbing the activities so that it consume lesser time to improve available hours for productive work.

Let us consider the example from the above matrix, select a loss due to set-up change which is highest among all the losses. Time should be converted in cost. Cost as we understand as it is associated the material cost and direct labor cost. On the other hand, benefits achieved by eliminating non-value-added time also should be noted.

As we know that every activity involves some cost, therefore each activity should be broken-up into cost.

Change over cost = Change over time x Number of people used x wage rate.

Change over time can be reduced significantly through the study of each element of set-up through Functional approach and using FAST diagram. Listing of all functions involved in the process to be carried out first from start to end of the set-up activity.

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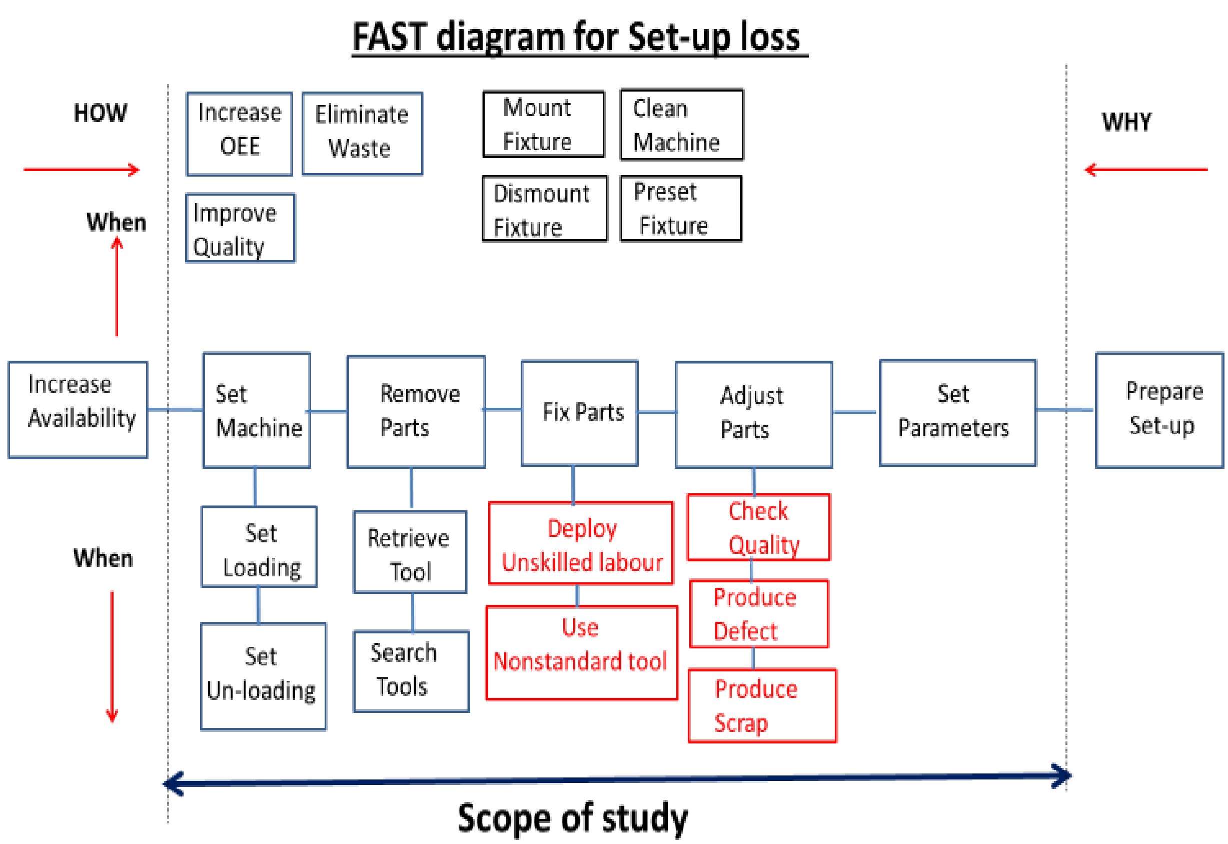
THE VE FUNCTIONAL APPROACH

Now the placement of Functions is required to be done while making FAST diagram. Example of listing of functions in verb and noun principle.

Verb	Noun
Remove	Parts
Fix	Parts
Adjust	parts
Set	Parameters
Set	Loading
Set	Un-loading
Retrive	Tools
Search	Tools
Deploy	Un-skilled Loabor
Use	Non-standard Tool
Check	Quality
Produce	Defect
Produce	Scrap
Clean	Machine
Mount	Fixture
Dis-mount	Fixture
Eliminate	Waste
Improve	Quality



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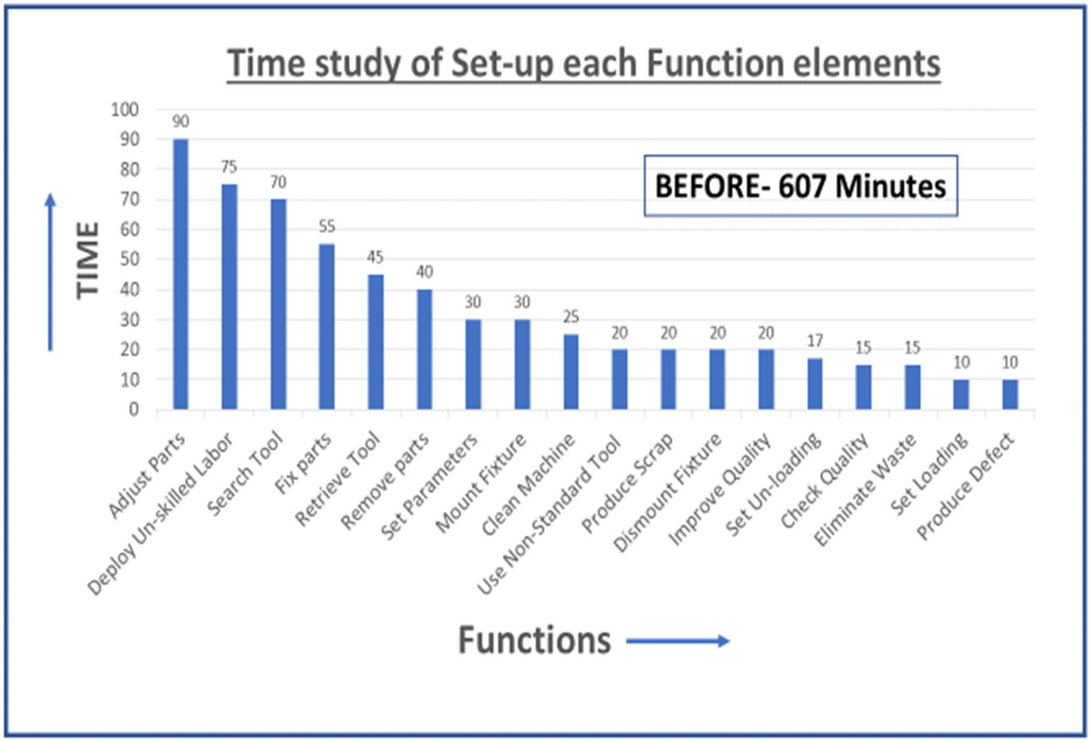
The red colored function denotes the un-wanted functions which doesn't add value to the process. These needs to be eliminated to reduce the total cost. Carried out time study of each set-up change Functions.



The next step is the F-C-W (Function -cost-worth) analysis which is to be carried out for each function which is another power full tool to determine the value index. The functions having value index more than 1 should be Prioritized for actual improvement to be focused.

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Function - cost - worth analysis							
Verb	Noun	Type	Function Cost	Function Worth	Basis of Worth	Value gap	Value index
Set	Machine	Basic	40%	25%	Time consumed per set-up change	15%	1.6
Remove	Parts	Secondary	15%	10%	Faster removal of old set-up parts	5%	1.5
Fix	Parts	Secondary	20%	10%	Quick fixing of parts	10%	2
Adjust	Parts	Secondary	30%	20%	Pre set fixture availability	10%	1.5
Set	Parameters	Secondary	30%	25%	Improved quality of machining.	5%	1.2
Set	Loading	Secondary	30%	25%	Preset loading unit	5%	1.2
Set	Un-loading	Secondary	20%	20%	Faster opening of parts.	0%	1
Retriving	Tools	Secondary	10%	5%	Faster retrival	5%	2
Searching	Tools	Secondary	5%	2%	No seaching	3%	2.5

The output of F-C-W based on the value index obtained, the following function considered for further analysis having value index more >1

Searching Tools

Fix parts

Retrieving Tools

Adjust Parts

Remove Parts

Set Parameters

In the creativity phase of VE the team members involve themselves in analysis of elements of Functions selected for brainstorming and listing of ideas from each member to arrive at alternate solutions to get desire objectives.

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Here are few creative proven ideas to eliminate Searching and retrieving tools

like pre-existence of required tools and assemblies before - hand in front of machine to avoid searching and retrieval. Each parts and tools should have designated place of availability during change over.

Minimize movement of person confined to the periphery of machine only. Re-organize the work place like change in cell design.

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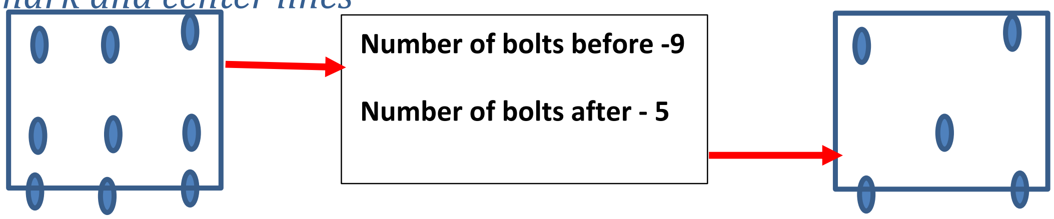
Here are few creative proven ideas to reduce time or eliminate adjustment of parts

Use standardized tools and fixed setting

Use of mark and center lines

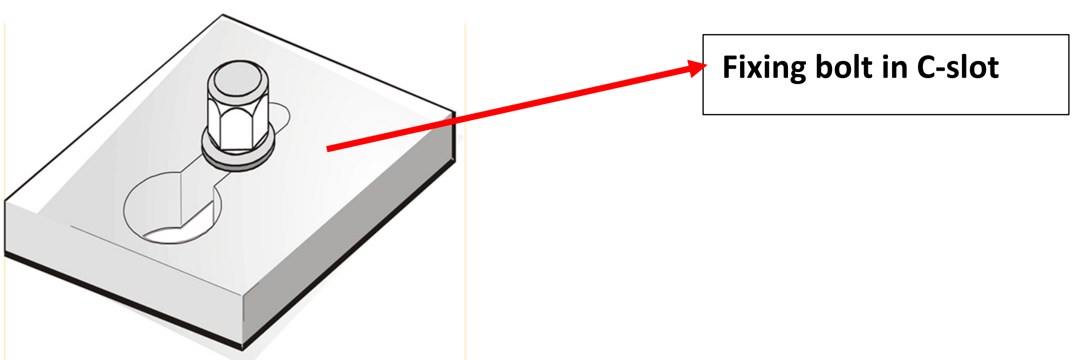


3.Reduction of length of fasteners and thread pitch and number of turns etc.

4.Use of standard shims – no need to adjust.

Here are few creative proven ideas to reduce time or eliminate removal of parts

Eliminate bolts, use quick release mechanism and other type of holding the parts



Convert internal to external setting with different fixture.

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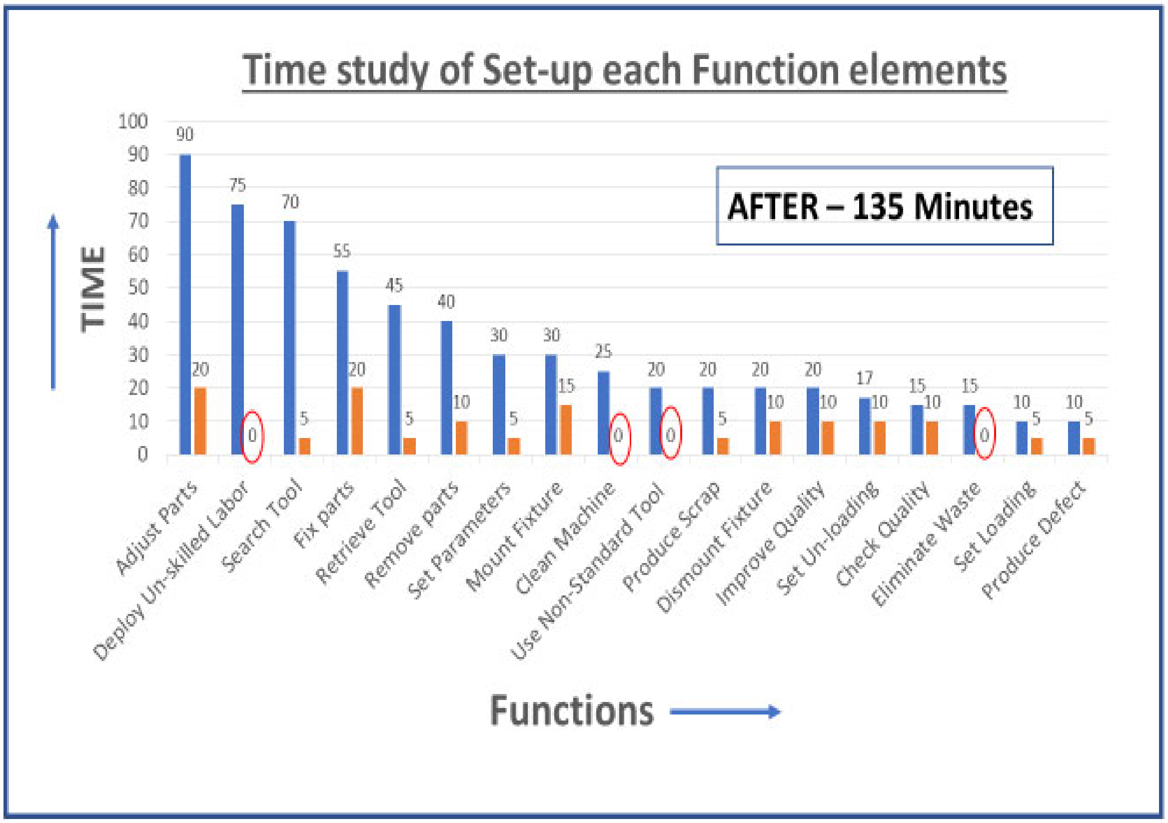

Conclusion

Benefits of using Functional approach through FAST for reduction and elimination of losses in manufacturing i.e. Set -up loss could have reduced by 70% means more production time is available.

Thus, company becomes more flexible to respond customer demand in volatile market and agile to give services with minimum lead time.

The functions give us the direction and opportunity to address all the manufacturing losses. It requires Identification of Functions (Basic, Secondary, unwanted) it must be clearly defined and organized in-order to achieved the objective and purpose of the project undertaken. The FAST diagram is a systematic tool which shows the logical relationship between the Functions defined.

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During development of FAST diagram, various thoughts process will emerge out among the team members which clarifies and simplifies the problem and its understanding to stimulate the creativity.

Next tool in VE methodology which helps us to derive the improvement activity in terms of cost reduction is called Function - Cost -Worth analysis where Cost associated with each Functions and its Worth determine. This guides the team how to fix and prioritized the Functions to be taken for improvement. Finding of alternate solutions to the Function at minimum cost so that its value is achieved without sacrificing the performance and its quality.

It is followed by the creative phase of value engineering where ideas need to be generated. The ideas for the selected functions to improve its value should be comprise of the following aims to achieve the function at least possible cost.

- Elimination of unwanted and un-necessary Functions

- Simplification of Basic and secondary function

- Standardization of required Functions

- Reduction in cycle time to complete the Function at minimum cost

- Improvement in productive time to increase margin.

Benefits achieved in terms of financial gain can be calculated based on reduction in time saved and improvement in availability of machine for production.

Arun Kumar Bhatnagar, INVEST – Life member

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Acting on Low Emission Zone Plans during COVID-19 Crises Using Value Analysis Approach

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Abstract

Deciding on urban management issues related to citizens' health such as air pollution reduction plans has significant importance. Especially when an outbreak coincidence, adopting an integrated management policy and a comprehensive decision-making process is necessary. Suspension and resumption traffic and clean air schemes in cities such as Low Emission Zone (LEZ) implementation in the period of COVID-19 pandemic and the exacerbating effect of air pollution on COVID-19 infection risk is of that kind with an ongoing concern of societies of its outcomes. In this study, a multi-criteria decision-making approach through the value management process is implemented to act on traffic and air pollution reduction schemes as a response to the unprecedented crises of COVID-19 in the city of Tehran. The result of NOx pollutant analysis showed 17.5% reduction as the result of COVID-19 lockdown and postponing LEZ restrictions within its stations in comparison to the last four years. Besides, the cost analysis estimated an increase in air pollution morbidity and social distancing cost in implementing LEZ scenario in comparison to postpone it. The proposed alternative of VM methodology was a suggestion of increasing the allowed entrance days in a season, which will mitigate the public transport demand.

Keywords: air pollution, value engineering, MCDM approach, Clean air zone, traffic scheme, COVID-19 pandemic

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1. Introduction

Applying a clean air zone plan is a long-term reduction and control strategy for air pollution in most industrial and high polluted cities. As a result of the COVID-19 pandemic emerging in late 2019 and severing in 2020, many countries and regions have imposed quarantines, entry bans, or other restrictions for citizens of recent travelers to the most affected areas. Additionally, postponing clean air zone (CAZ) plans to reduce city-center traffic and contributed air pollution is applied in most cities as an urgent short-term solution for social distancing regulations and traffic restrictions. As early studies have shown that people with long-term exposure to air pollution have much higher death rates from COVID-19(Xiao Wu, 2020.04.05, Domingo et al., 2020), policymakers get confused confronting with a two-way approach problem. Postponing CAZ plan in any form of it such as Low Emission Zone (LEZ) leads to a decrease in public transportation demand which is a positive aspect due to social distancing protocols that necessitate during COVID-19 lockdown. While these social distancing measures save lives, they also impose significant costs on society(Thunström et al., 2020).

Most polluted cities of the United Kingdom like London and Glasgow canceled LEZ plans. In Tehran, the Capital of Iran also the cancelation of LEZ and traffic restriction scheme was implemented by the government as a response to tackle the COVID-19 pandemic from 2 April 2020 and resumed on 6 Jun 2020. Tehran is one of the most air-polluted cities in the world and is ranked 12th among 26 megacities in terms of ambient PM_{10} levels(Martin Heger 2018). Researches indicate that slightly more than 4000 people die prematurely from ambient $PM_{2.5}$ air pollution in Tehran per year(Martin Heger 2018). Following this, making a sustainable improvement for air quality besides the correct strategies to fight COVID-19 crises seems to be dramatically important.

Table 1 shows a comparison in cities enacting LEZ plans, effectiveness of measures, and air quality improvements due to COVID-19 lockdown and during cancellation of LEZ restrictions from 1 April to 15 May 2020. As shown in Table 1 there are significant improvements in NOx emissions measured in stations within low emission zones in London and Glasgow that is available in databases Department for Environment, Food and Rural Affairs (https://uk-air.defra.gov.uk/) and with a lower difference in Tehran that is available in database Tehran Air Quality Control Company (http://airnow.tehran.ir/) despite the suspension of the traffic schemes in that period. It seems traffic schemes have not led to that much reduction in NOx emission especially within low emission zones in Tehran compared with other cities (Table 1).

Table 1 Mean difference with 2020 of NOx concentrations within LEZ stations

City	Station within LEZ	LEZ Suspension and resumption dates		1 April-15 may **Mean Difference (%)**				
				2016	2017	2018	2019	4-Year-Avg
London, England	Camden	March 23	May 18	-63	-54	-57	-41	-55.7
Glasgow, Scotland	Towhead	May 7	undefined	-56	-47	-54	-54	-54
Tehran, Iran	Setad Bohran	April 2	June 6	-31	-21	-6.9	-4.7	-17.5

As the economic cost of social distancing due to COVID-19 and CAZ plans is inevitable and undeniable, decision-makers and the general public can benefit from systematic policy evaluations to help determine whether those costs are justified by the value of the lives saved(Thunström et al., 2020). Applying value methodology (VM) may be beneficial in these cases by balancing the cost of social distancing imposed on societies due to the pandemic and air pollution morbidity and mortality costs. In some cases, VM can be applied to prescribe a systematic, structured approach to study and optimize the project’s scope, schedule, and cost (Heralova, 2016) in the light of the desired

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criteria of the project. Consequently, the existing alternatives may be evaluated and improved using value methodology adoption and value-based methods.

While many studies have addressed the impact of COVID-19 as a moderation parameter on urban traffic and the contributed air pollution (Chen et al., 2020; He et al., 2020), this paper deals with the possibility of using value engineering for appropriate decision making about CAZ plan revocation or retention in the city of Tehran. Accordingly, the authors believe that value engineering methodology can help to find ways to improve solutions to these problems by balancing cost, schedule, and scope through the generation of innovative alternatives. consequently, the cities like Tehran encounter the exacerbating effect of air pollution morbidity on COVID-19 as an interact cycle shown in Fig 1.

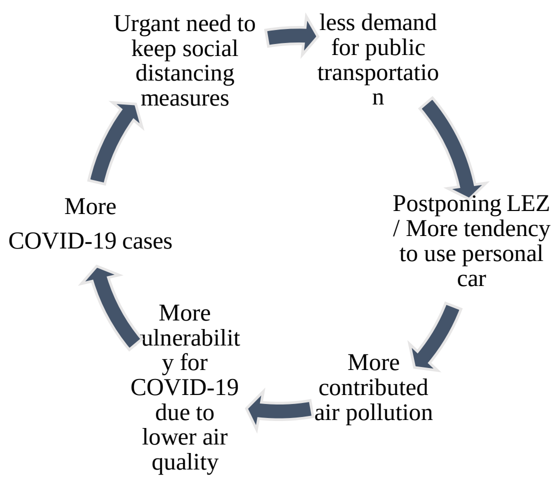

Figure 1 problem statement of the study, COVID-19 lockdown and LEZ implementation consequences

2. Value Engineering Methodology Application

The Value Methodology (VM) is a systematic and structured approach for improving projects, products, and processes. The value engineering methodology applied in this research is based on the Society of American Value Engineers (SAVE) that is an international society job plan. The 6 phases of SAVE are described as (Heralova, 2016):

1. Information (understanding the background, analysis of the key functional issues, the cost and impacts associated with function)
2. Function Analysis
3. Creative
4. Evaluation
5. Development
6. Presentation phase and key cost impacts

Adopting these value-based phases leads to the generation and evaluation of the alternatives by the defined criteria of the project. The criteria will be weighted through a Multi-Criteria Decision Making (MCDM) approach and ultimately the alternatives will be ranked in the VM process.

2.1 Information phase

In the information phase of VM, understanding the background, analysis of the key functional issues, and gathering other information that leads to a better decision-making process is essential.

2.1 1 Define LEZ definition and restrictions

LEZ and traffic restriction schemes are defined to improve air quality as a long-term plan. In Tehran, there are two kinds of CAZ plans are implemented. One is the smaller LEZ designated in the Central Business District (CBD) and

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requires a special entry permit. The other LEZ plan that is implemented from June 22, 2019, in Tehran is by limiting entrance and access days to the LEZ areas to 20 days in a season. The mentioned traffic restriction schemes are shown in Fig 2 with the active air quality stations within the area. The main admission hospitals and health centers for COVID-19 patience as well as key drugstores are defined within the LEZ and traffic scheme, showing one part of the possible urgent trips as well as potential supply chain links within the area. The 20 times entrance permit to LEZ areas in a season seems to not be justified in this COVID-19 pandemic circumstance.

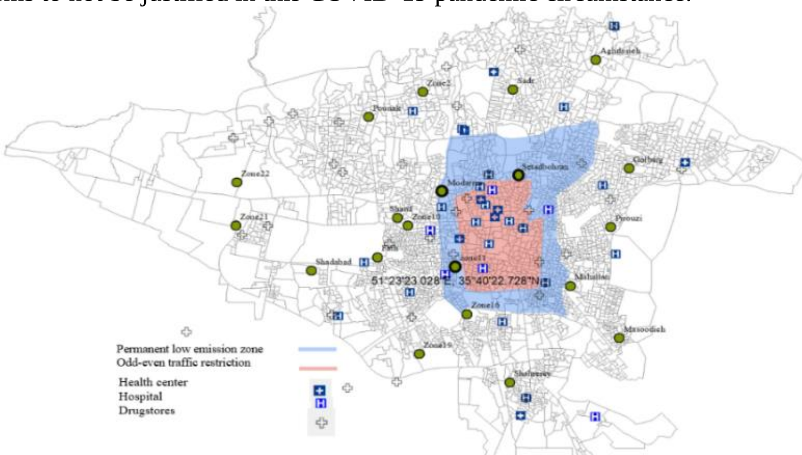

Figure 2 location of traffic scheme and LEZ, active air quality stations and COVID-19 patience admission centers in Tehran

2.1 2 Active air quality stations within LEZ

Within the LEZ areas defined in Tehran, there are three air quality stations (Fig 2) that monitor all six criteria pollutants PM, O_3, CO, NO_x, and SO_x emissions located as Setad Bohran station (urban, 35.7 ° N, 51.4 ° E), Tarbiat Modarres station (urban, 35.7 ° N, 51.3 ° E) and zone11 station (urban, 35.6 ° N, 51.3 ° E).

2.1 3 Analysis of NO_X emissions and AQI trend

Stationary sources and mobile sources are two important causes of air pollution in megacities. In the case of Tehran, mobile sources including public transportation fleet, personal vehicles, and motorcycles are the main contributor to air pollution(Mohammadiha et al., 2018). As NOx emissions are the main pollutants of traffic and transportation sector(Chen et al., 2020), the differences of emissions of it, in 20 March/20 May of 2019 and 2020 may be beneficial in gathering information of the air quality as a result of traffic and human mobility parameters of the area. Accordingly, the concentration of NOx pollutants in the three active air quality stations including Setad Bohran, Tarbiat Modarres, and Municipally Region11 is analyzed in the COVID-19 lockdown period that LEZ restrictions were postponed and the similar period of the year in 2019 when LEZ restrictions were implemented (Fig.3)

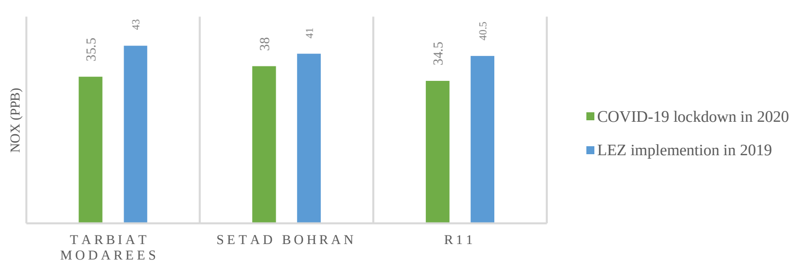

Figure 3. NOx concentration during COVID-19 lockdown inside LEZ air quality stations compared to 2019.

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The total change in AQI trend in the city of Tehran in March 20 till August 7, 2020, is compared to the average of the last four years in the same period as shown in Fig 4. It seems Traffic schemes during the COVID-19 pandemic spread, fail to Improve Tehran air quality as no decline in air pollution levels after the resumption of traffic restrictions has happened

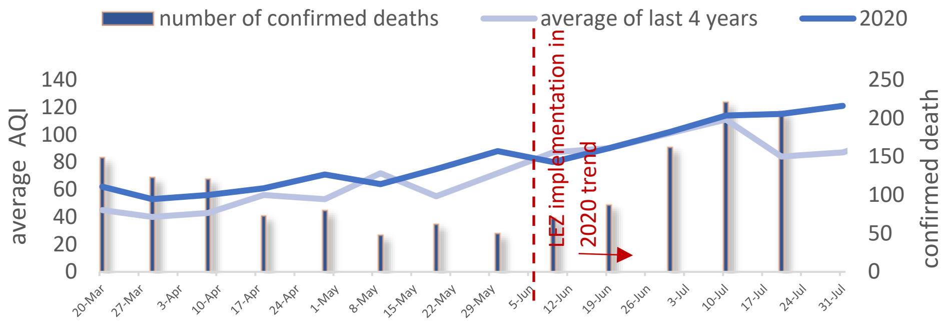

Figure 4. AQI trend number of confirmed deaths as a result of the COVID-19 pandemic in Tehran.

As studies have found that human mobility restrictions could not only prevent the spread of COVID-19 but also improve the air quality(Zhu et al., 2020), an increase confirmed the death of COVID-19, increase in AQI beside as resumption of LEZ and traffic schemes and easing other social distancing measures have happened from the middle of June 2020 (Fig 4). From the first day of spreading COVID-19 viruses in Iran, Tehran was one of the most affected cities because of the vicinity of Qom, the epicenter of COVID-19 in Iran, and the high population density. As there is no statistical record on mortality of COVID-19 by each province in Iran, the graph is defined hypothesizing the large share of Tehran in total countries statics.

2.1 4 Establish Cost on All Ideas

Assessing the cost side of the recommended alternatives in the VM process for this project, social distancing costs in societies due to the COVID-19 pandemic and air pollution mortality and morbidity costs should be calculated and considered in the value index. In other words, in the context of our study, the economic value of ultimate decision makings is the cost they impose to society that is proportionate to their impacts on the economy. Among the indicators of macroeconomics, gross domestic product is of particular importance. Accordingly, using GDP in evaluating social distancing economic impacts in societies and also air pollution attributed costs may be beneficial. As many local and state officials are making social-distancing policy decisions based on the actions of other locations rather than through a decision making framework that evaluates the effectiveness of these measures and their potential possibility in reducing the spread of COVID-19 (Strong and Welburn, 2020), assessing the imposed cost for each country based on its economic and statistical indicators may be effective for comprehensive decision-making in line with management policies. The net present value of social distancing can be written as the value of the lives saved by social distancing minus the present value of GDP lost due to social distancing (Thunström et al., 2020):

$$\boldsymbol{NPV = VSL \times (D_1 - D_2) - \sum_{t=0}^{T} (Y_{1t} - Y_{2t})(1+r)^{-t},} \tag{1}$$

where D_1 and D_2 are the numbers of deaths without and with social distancing. Y_{1t} and Y_{2t} are the forecasted levels of GDP in year t without and with social distancing. For calculating Y, the estimated and forecasted dataset in light of negative impacts of COVID-19 and other exogenous shocks affecting GDP, provided by global economic prospects of The World Bank (MPO, 2020) for Iran is used. r is the discount rate, and T is the planning horizon. The planning horizon is assumed to be upon one-year calculations and the discount rate is assumed 5.8% according to the literature (Daneshmand et al., 2018).

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The proposed alternative in this VM study is defined based on the two main scenarios on whether to implement LEZ and traffic restrictions or not. Accordingly, in the case of the first scenario, which is implementing LEZ, it is hypothesized that an infected person uses the bus to have a ridership within LEZ area. In order to assume the potential risk of getting COVID-19 in the case of using a bus, the result of the study (Shen et al., 2020) is of 41.5 times higher risk of getting it by using a bus containing an infected person is hypothesized. Accordingly, the social distancing cost for both scenarios is calculated by Eq1.

The cost of air pollution for both scenarios is estimated base on the AP3 model from EPA that accounts for the dose-response relationship and demographics of the affected populations to calculate the premature deaths from a unit of pollution emitted in each county. Therefore, to estimate the morbidity cost of air pollution for both scenarios, the International Vehicle Emissions (IVE) model is used to define the local emission factors of the fleet. Accordingly, the characteristics of a typical city bus in Tehran and the most frequently used light vehicle entered as the fleet file. The emission of NOx pollutants and expected death rates modeled for per billion miles according to the data of light-duty vehicle fleet emissions and contributed death rates that are obtained from (Steve Cicala, 2020). The comparison of the cost of the aforementioned scenarios is shown in Fig 5.

As shown in Fig5, alternatives that are proposed based on implementing LEZ, are mainly upon the first scenario that imposes a higher risk of social distancing and contributed air pollution in comparison to scenario 2. Thus, in the creativity phase, the main framework of the proposed alternatives will be based on the second scenario.

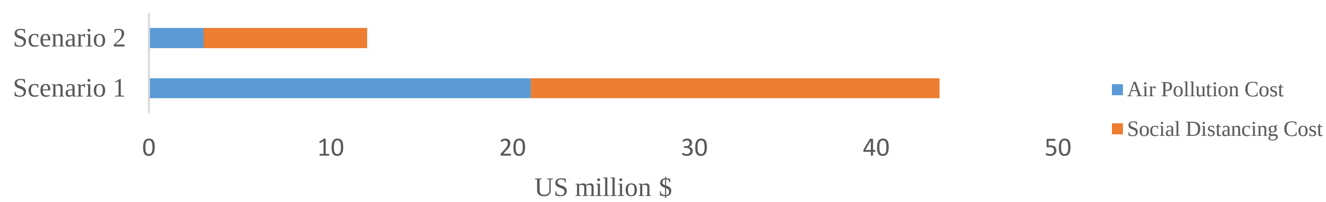

Figure 5. Assessing the Cost if Scenarios

2.1 5 Defining project criteria and constraints

The effective criteria in decision making to choose the optimum strategy to act on implementing LEZ restrictions due to COVID-19 are defined based on the basic and supportive functions of the addressed subject. Consequently, six attributed criteria are defined as below.

- Ease of accessibility,
- Reduce human mobility index,
- Improving air quality (as a long-term plan),
- Maintain all links in the supply chain,
- Reduce Fuel demand and mitigate consumption.

Following this, the constraints of the project defined as to keep on social distancing measures, improve air quality in the short term and long-term horizons and minimize health risk and the imposed cost of COVID-19 and air pollution side effects.

2.2 Function Analysis phase

How the project is supposed to accomplish is defined in this phase. The major functions identified are as to the Function Analysis System technique or systematic FAST diagram shown in Fig5.

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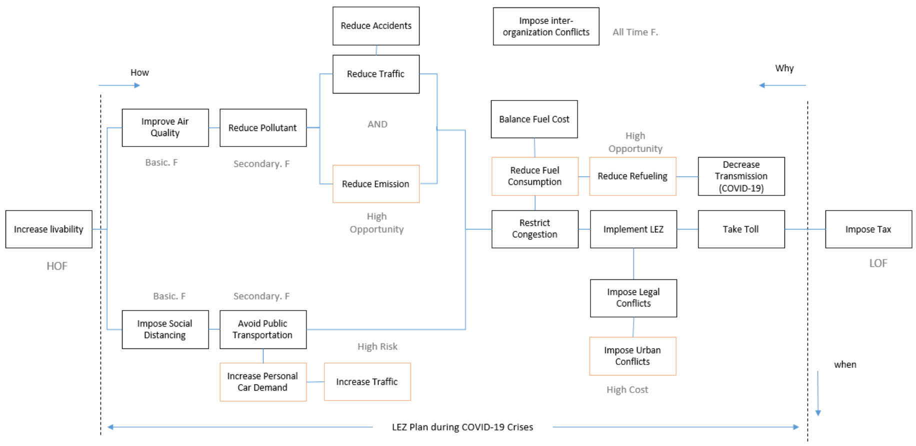

Figure 5. Systematic FAST diagram for LEZ and traffic restriction implementation during COVID-19

2.3 Creative phase

In this study, the present alternative which is implementing the LEZ and traffic scheme is modified and improved through the creativity phase in the VM process. The modification and improvement aspects of the plan are modifying scheduled time for restrict measures within LEZ, imposing different deterrent policies in transportation demand management (TDM) like pricing policies, the exemption for special groups of society beside as implementing LEZ strictly and limit the permitted number of entrance days to LEZ.

2.4 Evaluation phase

In this step, based on the VM methodology, we should reflect back to the project constraints and objectives and consensus on the values as measures of whether or not an alternative has enough merit to be carried forward in the VM process. To define the weight of the values in the decision-making approach, we used the Analytic hierarchy process (AHP) which is an accurate approach for quantifying the weights of decision criteria in the scope of the study. In this method, the relative importance between every two criteria is compared. Judgment consistency can be checked by taking the consistency ratio (CR) and it is acceptable if it does not exceed 0.1. If it is more, the judgment matrix is inconsistent (Saaty, 1987).

2.5 Development phase

The value index is calculated as Equations 2. Assessing the value index of VM alternatives defined in the creativity phase, the best scenario should be chosen by multi-criteria decision approaches. Studies suggest that chronic exposure to certain air pollutants leads to more severe and lethal forms of COVID-19 and delays or complicates recovery of the patience of this disease (Domingo et al., 2020). Accordingly, considering basic and secondary functions of the project and the cyclic interact of air pollution and COVID-19 infection, the appropriate MCDM method for the study should be chosen. As both air pollution morbidity and mortality and COVID -19 affection risks are inevitable and undesirable, the Maximin approach may be appropriate in defining the best of the worst decision.

$$\boldsymbol{value\ index = \frac{function}{cost}} \quad \textbf{(2)}$$

Recommended alternatives

Discussed alternatives in this research are basically to mitigate the LEZ and traffic scheme plan under the COVID-19 crises. The chosen alternatives are:

A: Doubled charging for defined traffic control scheme area,

B: increase the allowed number of entrance days from 20 to 30 in a season within LEZ,

C: reducing the LEZ implementation hours

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3. Value engineering Applications on CAZ during COVID-19 results

While detailed epidemiologic and economic studies would be required to find the answer to this question to maximize the control over the spread of the virus and minimize the negative impacts on the society due to the isolation/lockdown initiatives (King and Striolo, 2020), the multi-criteria decision-making approach is applied for the addressed problem specifying the social and economic related index. Table 2 represents the weighting process assessed by the AHP method. The value of each criterion is defined as a factor for ranking the alternatives.

Table 2 criteria scoring matrix for the project

criteria weighting process

	Criteria	weight	score
A	Ease of accessibility	0.117	3
B	Reduce human mobility index	0.273	10
C	Reduce mortality and morbidity rate	0.318	11
D	Improving air quality (as a long-term plan)	0.126	3
E	Maintain supply chain	0.104	2
F	Reduce Fuel demand and mitigate consumption	0.063	1

criteria scoring matrix

	B	C	D	E	F	Total
A	B-1	C-3	D-2	A-1	A-2	3
	B	B-C	B-1	B-3	B-4	10
		C	C-2	C-3	C-3	11
			D	E-1	D-F	3
				E	E-1	2
					F	1

(4) major difference in importance

(3) medium difference in importance

(2) minor difference in importance

(1) slight difference in importance

One point for each (letter/letter)

The decision matrix of the project is shown in Table 3. Each alternative is ranked with a number from 1 to 5. The base alternative is ranked as 3 and other alternatives are ranked in comparison to that whether or not they satisfy the criteria of the projects in accordance with its basic and secondary functions.

Table 3 decision matrix of the project

Desired Criteria							
Ease of accessibility	Reduce human mobility .	increase public health	Improving air quality (as a long-	Maintain supply chain	Reduce Fuel demand and mitigate	total	raking
A’	B’	C’	D’	E’	F’		

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weight of importance 0→10		1.17	2.73	3.18	1.26	1.04	0.63		
A	w. rating	3.5	10.9	6.3	2.6	4.1	1.3	28.7	2
	Rating	3	4	2	2	4	2		
B	w. rating	4.7	10.9	12.7	5.04	2.08	2.5	37.9	1
	Rating	4	4	4	4	2	4		
C	w. rating	2.3	8.2	6.3	3.2	4.1	1.5	25.71	4
	Rating	2	3	2	2.5	4	2.5		
D	w. rating	5.8	5.4	6.4	3..8	4.2	1.3	26.96	3
	Rating	5	2	2	3	4	2		

4. Conclusions and Recommendations

This study aimed to have a consistent effort to alleviate the side effects of social distancing due to COVID-19 mortality and air pollution consequences in city of Tehran through a value methodology approach. The morbidity side effect of air pollution in cities acts as an aggravating factor that leads to more susceptibility of COVID-19 incidence. Besides, as the unprecedented impact of the COVID-19 outbreak has resulted in changing the city management priorities such as air quality improvement plans and implementing LEZ, the problem is investigated by considering the cost of the alternatives by two hypothesized scenarios. Accordingly, the proposed alternatives as to the result of VM adoption through the 6 phases of the study step, suggested based on these two scenarios framework. The first scenario is implementing LEZ and subsequently increased demand for public transportation. Following this, the social distancing cost and air pollution cost of using public transportation measured. The second scenario is the cancelation of all traffic confinement measures and an increase in demand for personal vehicle usage in intercity travels within LEZ. The air pollution cost of the scenarios is defined by AP3 and IVE models. Based on the cost evaluation of scenarios, different alternatives are assessed in the creativity phase through appropriate criteria based on the basic and secondary function of the problem. The criteria are defined as the ease of accessibility, reduce human mobility index, improve air quality (as a long-term plan), maintain all links in the supply chain, reduce Fuel demand, and mitigate consumption. As the result of cost analysis (social distancing cost and air pollution cost) of implementing LEZ (scenario 1) is high, the suggested alternatives are based on mitigating it in accordance with the framework of scenario 2. Accordingly, the ultimate proposed alternative of VM adoption for this case is to increase the allowed number of entrance days from 20 to 30 in a season within LEZ.

By increasing the allowed number of entrance days to LEZ areas, more flexible schemes for remote working, mitigating the transportation demand, and other revolutionary plans to boost sustainable traffic schemes such as walking and cycling within LEZ might be consequently implemented. Moreover, the results of mitigating the high demand within the traffic restriction areas in Tehran due to the COVID-19 pandemic motivates us to move on through sustainable transportation strategies, improved fleet, and adopt new urban mobility policies to increase the effectiveness of LEZ areas.

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ADDING VALUE + TO COMPLEX PROJECT SOLUTION DEVELOPMENT

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About Author

Sudhir Kumar is a Chartered Civil Engineer having 24 years of experience in water and wastewater engineering covering feasibility studies, master planning and detailed design. He is currently working with Jacobs as Technical Director-Water in Dubai, UAE office. Sudhir is a VMA and got a keen interest in Value Methodology application in the last seven years. He recently applied Value Methodology practice in project delivery with great success resulting in excellence in project delivery and improved project financials. He got extensive work experience delivering large scale water and wastewater projects in the Middle East covering UAE, Saudi Arabia, Qatar, Oman, Bahrain, Kuwait, Lebanon and Libya.

Abstract

Although average annual rainfall in most of Middle East countries is deficient, stormwater management is a serious issue in most of its urban cities. The Author is currently working on a multibillion-dollar strategic stormwater management scheme covering a large 500 km^2 of an urban area. Value Engineering studies at the design stage are part of the scope of this project. The optioneering stage followed the three guiding principles of Value Methodology (VM) in the identification, screening, development and evaluation of alternative options and selection of optimum strategic stormwater scheme. The application of VM concept at the optioneering stage was a Value+ addition to the complex project solution development.

1.0 Introduction

Most of the Middle East countries falls in the desert zone with an average annual rainfall of 1-3 inches. However, stormwater management is a critical issue in most of the cities due to flat topology, urbanization, rising groundwater (GW) table and obstruction to the natural overland flow path. In the last decade, more and more water authorities realized the need for efficient groundwater and stormwater management infrastructure. Such infrastructure requires a sizable capital investment and client focus always remains on the right balance between the level of service and project cost.

One such project was initiated recently to develop a multibillion-dollar strategic stormwater management infrastructure for a large 500 Km^2 of urban area for safe collection, transfer and disposal of stormwater from the project catchment. The project requirement is to go through the study and optioneering phase followed by the design development and tender documentation for project execution.

As per contract scope, the stormwater management infrastructure shall cover the connection of existing and planned local storm collection system within the catchment to a strategic link and tunnel system. The tunnel system includes deep tunnels, pumping station and marine outfall to collect and convey the stormwater for safe disposal to sea through engineered outfall for minimal environmental impact. The system design requirement shall cover managing storm flows generated up to 1 in 100 years annual return intervals.

The project key objective is "selecting an optimum strategic drainage scheme to provide the best hydraulic solution with minimal environmental impact at the least whole life cycle cost. The solution shall also provide the maximum operational flexibility to Client, including the potential for future real-time control of the entire strategic stormwater drainage system".

2.0 Value+ Concept

Development and selection of an optimum strategic scheme for a large (500 Km^2) catchment area is a challenging task to keep the right balance between project cost, reliability, performance and schedule. An early assessment of the storm flow estimate suggested that the storm flows from the catchment could be as high as more than 250 m^3/sec capacity making it financially not feasible. So, finding an optimum solution as per the project key objective was one of the most critical tasks during project study and optioneering phase.

The project requirement includes the Value Engineering workshop during the design stage of the project. The Author's experience in Value Management practices encouraged him to apply the same concept during the project study and optioneering stage to drive the most benefit out of it.

The early value+ involvement during optioneering stage follows the three fundamental guiding principles of Value Management (refer Figure 1):

- Following a structured VM Job plan
- Understanding functional performance and requirements
- Focus on value by keeping right balance between functions and cost

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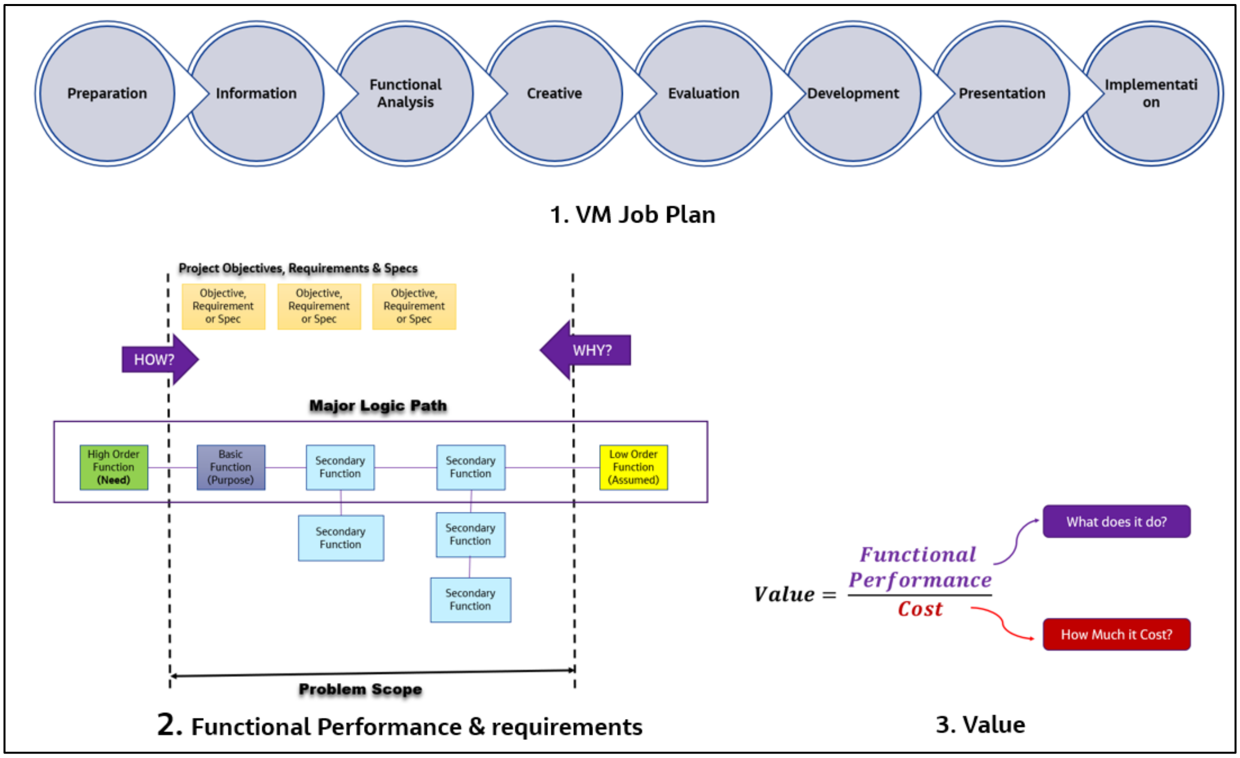

Figure 1. Value Management Guiding Principle (reference VM Guide 2020)

3.0 Finding Optimum Solution through Optioneering Phase

Similar to VM Job Plan, Figure 2 outlined the optioneering process steps planned into several stages with active stakeholder involvement. During project initiation, consultant collected relevant information from multiple sources and identified a list of key stakeholders for their direct involvement. An early one day (1st) workshop, named as project information, was organized with all key stakeholders to brief them about the project, project objectives and the process to be followed during the project optioneering and design phase.

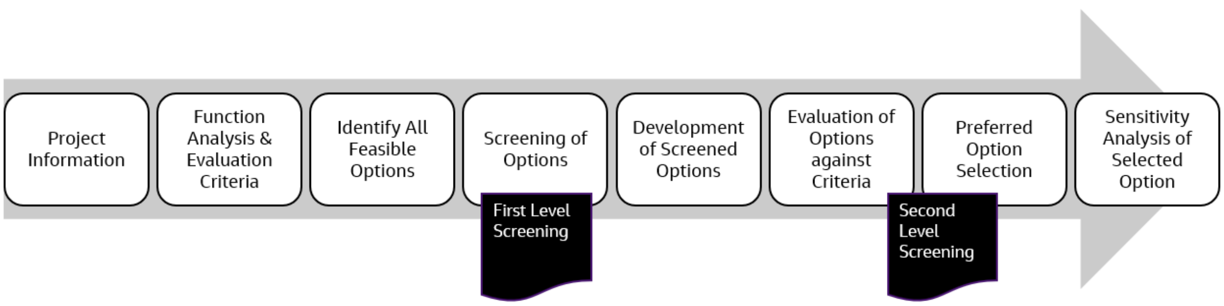

Figure 2. Optioneering Phase Value+ Job Plan

Following the early project information workshop, a 2nd workshop was organized to discuss the project (random) functions and identifying related functional performance assessment criteria and associated weightage in the evaluation of options during optioneering phase. During the workshop brainstorming session, the team carried the random functional analysis for the strategic stormwater management scheme and its vital component, namely conveyance inland tunnels, pumping stations and marine outfall. Figure 3 shows the high level, basic and secondary functions identified during the workshop. A long list of secondary functions for the project component was also recognized during the process and agreed to use during Value Engineering workshops at a later design stage.

Strategic Scheme	Inland Tunnel	Pumping Stations	Marine Outfall
Prevent Flooding	**Connect** LRDP network	**Pump** Stormwater	**Convey** Stormwater
Protect Public Health	**Collect** Stormwater/GW	**Transfer** Flow	**Discharge** Flow (to Sea)
Protect Environment	**Convey** Stormwater/GW	**Control** Flow	**Apply** (pollutant) Dilution
Manage Stormwater	**Store** Stormwater/GW	**Screen** Stormwater	
Reuse Water	**Secure** Access	**Remove** grit/sand	
Dispose Stormwater	**Reduce** Maintenance		
Optimize Flow	**Secure** Future Connections		
Control (inter-catchment flow) Transfer	**Monitor/ Control** flow		
Lower GW Table			
Increase Flexibility			
Increase Reliability			
Increase Efficiency			
Simplify System			
Monitor System			

Figure 3. Random Function Assessment

For option assessment, the team identified five (5) critical functional performance assessment criteria and seventeen (17) sub-criteria (Multicriteria analysis toolkit, Jacobs). Project team asked Stakeholders to rank the suitability of these criteria and sub-criteria for optioneering and score it for priority/ weightage. Following the conclusion of the workshop, the team considered an average of stakeholders scores to finalize the criteria weighting, as shown in Figure 4. The team gave the technical aspects highest weightage (30%) followed by environmental (24%), economic (22%), social (14%) and legislative impact (10%).

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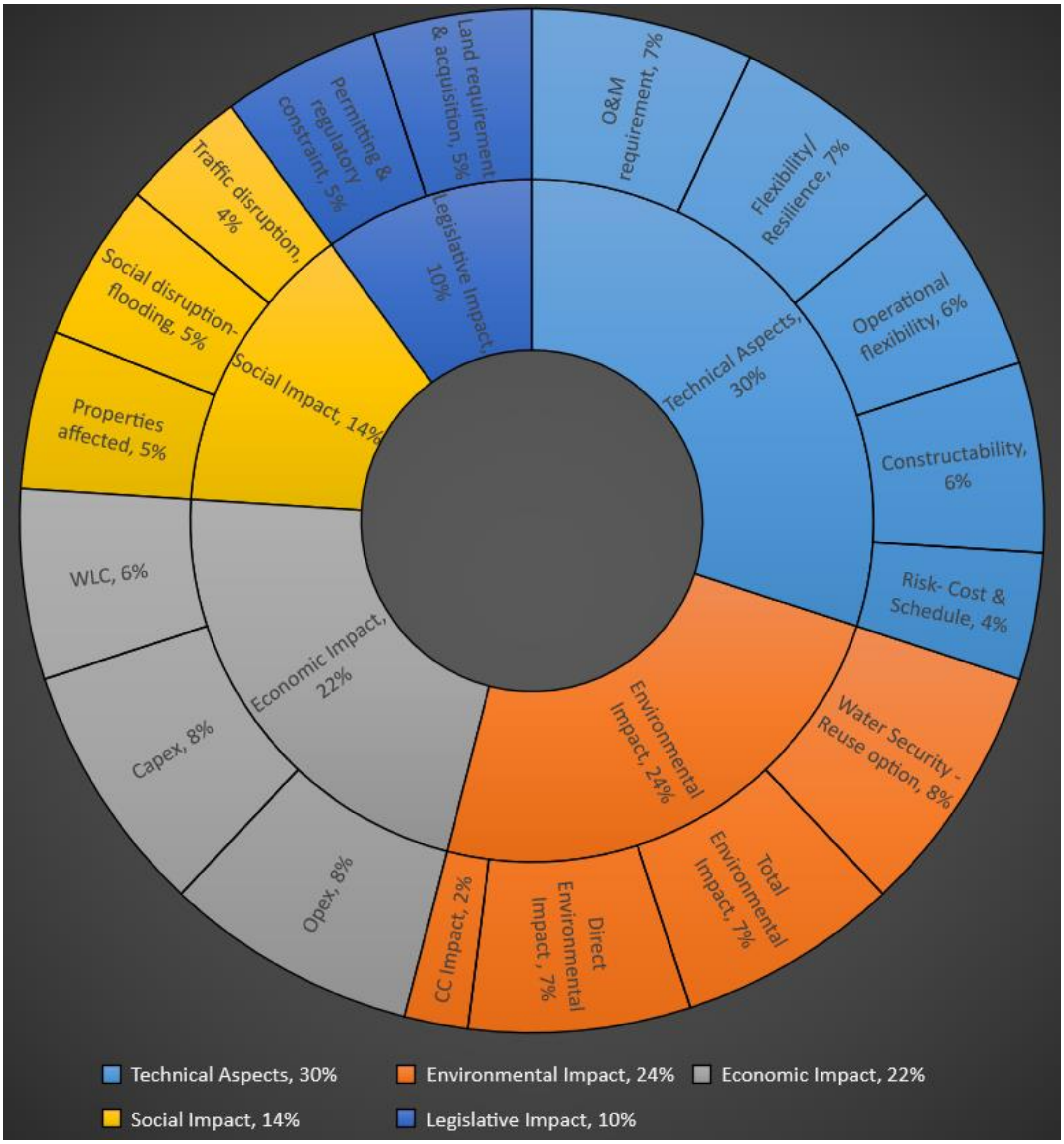

Figure 4. Functional Performance Assessment Criteria & Sub-criteria

Project team organized a 3rd workshop with stakeholders to identify all feasible options for optioneering and selection of a preferred strategic scheme. During the workshop, the project information and performance assessment criteria and weightage selection carried out in previous workshops was summarized along with project location and identified project constraints. The project team further split the strategic scheme into three critical components of inland conveyance tunnel, pumping station & storage and marine outfall. The optioneering team presented several identified options to the stakeholder. The team organized a brainstorming session by grouping all participants into four teams, and assigning each the project component, namely conveyance tunnel, pumping stations, marine outfall & strategic (overall) scheme. The team gave each Group 45 minutes to brainstorm and come up with all possible ideas for optioneering and 15 minutes to summarize and present their ideas to other teams. Other teams were encouraged to add to the identified ideas. During the whole process, it was made clear that the individual will not discuss the feasibility of an idea as the aim of the workshop was to exhaust all possible ideas.

The outcome of the workshop was very positive, as stakeholder felt part of the team and actively participated in identifying possible options. Stakeholders were well aware of the project objective, conceptual scheme and its component, functions of each component, project location and key project constraints. The team identified a total of 92 options during the workshop to cover strategic scheme and its component (refer to Figure 5). The workshop was concluded with the aim of optioneering team assessing the identified options and further developing the feasible alternatives for evaluation and selection of the preferred scheme.

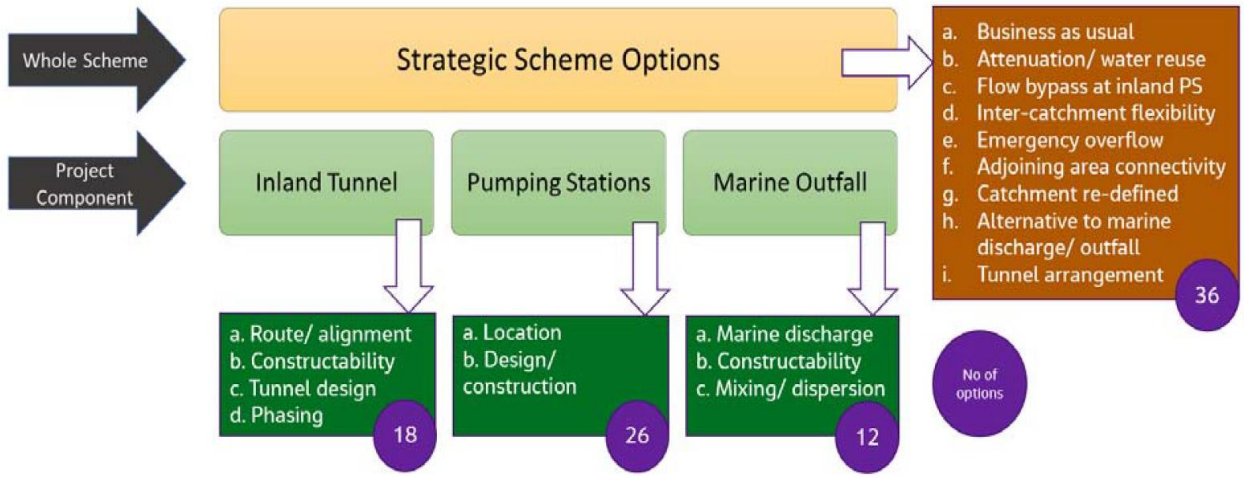

Figure 5. Identified Options Group and options (3rd workshop)

After the 3rd workshop, optioneering team started evaluating the identified options. The team developed a two-level screening process to assess options (refer to Figure 6). A qualitative evaluation process was adopted for first-level screening to discount such options that does not meets the critical project objectives & requirements or not feasible to implement due to significant constraints or do not meet the regulatory requirement. The team further marked the options selected to carry forward for detailed assessment (Second Level of Screening) in two categories:

- Category 1: Strategic options that require assessment during optioneering
- Category 2: options that do not impact the strategic option selection can be assessed during the design development and associated Value Engineering workshops.

The storm modelling and design team developed the options tagged under Category 1 for detailed assessment. A class 4 cost model was developed as per AACE Cost Estimate Classification System (AACE, 1997) for the project optioneering assessment based on similar Middle East projects cost detail and consultant cost database.

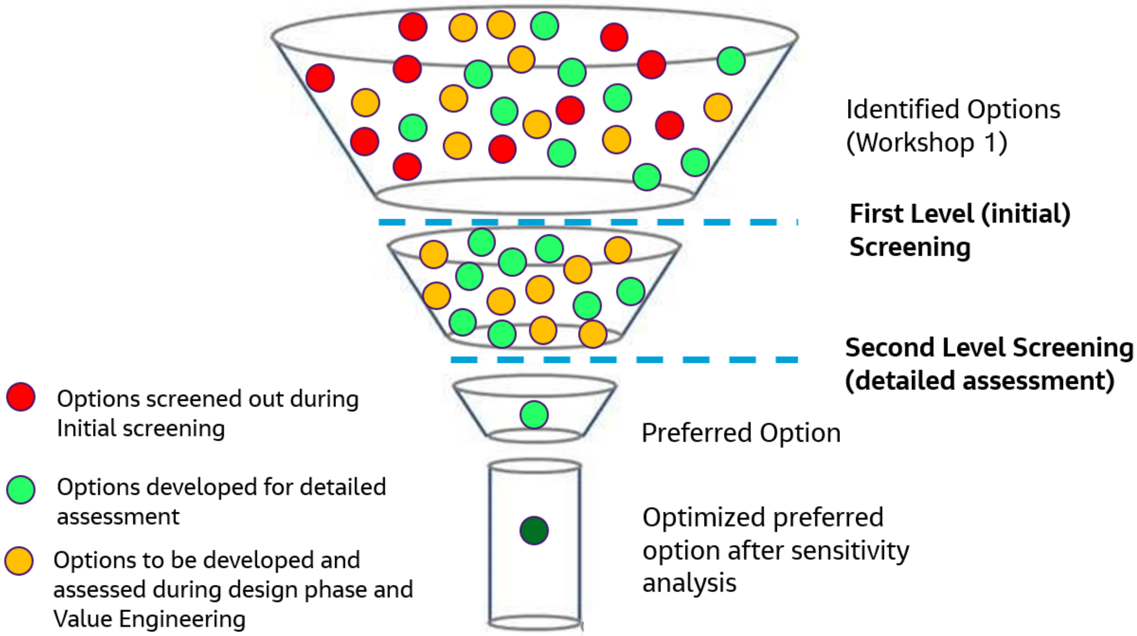

Figure 6. Identified Options Screening Process

Following approach were followed in development and assessment of options:

Step 1: Screened options categorized in groups for assessment and comparison

Step 2: Screened options assigned to optioneering team members based on option requirement and team member skillset

Step 2: Storm modelling team developed the model and model run output for the options

Step 3: Design team further develops the option based on modelling output and assessment criteria

Step 4: Cost estimation team estimates the Capital Expenditure (Capex), Operational Expenditure (Opex) and Whole Life Cycle Cost (WLCC) of the options

Step 5: Options evaluation in groups (example Conveyance Tunnel) and selection of top 1-2 options from each group

Step 6: Developing combined options for whole scheme by considering top selected options from each group

Step 7: Assessment of combined options and selection of preferred option

A total of nine (9) combined options were finally evaluated on assessment criteria (refer Figure 7) for the selection of the preferred option. The top selected options include provision of two large diameter deep conveyance tunnel and pumping station, a large storm storage lagoon and a marine outfall. The optioneering team organized a 4th workshop with stakeholders to present the outcome of options development and assessment process and selection of the preferred scheme. The team presented top two selected options out of which one option was discarded due to extensive land area requirement. The selected option was further considered for detailed sensitivity analysis to optimize the preferred solution.

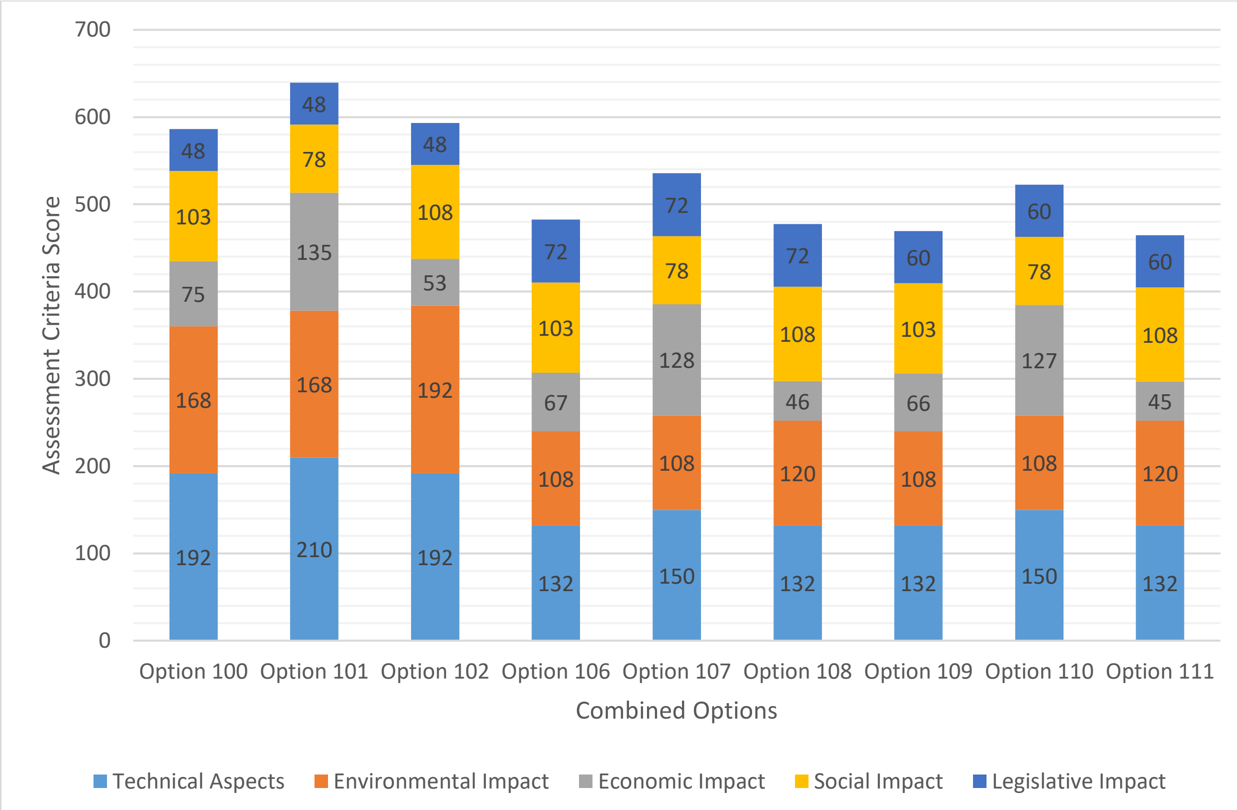

Figure 7. Combined Options Evaluation Based on Performance Assessment Criteria

4.0 Conclusion

The Value Methodology (VM) is a proven project management best practice and an exceptional decision-making tool to find alternative solutions to problems and achieve improved Value. The Author used the well-proven Value Management guiding principles at the optioneering stage on this multi-billion dollar large and complex stormwater management project for the assessment of options and selection of preferred scheme. Following a VM Job Plan at optioneering stage gave a well-structured approach to the whole process in the selection of the most optimum solution that meets client key objectives and all other project requirements. The entire process shows the Value+ addition of VM approach in finding a solution to a complex project. The optioneering process and preferred solution selection offer a saving of more than $100 Million between the top two rated options. Value optimization is further anticipated during Value Engineering study scheduled during the design stage of the project.

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Sustainable Result-Based- Management Projects using VM Techniques

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Abstract

In highly competitive markets, and in a world of globalization and rapid change, traditional project management techniques and tools have to be updated, modernized, and some to be excluded. The world of Artificial Intelligence (AI), Internet of things, Virtual and Augmented Reality (VR & AR), Big Data, and technology based solutions, products, and services require new techniques and tools.

This paper addresses the integration of Result- Based Management cycle and result chain concept with techniques and tools of Value Management and Engineering to set a guidelines for designing, planning, implementing, and evaluating a sustainable project based deliverables.

The United Nations in its 2015 agenda introduces the concept of Sustainability through the issuing of its 17 SDG's (Sustainable Development Goals) for a better future on the planet and for sustainable cities and communities for people to live.

Introducing the 9 nine criteria in this paper to evaluate based on the Weighted Matrix Technique of evaluation which will help achieving sustainability in projects deliverables through the result chain of these project deliverables on short term, intermediate term, and strategic impact.

Key Words :

Result- Based Management , Result Chain, SDG's , Sustainability Criteria, Project Life Cycle, Weighted Matrix Technique, Job Plan of VE

Introduction

In a rapid world of change, and presence of several challenges facing organizations , societies, and countries, sustainable solutions for communities through projects become a corner stone for development and facing such accelerated change and continuous challenges.

The United Nations set 17 SDG's (Sustainable Development Goals) for its agenda 2030. In all sectors of education, health, energy, technology, social, and technical, sustainable results are the target for continuity of impact, and these SDG's would be achieved through several programs and projects both in private and public sectors.

This paper addresses the Result- Based- Management (RBM) approach in projects that would serve achieving criteria of sustainability in all types of projects. The use of Value Management tools, techniques and approaches will be integrated with RBM to maintain the target of sustainable results. The paper presents criteria for sustainable result based management projects, and the approach of value engineering phases would be used to help satisfying the projects objectives.

Result- Based Management provides a coherent framework for strategic planning and management based on learning and accountability to achieve results with the most added values possible.

With the value management job plan and applying creativity techniques, and the weighted matrix

techniques , projects will be directed towards achieving the sustainable expected results.

Paper Objectives

The objectives of this paper include :

1. Present the modern challenges facing organizations that require the ability of projects to provide sustainable results with strategic impact
2. Introduce the integration of result-based management and value management to maintain sustainability in project results
3. Present the criteria to be applied through the life cycle of projects to ensure achievability of projects deliverables .
4. Emphasis the importance of value engineering and management job plan and different tools in use through the design and implementation phases of projects.

Challenges and the need for sustainable projects' deliverables

In the world of globalization, where change is accelerating in almost all aspects and industries, the ordinary traditional project management techniques is out of date, new techniques, standards, and strategies have to be adapted to be able to get sustainable project deliverables. Some of the challenges include the future of jobs which will be dependent mainly on robotics engineering, artificial intelligence AI), internet of things, virtual and augmented reality (VR and AR), renewable energy, and smart usage and applications. Such challenges open the door to start doing things differently , and through using adaptive managerial techniques, projects could be managed differently to maintain sustainable results.

The United Nations in its agenda signed in 2015 by most countries (www.sustainabledevelopment.un.org/post2015) announced the 17 SDG's (Sustainable Development Goals) to support sustainability in projects' deliverables in all sectors affecting people on planet.

The ability to plan , and implement such projects require new integration application of result based management with value management techniques through a set of criteria to ensure sustainable deliverables.

Three main phases are defined in the project life cycle :

1. Planning Phase : Strategic, tactical, and Operational
2. Implementation Phase
3. M & E Phase (Monitoring and Evaluation)

Fig. 1 shows the cyclic approach that is applied in all projects with linkage to RBM

Fig. 1 The Cyclic Result Based Management (RBM) Approach

Then the result chain has to be determined to define the projects deliverables. The chain will determine three time estimates for each project deliverables :

1. Outputs : which are the short or immediate results obtained once the project is in operation , and the results in this category are tangible and measurable.
2. Outcomes : which are the intermediate results obtained and contains tangible and intangible deliverables.
3. Impact : which represent the sustainable result and the strategic deliverables of the project.

Fig. 2 shows the concept of a result chain.

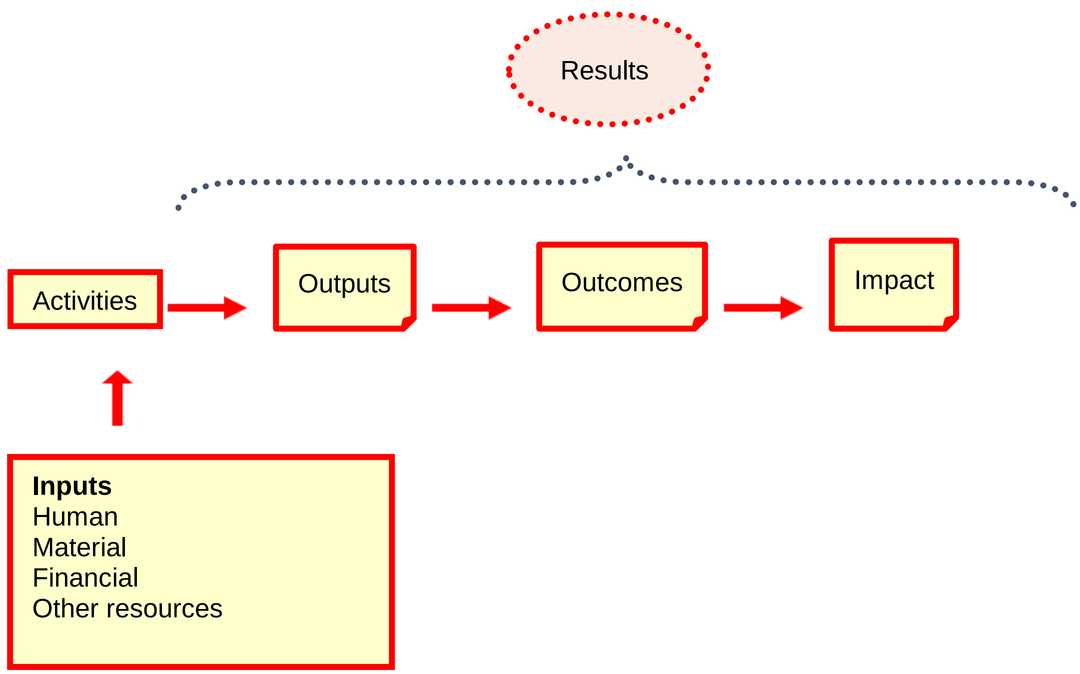

Fig. 2 Result Chain Diagram for a Project

In each phase , several tools and techniques are applied to achieve the objectives of the projects. Value management and engineering job plan phases are applied to integrate with the cyclic approach of RBM. Starting from defining the project functions through the FAST Diagram , and going through the cycle of brainstorming , and creativity , and evaluation.

Criteria for Sustainability in RBM Projects

All designed and planned projects following the RBM approach have been linked in evaluation with the following set of criteria to ensure sustainability . Then by applying the technique of Weighted Matrix for evaluation and getting the value index of the projects, functions are achieved, result chain is maintained and thus sustainability is gained and ensured.

The criteria of evaluating projects' deliverables are :

1. Life Cycle Cost (LCC)
2. Strategic Impact ; and this to be evaluated by set of Key Performance Indicators (KPI's)
3. Linkage with the SDG's of the United Nations
4. Risk Associated with the Result
5. Accelerators and Time Estimates
6. Technology based solutions
7. Environmental Friendly Results; by setting indicators for each project related with environmental outputs and impacts
8. Sustainable use of resources and renewable energy
9. Stakeholders' expectations

These nine criteria for different projects and deliverables are evaluated , then the Value Index is determined for each project.

By integrating the RBM approach with the Value Management tools and techniques , project deliverables would ensure sustainability of the strategic impact .

Conclusions and Recommendations

With the several challenges facing communities, societies, and organizations, sustainable solutions are required to be implemented by projects which satisfy the criteria of sustainability through the result chain of the projects' deliverables. These criteria to be evaluated using the techniques of Value Management and in integration of the concepts and techniques of Result Based Management.

United Nations SDG's are recommended to be the guidance for sustainable projects' deliverables.

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The Agility of Value Methodology

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Abstract

Due to the continuous needs to improve the value, Value Methodology has been practiced for more than 60 years in several industries, especially construction.

The concept of value cares for both the customer's needs and the organization's interests in better using the available resources to satisfy these needs. VM also focuses on the idea of a function as the means to describe the customer's needs and wants which will be detailed in a manner to broaden the understanding of the problem or opportunity in such a way that it drives the generation of creative alternatives.

On the other hand, Agile is mindset that has been enthusiastically welcomed by many industries due to the ability to manage changes, increase team productivity, customer satisfaction, effectiveness in resolving unexpected risks. Many Agile-related topics had successfully discussed its application in other industries, like but not limited to construction, manufacturing…etc

The main objective of this study is to highlight the agility of value methodology and how it could serve Agile practitioner delivering only what the client consider has the maximum value.

Keywords: Agile, Value Methodology, Product owner , Backlog , Function ,Value, APM Agile Project Management, Construction.

Introduction

Novel coronavirus (COVID-19), which originated from Wuhan, China, has spread to more than 125 countries of the world infecting more than 100 000 population [1 ,2]. Apart from being a global health concern, COVID-19 is having major consequences on the world economy, and experts have predicted that COVID-19 will lower global gross domestic product growth by one-half a percentage point for 2020 (from 2.9% to 2.4%). The whole world is now a single global community, where any major happening in one part is bound to have repercussions in rest of the world [1,3]

Some of the world's leading suppliers are developing strategies to move into the provision of innovative combinations of products and services as 'high-value integrated solutions' tailored to each customer's needs. Rather than simply 'moving downstream' into services (as much of the business strategy literature assumes) [4].

Which emerged the need to study the possibly of merging the value methodology as a value improvement approach with the mindset that welcome changes, fast delivery, uncertainty and prioritize the customer satisfaction.

The research question of the present article is : 'could we consider VM an agile problem solving approach ? '

To answer this question we've done a comparative analysis according to agile principles and 6 rules of declaration of interdependence .

The article consists of five sections.

In section 1, What's the VALUE means as per VM guide to clear any misunderstanding

In section 2, What's Agile? To introduce Agile for value specialists.

In Section3, . A comparative Analysis based on the 12 principles on Agile to find the common points between Agile & VM

In Section 4, The importance of VM for Agile Practitioners.

In Section 5, The Agility of Value Methodology.

But highlighting 6 rules of Agile declaration of interdependence .

Method used: Comparative Analysis to find the common points between Agile &VM

Materials/ references used:

1- VM guide, A Guide to the Value Methodology Body of Knowledge, published by SAVE international 2020, as a main reference for Value Methodology Specialists.

2- Agile Practice Guide, published by PMI and represents the main guide for Agile Practitioners.

3- Other Articles , research papers ,…etc related to the 2 topics .

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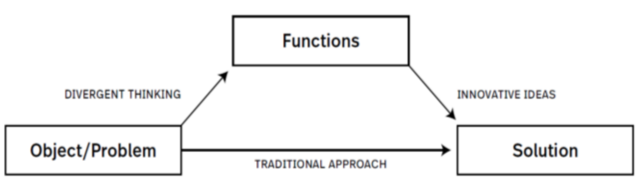
1. What the Value Means (As per VM guide)

Value Since its creation in the late 1940s, the Value Methodology described in VM Guide has received different names, like value engineering or value analysis. Nevertheless, the word "value" is always there. To really understand the power of Value methodology, the VM practitioner must grasp the essence of value.

It is not uncommon to find analysts or decision-makers using the word "value" interchangeably with "price" or "cost"; this common misunderstanding may lead to the wrong decision being made, cutting corners, and cheapening the project. This misconception has also led many practitioners to refer to any cost reduction activity as "value engineering" a very risky mistake. When Larry Miles stated his famous axiom "All cost is for function**," he was stating that value is first established by the user's (or customer's) needs and wants.**

The concept of value cares for both the customer's needs and the organization's interests in better using the available resources to satisfy these needs. VM also focuses on the idea of a function as the means to describe the customer's needs and wants which will be detailed in a manner to broaden the understanding of the problem or opportunity in such a way that it drives the generation of creative alternatives[5]



VM helps to find solutions for all kinds of challenges. Because VM is, by design, a multidisciplinary, multicriteria method that looks at both value and costs, it can solve problems and produce solutions that can easily be implemented. By looking for the function, VM takes you away from a monodisciplinary approach and opens a fresh perspective on the challenge at hand. The language (verb and noun) and the method allow people with totally different backgrounds, disciplines, and interests to work together and find common ground and "out of the box" solutions [5]

2. What's Agile?

Agile is a mindset defined by the Agile Manifesto values, guided by the Agile Manifesto principles, and enabled by various practices.

Agile Values :

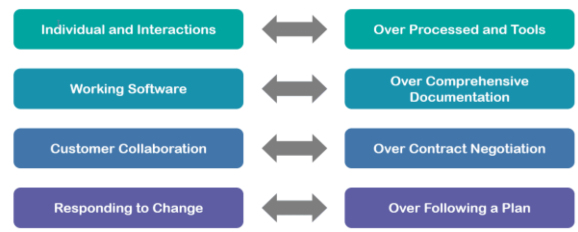


Figure 2– the 4 values of Agile

Twelve clarifying principles flowed from these values (as per PMI ,Agile Practice Guide) [6]

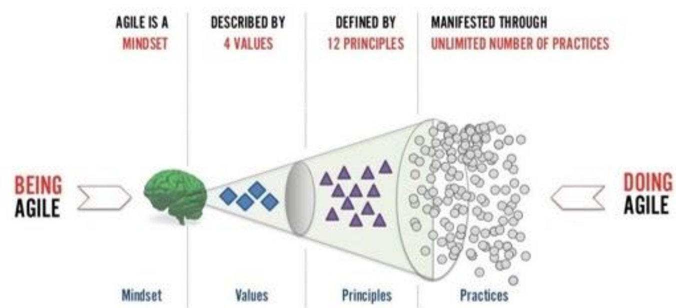


Figure 3- The 12 principles of Agile Manifesto

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development.

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The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity—the art of maximizing the amount of work not done—is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly [6]

3. A comparative Analysis based on the 12 principles on Agile.

Agile is a mindset

- Defined by 4 values
- Guided by 12 principles
- Manifested through many different practices.

The main objective of this analysis is to measure the agility of value methodology and whether we can consider VM as an agile problem solving approach or no according to the 12 principles, as following:

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software [6]
As per VM guide: the concept of value cares for both the customer's needs and the organization's interests in better using the available resources to satisfy these needs. [5]
The concept of customer value is based on the idea that people make rational buying decisions based upon the relationship between the total cost of ownership and performance [5]

2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
As per VM guide: VM could be applied any time, but the earliest application could lead to highest value.

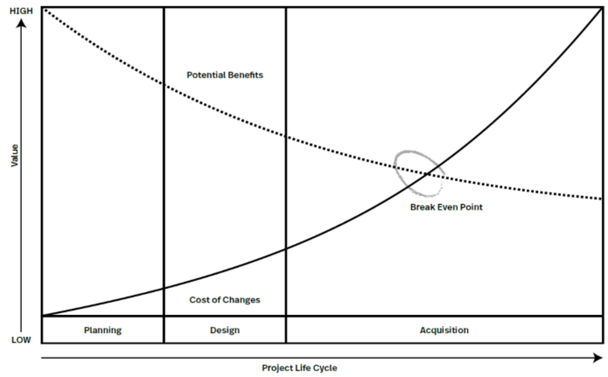

Figure 4- Project Life Cycle

For projects, as development progresses, the cost to make changes increases until a point-of-no-return is reached and the cost of redesigning, reordering, and rescheduling overwhelm the potential benefits [5]

3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale [6]
Traditionally requirements capture methods usually discourage further adaptation once the plan is running. After the requirements are described they are broken down and recompiled into logical groups, often to create delivery milestones. It is obviously in the developers' interest to strive to meet these milestones as payment is usually attached to them; change is seen as adding risk.
APM relies on incremental and iterative development with continuous learning being essential to the evolution of the optimal value (to the customer) within the constraints of time and cost. Thus, the 'iron triangle' of traditional project management is turned on its head, as shown in Figure 5 [12]

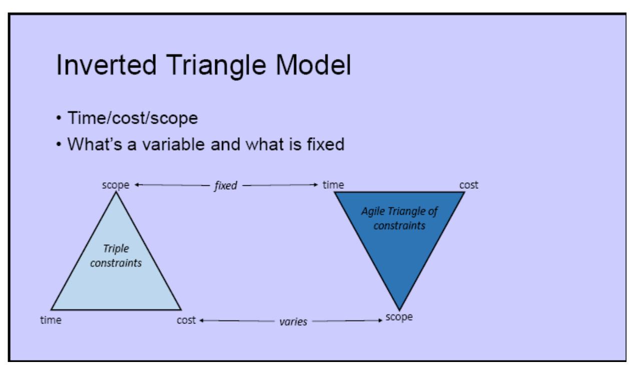

Figure 5 – Inverted Triangle Model

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In VM , we have a time box for a value study that could varies from 3 to 8 days (Exclude preparation and implementation),, And at the end of the agree duration we deliver workable solutions to improve the value of the subject understudy.

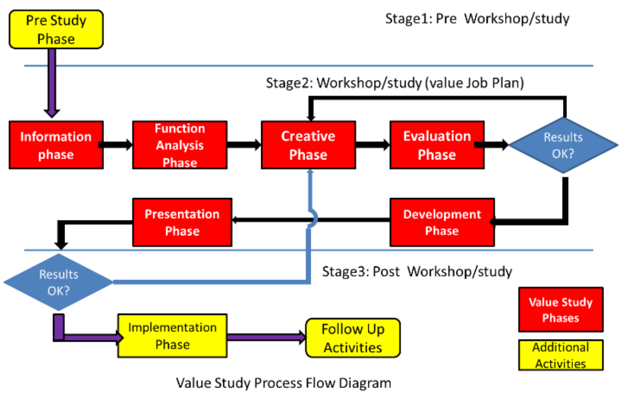

Figure 6- VM Job plan

4.Business people and developers must work together daily throughout the project[6].

One of the foundational concepts of the Value Methodology states that a multidisciplinary team is responsible to improve the value of a project, product, process, service, or organization through the analysis of functions. Teams assembled for VM studies are normally shaped as a task force, which implies the formation of a requisite group of subject matter experts who bring together a specific set of skills and disciplines to accomplish a specific goal. Team members may come from different areas within the same organization or outside it, such as clients, designers, or any other stakeholders who will bring the required set of knowledge expected to achieve the desired results [5]

The language (verb and noun) and the method allow people with totally different backgrounds, disciplines, and interests to work together and find common ground and "out of the box" solution [5]

5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.

In VM Study, special consideration should be given to the following points.

– Encouragement of cooperation within interdisciplinary teams in order to find solutions that find a consensus.

– Praise and recognition of the team's achievements;

– Improvement of interpersonal communications to promote common understanding.[5]

6. The most efficient and effective method of conveying

information to and within a development team is face-to-face conversation [6]

The application of VM within the context of a VM study is an intense, focused effort in which members of the VM study team, project team, the project owner, and user representatives come together in the same room as a single team possessing a single goal: to improve project value [5]

7.Working software is the primary measure of progress.

The word 'Working Software 'refer to working product or acceptable deliverables. In VM , It refers to workable solutions .

A major focus of APM is the early and sustained delivery of value, as seen by the customer or stake holders.

At the end each timebox recognizable (by the customer) value must be delivered; feedback and learning are core to the dynamic realization of customer value. At the end of the project the customer has received what they by then realize are their dynamically prioritized value deliveries, rather than what the supplier and they would have originally identified under traditional processes. The structure of APM value delivery is shown at Figure 6. This contrasts starkly with the traditional approach of value residing with the developer/ contractor until the customer is prepared to accept the phase/ project as complete [12]

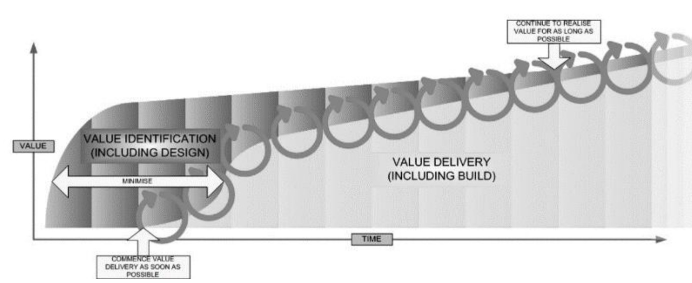

Figure 7-APM value delivery in Construction projects

8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.[6]

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In VM , to sustain a VM program ,we consider one of the key components of a successful VM program is the need for a strong implementation process that is both transparent and assigns accountability.

Many programs succeed in the performance of VM studies and identification of good potential alternatives, but they fail to successfully implement the recommended changes

9. Continuous attention to technical excellence and good design enhances agility. [6]

In VM , The VM study team can only be successful if the team not only has the necessary expertise and experience but is also familiar with the methods and tools.[5]

10. Simplicity—the art of maximizing the amount of work not done—is essential.[6]

In VM, this is what we normally do by working on eliminating unwanted functions or secondary function that has no value to the customer and are not required for the existence of basic functions [5].

11. The best architectures, requirements, and designs emerge from self-organizing teams.[6]

In VM Study, Special consideration should be given to the following points.

– Maintaining a skeptical view of the status in order to drive beneficial changes.

– Support for decision-making in the team; and,

– Responsibility for decision-making to lie with the team which developed the solutions.[5]

12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly [6]

In VM, during the implementation phase, we work on finding what could improve value of future VM studies.

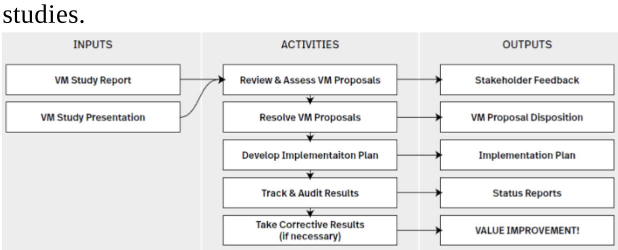

Figure 7. The inputs and outputs of the implementation phase

4. The importance of VM for Agile Practitioners.

1- The Value Methodology may be applied to anything that performs a function. Applications encompass construction, product design and manufacturing, supplies, transportation, health care, government, environmental engineering, business processes, and service industries. While the types of information and team structure vary, depending upon the VM study subject, the VM Job Plan is applied in the same sequential order in all cases. VM helps to find solutions for all kinds of challenges. Because VM is, by design, a multidisciplinary, multicriteria method that looks at both value and costs, it can solve problems and produce solutions that can easily be implemented.[5]

2- Everything that does not deliver value to the customer is omitted, the focus is on the outcome rather than the process.[7]

Examples of methods that fall under agile are eXtreme Programming (XP), Scrum, Crystal Clear, Feature Driven Development (FDD), Lean Software Development, Dynamic System Development Methodology (DSDM) and Kanban. New research shows that organizations that use agile most often apply Scrum, or in 52% of cases [7,8]

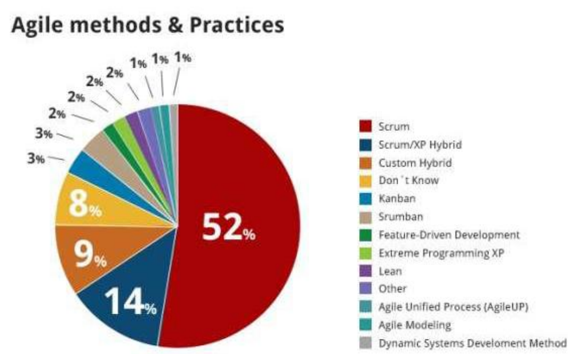

Figure 8. Agile Frameworks

Scrum roles A Scrum team consists of 3 roles, **Product Owner (PO),** Team Member and Scrum Master (SM). All members of a scrum team have different roles in the management and supervision of projects. All roles are necessary for the Scrum process to work efficiently. Scrum teams are self -controlling and they typically consist of people with various professional backgrounds.

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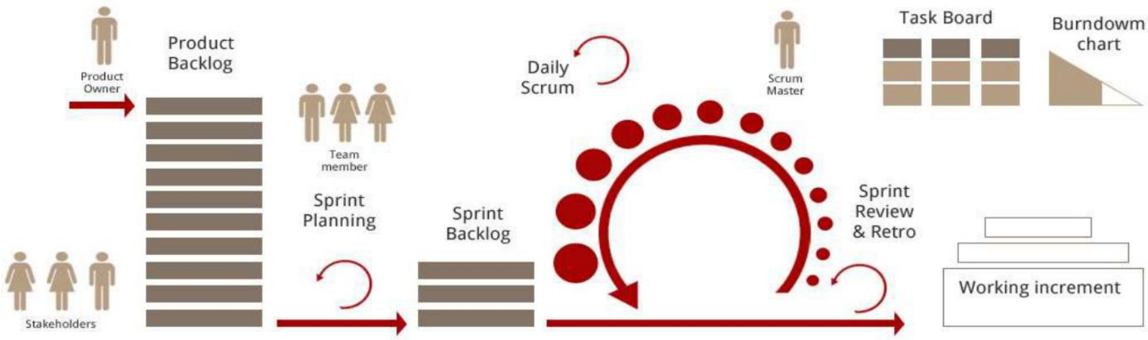

Figure 9. Scrum cycle

Each and every team has all the knowledge that is considered to be necessary to execute the project, and therefore the team doesn't need to rely on other input for the work [7,9].

The role and responsibility of the PO, according to Scrum The PO role is one of the most important roles in Scrum and often the most difficult one. He is responsible for the financing of the project during its life-cycle and he puts forwards the requirements and objectives of the project. His most important role is to maximize the output of the team, and the output for each task, based on Return on Investment (ROI). Milanov and Njegus (2012) define a simple formula that is frequently used to calculate the feasibility in Scrum. They claim that this calculation is very important for the team and for the managers. The formula is ROI = Business value/Effort. Business value and effort reflects the assessment of the tasks on the product backlog. The ROI of projects depends on many variables, such as quality of the product, the features, the services, and the content of the product. Also, market assessment, good market strategy, contracts, marketing etc. The PO therefore has a clear role regarding profit or loss from a direct product. He is nevertheless **supposed to maximize the value of the tasks at hand during each phase**, maximizing the value for the lowest number of working hours [7,10].

In agile, the product owners create the backlog for and with the team. The backlog helps the teams see how to deliver the highest value without creating waste.

A critical success factor for agile teams is strong product ownership. Without attention to the highest value for the customer, the agile team may create features that are not appreciated, or otherwise insufficiently valuable, therefore wasting [6}

That’s why it’s highly recommended that PO get familiar with VM to get the required skills that allow playing this role in a professional manner.

VM main role is to bridge the gap between the current design and the customer expectations to avoid dissatisfaction at delivery phase. And to work on achieving what the client considers with high value for him.

5. The Agility of Value Methodology:

In order to understand how we can achieve agility we can take a look at the further definitions that are available, especially from sources that look into agility from a perspective that is wider than that of just one team [11]

One of these attempts to define agility in a larger context took place in 2005, when Cockburn gathered a group of project managers together to discuss agility within a project context and from a project management viewpoint. This gathering resulted in the Declaration of Interdependence (DOI), which links people, projects, and value with agile and adaptive approaches. The Declaration of Interdependence states: [11]

We are a community of project leaders that are highly successful at delivering results. To achieve these results:

• We increase return on investment by making continuous flow of value our focus.

• We deliver reliable results by engaging customers

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in frequent interactions and shared ownership.

• We expect uncertainty and manage for it through iterations, anticipation, and adaptation.

• We unleash creativity and innovation by recognizing that individuals are the ultimate source of value, and creating an environment where they can make a difference.

• We boost performance through group accountability for results and shared responsibility for team effectiveness.

• We improve effectiveness and reliability through situationally specific strategies, processes, and practices.

The 6 rules of DOI ,could be summarized as :

1- Increase ROI.
2- Deliver reliable results by engaging customers.
3- Expect uncertainty.
4- Unleash creativity and innovation.
5- Boost Performance
6- Improve Effectiveness and reliability

The Question now : Could we consider the Value Methodology as an Agile approach ?

1- Increase ROI:

Value Methodology works on improving ROI . The calculation of ROI before and after VE .
VM programs use ROI as a way of communicating its performance [5].

2- Deliver reliable results by engaging customers:

VM programs are better positioned for success when they align with customer and stakeholder interests. After all, VM should be focused on the voice of the custom- er; therefore, isolation is dangerous.[5]

3- Expect uncertainty:

The word ‘RISK’ was mentioned 282 times in VM guide because VM specialists understand than uncertainty could exist in each phase and all VM teams & specialists should be skilled enough to deal with it.

4- Unleash creativity and innovation.

The VM Job Plan includes the following phases: 1. Preparation 2. Information 3. Function Analysis 4. Creativity 5. Evaluation 6. Development 7. Presentation 8. Implementation [5]

A main phase called creativity is dedicated to unleash creativity and innovation .
(Before 2020, the VM job plan was composed of 6 main phases starting by information till Presentation, now the pre and post workshop phases are named preparation and implementation)

5- Boost Performance

In VM guide , the word performance was mentioned 193 times . In VM we boost performance not only through group accountability for results and shared responsibility for team effectiveness which already exist because VM is a cross functional (multi -disciplinary) team approach, but as per VM guide ,Performance is defined as the capacity of a project, product, process, service or organization to fulfill its functional requirements. Performance can be measured quantitatively or qualitatively. The level of desired performance should be determined by the customer or user.
Measuring the impact on ‘Performance’ is normally a part of the evaluation phase to filter the ideas and select only what have positive impact on performance for the development phase.

6- Improve effectiveness and reliability through situationally specific strategies, processes, and practices:

‘Improve/improvement’ words are mentioned 155 times in VM guide 2020, which highlight that the purpose of every VM study is to generate proposals that will **increase the value** of a given project, product, process, organization, or service.[5]
The improvement could be in strategies, processes, or practices. It varies according to the subject under study.

In the information Phase:

One of the key activities of the Information Phase is to transform the “raw” information into a form that the VM study team can use to focus them on **value improvement**. This effort ultimately assists the team in identifying areas of opportunity and allocating the most pertinent information to functions in the subsequent phase.[5]

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In Function Analysis:

We allocate resources to functions. Project information related to cost, performance, schedule, risk, and other information (such as size, weight, etc.) is associated with specific functions to identify an understanding of these relationships and enhance the team's understanding of **value improvement opportunities.**

Then we prioritize functions for value improvement. Ultimately, the objective of function analysis is to prioritize specific functions for **value improvement**. These will serve as the focus for the Creativity Phase and aidthe team in thinking laterally about potential alternative solutions.[5]

In the Creativity Phase:

Creativity techniques are typically employed to identify numerous ideas on each function **requiring improvement.** Generating a large quantity of ideas is the goal, rather than the quality of the ideas. A large quantity of ideas leads to a greater number of quality ideas. A key element of creativity is to avoid evaluating ideas generated during the creative process.[5]

In the Evaluation Phase:

We Select ideas for further development. Ideas with the greatest **value improvement** potential are normally chosen to be developed with further study, testing, refinement, and information gathering. [5]

In the Development Phase:

We assess performance and quality impacts Once the technical feasibility and costs have been determined, the VM study team should have a fairly good idea whether the VM proposals will provide **an improvement in value.** The next step is to assess the anticipated impacts that the VM proposal will have on project performance and/or quality.[5]

In The Presentation Phase:

After the completion of the Development Phase, the VM proposals developed should be richer in information regarding their power **to improve the value** of the subject under study. The presentation phase represents the time to introduce those VM proposals to stakeholders and decision makers who were not part of the VM study.

Results :

The comparative analysis used to score the agility of Value Methodology could be summarized in the following table.

Evaluation Criteria		Agile Mindset	Value Methodology
4 Values of Agile Manifesto	Individuals over processes	High	Medium
	Software over Documentation	High	Low
	Responding to changes over plan	High	High
	Customer collaboration over contract	High	Medium
12 Principles of Agile Manifesto	Customer Satisfaction first	High	High
	Welcome changing	High	High
	Delivery Frequently	High	High
	working together	High	High
	Motivated Team	High	High
	Face to face	High	High
	Working software	High	N/A
	Constant Pace	High	Low
	Good Design	High	N/A
	Simplicity	High	Medium
	Self-organization	High	Medium
	Reflect & Adjust	High	Medium
6 Rules of DOI	Increase ROI	Medium	High
	Deliver Reliable Results	High	High
	Expect Uncertainty	High	High
	Unleash Creativity	Medium	High
	Improve Reliability	High	Medium
	Boost Performance	High	High
Other VM Principles	Improve Value	Medium	High
	Function Oriented	Medium	High
	Visualization	High	High
	Depend on Management Support	High	High
	Clear Job Plan	Low	High
	Resources optimization	Low	High
	Time Boxing	High	High

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6.Conclusion:

In conclusion, this paper is to presents the results of a comparative analysis to score the agility of value Methodology according to the 12 agile principles and 6 rules of Agile Declaration of interdependence. And to introduce the VM for Agile practitioner as a good approach for value improvement .

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Enhancing the Performance of Value Methodology Using Key Performance Indicators and Critical Success Factors

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Abstract:

Value methodology (VM) enhances the value of different sectors. However, presently there is no tool available to measure the performance of VM. Hence, this research was aimed to investigate the key performance indicators (KPIs) of VM job plan. A rigorous measurement on the performance of VM studies is likely to improve the implementation of the VM and enhance the confidence of clients about their investment in it. We also found that Critical success factors can be used in value methodology workshops to determine the client value system, which in turn is critically important to the briefing process and the successful delivery of construction projects. This study aims to identify the key indicators and Critical Success Factors (CSFs) for evaluating the performance of VM practices in construction industry. An acceptable VM study must follow VM job plan entirely (includes all phases of workshop activities) will require proof via results of various phases. All these results must be measured as what you cannot measure you cannot manage. The present work attempts to identify critical success factors (CSFs) influencing the performance of development projects based on their key performance indicators (KPIs). We should apply the proper technique to achieve the expected outcome of the Value Methodology.

Key words: Value Methodology, key performance indicators, Critical success Factors.

Introduction:

Value is defined as a fair return for something exchanged. It can be expressed mathematically by dividing the functionality achieved in the project over the project's cost (SAVE International, 2007). The VM can be applied to almost any topic and at any stage of planning, development, execution or operation, with tremendous results for project improvement. VM is a method experienced in management that has an organized approach. It has a systematic and cooperative framework for evaluating functions and processes in order to achieve the least costly function that is optimal. In order to identify how effective these studies are in enhancing the efficiency, functionality, reliability, benefits and cost effectiveness, evaluating the performance of value management studies is an important necessity.

In order to reach this objective, we need to define some suitable, easy to measure and clear key performance indicators. There are many indicators that can be used to evaluate the performance of implementation the VM. The indicators with the heights importance weight can be expressed as a key performance indicator (KPIs). Critical success factors (CSFs) are factors that influence the success and promote the achievement of a project objective (Fadun& Saka,2018). Performance measurement and critical success factors are urgently required in VM studies to improve decision making processes and to ensure returns of investment on VM studies. There are various techniques and phases to obtain an effective VM study implement.

Value Methodology Workshop process:

SAVE International VM provides a very powerful means to establish best value solutions. Kaufman (1998) stated that these stages are as a job plan which is a well-organized approach including sequenced stages that help the VM team to answer questions and resolve the project's problems and challenges. One of the main characteristics of VM is that an approved job plan must be followed.

Figure 1 shows the common stages and process that would be followed in a typical VM study (Olawumi et al.,2016). Generally, main seven stages or phases are common in all VM studies which are stated in following

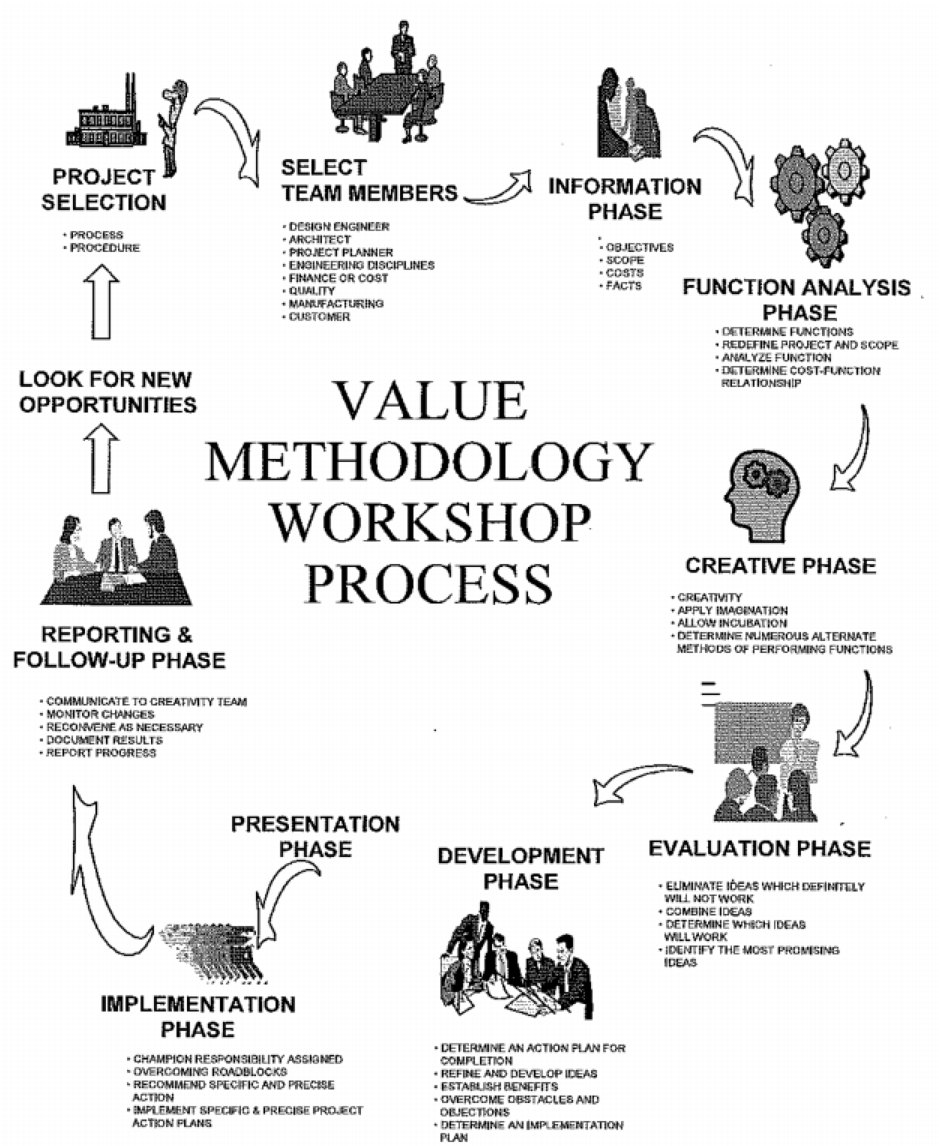

Figure 1. Value methodology workshop process.
Olawumi, T. O., Akinrata, E. B., & Arijeloye, B. T. (2016).

VM Methods and Tools:

Several methods and techniques can be applied during VM process according to the specifications and conditions of the project (Mesbah,2014). Table 2 shows some methods and techniques can be used in the VM study. It must be considered, there are not specific standard or unique tools to be used in VM process, these techniques are described in the following various innovative techniques can be created and designed by the VM team based on specifications of the project to evaluate the new ideas and alternatives which among them, “Brainstorming”,” function analysis (FAST)”, “Life cycle cost analysis” and “Evaluation matrix “are most important techniques that are always used in VM process(Mesbah,2014).

Table 1: Common Methods of VM Process
Mesbah, M. (2014)

Methods	Prominent feature
function analysis	Determining the function and objectives of project, each idea or alternative and then discussing about them among team
FAST chart	
life cycle cost analysis	Estimating all costs over life cycle of the project and then evaluating the new alternatives based on this lifecycle cost
Brainstorming	Rely on creativity thinking, Group activity, Group discussion, decision making based on group's idea
Synaptic technique	
Hierarchy diagram	Breaking down a project to sub parts and elements to focus them in detail
Value index	calculating value index based on cost and value of the project
advantages/ disadvantages method	Using advantages disadvantages method to evaluate each idea and also the project.
Risk Analysis	Determining the risks, threats and hazards of each alternative to evaluate them.
Simple multi-attribute rating technique (SMART)	Determining some simple explanation of the project to discuss about it to evaluate the project or each alternative
Time, cost and quality triangle	Evaluating a project's time, cost and quality
Stakeholder analysis	Determining the needs of stakeholder to evaluate project.
Issues Generation & Analysis	Defining main issues related to project to evaluate each alternative.
SWOT analysis	Review of alternative materials 'strengths, weaknesses, opportunities and threats'(SWOT). These specify the objectives of the project and identify all internal and external factors that will either be favorable or unfavorable in a project.
Assessment metrics	using special matrix such as weighted matrix and environment assessment matrix to score each alternative
Lever of value	Evaluating project based on dividing project in several value levels
cost estimation	Estimating the total investment cost each alternative
Spatial adjacency programming	Evaluating project through especial programs and computer algorithm based on knowledge system
Logical Framework	
Cost-Benefit analysis (B/C)	systematic approach in comparing the quantifiable benefits and costs for a particular project or indeed the overall value of the contributory components or sub-components

Key Performance Indicators:

In 1998, the KPI Program was propelled by the UK Best Practice Program. This program is upheld by the government, through national and regional offices. The motivation behind the KPI program is to empower estimation of project and organizational performance throughout a large number of projects of the construction industry to monitor the performance of the industry (Costa et al.,2004).

To choose the right KPIs many researches and studies are conducted to determine KPIs such as has presented a list of different techniques that can be used to select KPIs. Khalelovich (2016) presented seven steps for implementing KPIs as shown in Figure 2, which will help us determine which KPIs to use, how to collect and manage information, and how to report results, namely: Determining what should be measured; Data collection; Calculation of KPIs; Results report; Analysis of the results; Take appropriate action and measure again

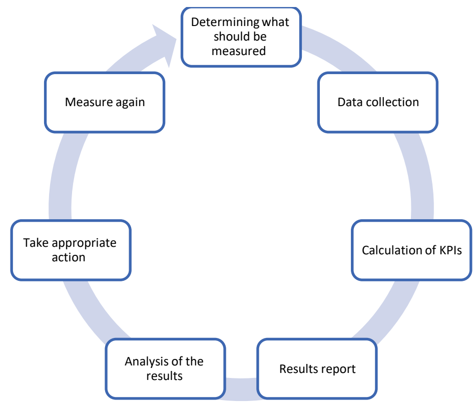

Figure 2. Steps for implementing key performance indicators.
Khalelovich, A. D. (2016).

Critical Success Factors (CSFs):

The term "Critical Success Factors" (CSFs) was initially used in the context of information systems and project management in the early 1980s by Rocart (1982). Since then, the term has been widely and popularly used among researchers to gauge project management success in their research. Knowledge of project success criteria and critical success factors is often reflected in project management as an important component to improving project implementation effectiveness (Hanafi, & Nawi, 2016). In (1989) it was indicated that many reasons for project success can be found. In the presence of many critical success factors (Al-Zahrani, 2013).

Research Methodology:

Previous measurements on the performance of VM studies have focused on reducing costs and improving project functionality, especially the savings achieved by implementing the proposals of VM studies. In this study we will present best practices of academic and practical side of different key performance indicators and critical success factors used for measuring the performance of value methodology in their different stages and are considered as critical for the successful implementation of VM workshops. Figure 3 shows relationship between stages and phases of value methodology job plan.

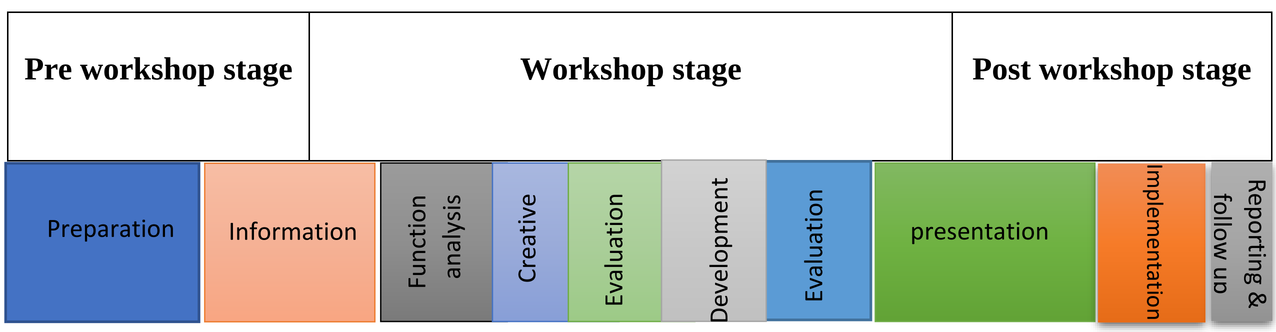

Figure 3. Relationship between stages and phases of value methodology job plan.
Source: Researchers

The relationship between CSFs and KPIs is vital, as illustrated in figure 4. If you get the CSFs right it is very easy to find your winning KPIs.

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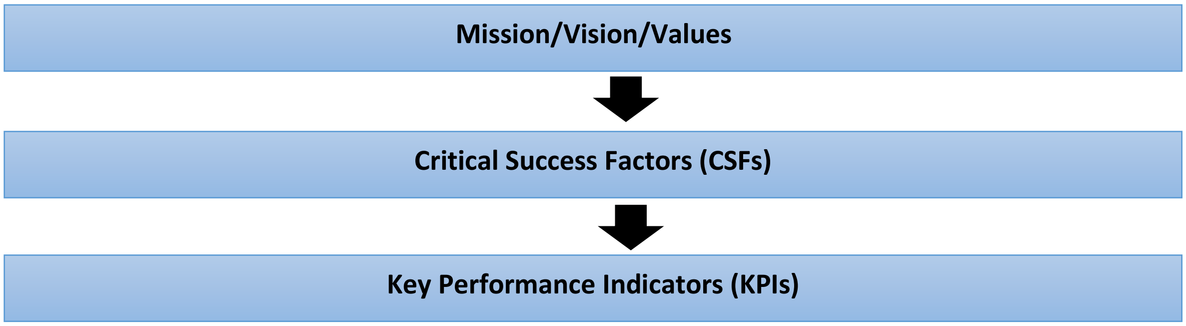

Figure 4. Relationship between Key Performance Indicators (KPIs) and Critical Success Factors (CSFs).
Source: Researchers

Table 2: List of KPIs& CSFs in VM job plan.
Source: Researchers

objectives	VM Job Plan	Critical Success Factors (CSFs)	Key Performance Indicators (KPIs)	VE Questions
Pre workshop Stage				
- Identify goals and objectives. Determine scope. Collect useful data. Determine team composition. - Identify customer attitudes.	**Preparation**	Obvious goals & objectives. Determining scope. Preparing value or data models Relevant departments' support. Qualification of facilitator Having a good clearly workshop preparation checklist VM knowledge of participants Clear objectives of workshop. Client's participation.	Meeting Stakeholder needs. Satisfaction of venue. Time. Percentage of feasibility of doing the VM workshop.	What are the goals and objectives?
workshop Stage				
Collect and gathering data. Get through understanding	**Information phase**	Background information. collected (during workshop). Number of related documents analyzed. Interaction among participants.	Time involved in gathering information. Number of VM team member. Satisfaction of the techniques used. No. of value models prepared.	What is it?
Define function	**Function analysis phase**	Primary function identified. Interaction among participants. Create a shift thinking. Create natural team bonding; not forced. Create understanding. Using suitable tools.	Time. No. of functions identified. Percentage of achieving levels of abstraction	What does it do?

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Create ideas	**Creative phase**	Interaction among participants. Let all team members participate.	Time. Number of ideas generated per function. Percentage of the functions selected to creativity out of the entire analyzed functions. Average ideas generated by each participant. Re-work.	What else will perform the function?
Evaluate ideas	**Evaluation phase**	Efficiency of idea generation Evaluating each alternative.	Time. Function. Performance. Quality. Value. Satisfaction of the techniques used. No. of successful ideas.	What idea will perform the function?
Develop alternates	**Development phase**	Recognize cost information. Financial assessment. Economic principles. Present & future consideration. The Methodology used	Time value of money. Order of change. Function. Performance. Cost. Satisfaction of technical audience. Satisfaction of business audience. Impact on Long Term Benefits. Return over investment.	What will alternates cost?
Sell ideas	**Presentation phase**	-Discuss expected benefits -Ask for action.	Time. percentage of changes presented. Function. Indicator's schedule. Client's satisfaction. Participant's satisfaction Facilitator's satisfaction Quality of the report Cost	What is the specific change? How does it perform the required functions?
Post workshop stage				
Support implementation	**Implementation**	-Follow up implementing the proposed ideas -Improving communication and understanding among participates	Satisfaction of implementation. No. of Recommendations. Completeness and implementation of VM six-phase job plan.	Will the results meet the customer's expectations?

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Table 3: The relationship between critical success factors and key performance indicators as inputs and procedures and outputs.
Source: Researchers

CSFs	KPIs		
Pre workshop Stage			
Obvious goals & objectives. Determining scope. Preparing value or data models. Relevant departments' support. Qualification of facilitator VM knowledge of participants Client's participation	Meeting Stakeholder needs. Satisfaction of venue. Time.	preparation	Input
Having a good clearly workshop preparation checklist Clear objectives of workshop.	Percentage of feasibility of doing the VM workshop.		
workshop Stage		Information phase	Procedures
Background information. collected (during workshop). Number of related documents analyzed. Interaction among participants.	Time involved in gathering information. Number of VM team member. Satisfaction of the techniques used. No. of value models prepared.		
Primary function identified. Interaction among participants. Create a shift thinking. Create natural team bonding; not forced. Using suitable tools.	Time. No. of functions identified. Percentage of achieving levels of abstraction	Function analysis	
Interaction among participants. Let all team members participate.	Time. Number of ideas generated per function. Percentage of the functions selected to creativity out of the entire analyzed functions. Average ideas generated by each participant. Re-work.	Creative phase	
Efficiency of idea generation Evaluating each alternative.	Time. Function. Performance. Quality. Value. Satisfaction of the techniques used. No. of successful ideas.	Evaluation phase	
Economic principles. Present & future consideration. The Methodology used.	Time value of money. Order of change. Function. Performance. Cost. Satisfaction of technical audience. Satisfaction of business audience. Impact on Long Term Benefits. Return over investment.	Development phase	
Discussing expected benefits. Asking for action.	percentage of changes presented. Function. Indicator's schedule. Client's satisfaction. Participant's satisfaction Quality of the report Cost	Presentation phase	
Post workshop Stage		Implementation	Output
Follow up implementing the proposed ideas -Improving communication and understanding among participates	Satisfaction of implementation. No. of Recommendations. Completeness and implementation of VM six-phase job plan.		

Figure (5) illustrates the proposed model showing the relationship between CSFs and KPIs to measure the performance of value methodology, and this is shown by expressing the relationship between them using a flow chart, as we proposed that pre workshop stage is input, and workshop stage as procedures, finally post workshop as output.

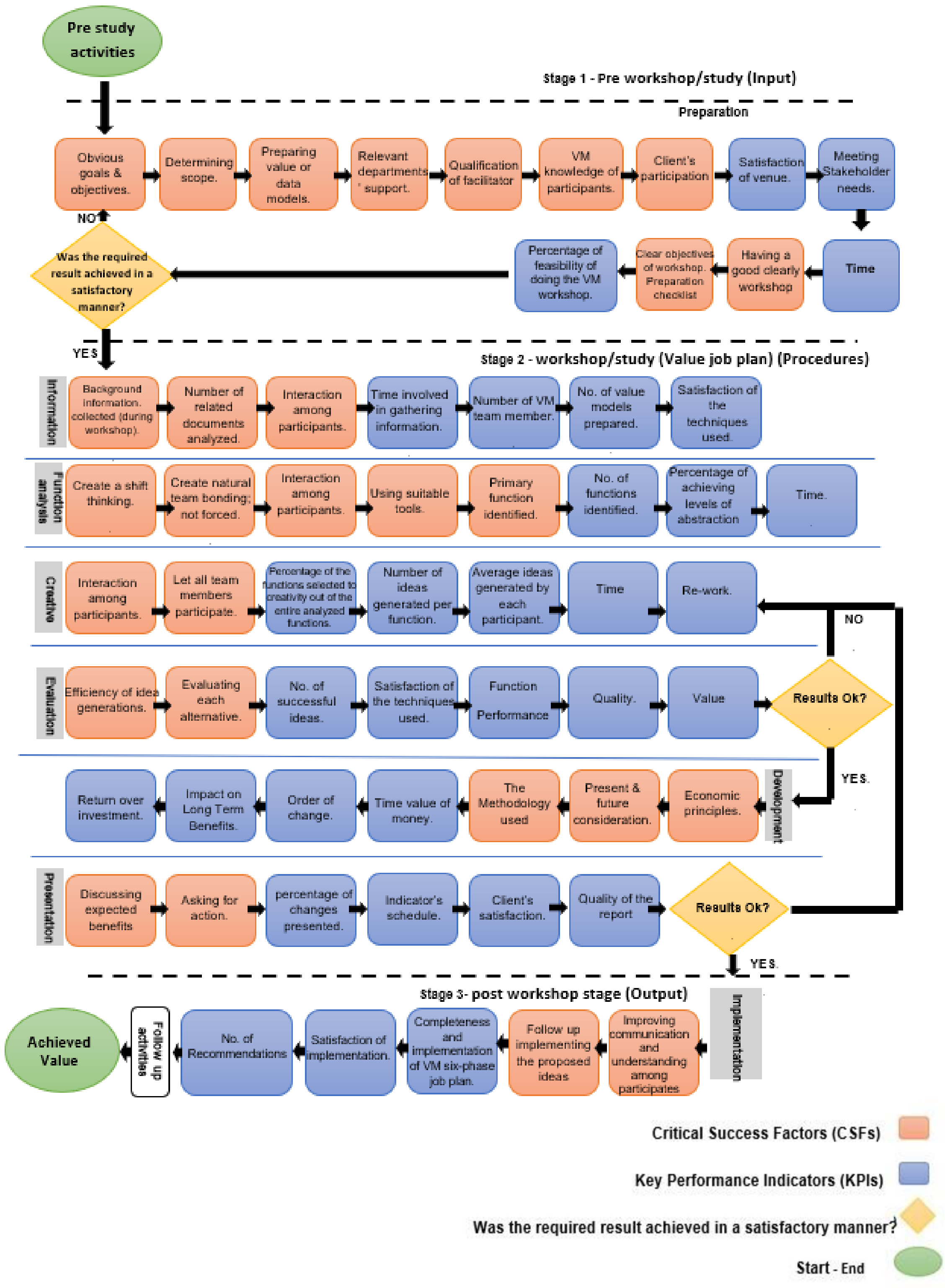

Figure 5. The proposed model illustrates the relationship between Critical Success Factors (CSFs) and Key Performance Indicators (KPIs) to measure the performance of the value methodology.
Source: Researchers

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Conclusion:

Value Methodology is a systematic framework aimed at studying and assessing all activities carried out in a plan. It's one of the most powerful ways to accelerate economic growth by rising value. Mentioned in the paper there is a positive relationship between each of the CSFs and KPIs for evaluation the performance of value methodology, as critical success factors translate into the impact of KPIs, the study identified that we can enhance the performance of value methodology job plan as what you cannot measure you cannot manage.

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Design of sustainable buildings through Value Engineering Methodology

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ABSTRACT Sustainability of current and new developments has become a major issue facing policymakers, developers, city and urban planners, and designers worldwide. Each new construction project entails, among others, the use of natural materials and the consumption of energy, which have a tremendous impact on the built environment over decades, and their environmental consequences only become fully apparent to future generations. The impact of construction projects on environment is especially significant in developing countries. The deterioration of building systems – including building materials – attributes to the economic, cultural and environmental problem, which is related to and affects the sustainable development of any society. In addition, developing countries have suffered for a long time from overlooking or underestimating the basic requirements that must be considered for designing sustainable developments. This article attempts to propose a practical solution for designing sustainable developments by focusing on the building as the primary unit. *First,* this article presents the requirements for designing a sustainable building, as well as the current process for selecting sustainable building systems and materials. *Second,* this article describes the Value Engineering program, including the different phases of the job plan. Finally, this article proposes a method for improving building sustainability. The proposed method utilizes the job plan of the Value Engineering program – together with a database that contains up-to-date information on construction systems and materials – as a gear for studying and analyzing the sustainability requirements.

Keywords: sustainability; Value Engineering; built environmental; job plan; building system; building materials; LEED Rating System

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Collaborate with Suppliers… work in multidisciplinary TEAM OUTSIDE company boundaries

Paola Mainardi, Irene Martinelli, Emanuele Checcacci

Abstract

After several year of contrition due to oil price reduction, the Oil & Gas market is recovering with new investments and projects, either public either private. We named a few of 2019, as the East Natuna Block (Natuna D-Alpha) Project in Indonesia with $30bn, Pengerang Refinery and Petrochemical Integrated Development (RAPID) with $27bn in Malaysia and the Zhoushan (Zhejiang) Refinery and Petrochemical Complex (Phases 1 and 2) in China with an investment of $25bn.

Despite it, main equipment suppliers are playing in a very competitive market, with specific focus on capex and opex cost.

Baker Huges Nuovo Pignone is investing in new technology and in cost out program to meet Customer needs and maintain the company solidity. Multidisciplinary team with different expertise from different functions, such as Engineering, Supply Chain and Product Leadership are putting in place to innovate and to find cost out ideas to be implemented following different methodology such as 3P, Value Methodology, Triz, etc.

The collaboration with Suppliers is crucial to extend the knowledge and learn outside Company boundaries.

In fact they are involved in the design basically with 2 approach: built to print or built to specification, that cause a different level of impact in selecting solutions and therefore in cost.

For this reason, Suppliers have been involved in several waves of worldwide conferences ideas contest or on specific Customer projects, to find alternative way to produce or design to reduce costs, without impact on safety and quality.

The paper will describe two real business cases where Suppliers have been involved in Value methodology workshops. One Supplier design with built to print approach, the other with built to specification. Advantages and disadvantages will be highlighted with a final guideline on how and when it is value added the involvement of a supplier.

Theoretical model… team definition and supplier involvement

Value Methodology team must be multidisciplinary, and it is composed by 5/7 members.

While selecting team members, a key driver for delivery high results is to mix people considering the following matter:

- gender diversity (male/female)
- different level of expertise (junior vs senior engineer)
- Generation (Baby boom up to 1965, X generation from 1966 to 1980, Millennial from 1981 to 1995)

Based on several workshop, BH TPS Value specialists define an internal guideline to support the company in team definition.

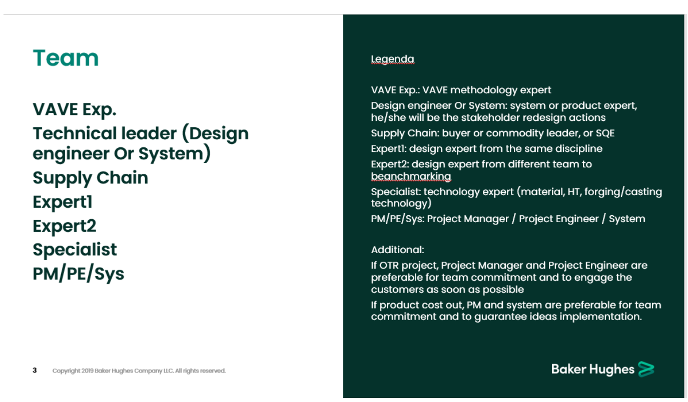
In details they suggest:

- VAVE Exp.: VAVE methodology expert
- Design Engineer Or System: system or product expert, he/she will be the stakeholder redesign actions
- Supply Chain: Buyer or Commodity Leader, or SQE
- Expert1: Design Expert from the same discipline
- Expert2: Design Expert from different team to benchmarking
- Specialist: technology expert (material, HT, forging/casting technology)
- PM/PE/Sys: Project Manager / Project Engineer / System

In additional:

If OTR project, Project Manager and Project Engineer are preferable for team commitment and to engage the customers as soon as possible

If product cost out, PM and system are preferable for team commitment and to guarantee ideas implementation.



In general team members are selected internally with no involvement of suppliers.

Typically, in the development of a project they can be involved in 2 different process:

- Built to print, in which suppliers are responsible to produce products according to Baker Hughes exact specifications and drawings.
  It requires more internal effort, especially as engineering hours. On the other side the domain knowledge remains inside the company and it gives the flexibility to put in competition and select the appropriate suppliers

- Built to specification, in which suppliers receive an order with a specification listing the main parameters for the system project. They have degree of freedom to utilize their design expertise and manufacturing skill to manufacture the part they will be supplying to their Customer.
  From a business perspective, it requires less engineering hours and it does not require internal resources to cover competencies outside the core business. In addition, business upload the responsibility and liability of the quality of the product outside on supplier.
  On the other side, business loose the domain expertise and familiarity with cost levers. In worst cases they can occur in sole source relation that require high effort to introduce a new supplier competitor.

In both cases, they represent a source of new cost out ideas, based on their design expertise, manufacturing process and capability.

For this reason, at least bi-yearly they have been requested by BH to submit ideas on legacy products with international suppliers' conference and contest to implement new solution on the market. In general, many ideas are collected in short term. On the other side it is a "front end" process that required a lot of effort to validate internal to the business, even if the ideas are incremental and not disruptive. Moreover, ideas are not born by a co-activity and in general they expire quickly.

To cover this gap, Baker Hughes Value methodology specialist suggest to involve supplier also in Value Methodology workshop as team member.

The hypothesis is that Supplier can help the team to deeply understand the system/product functions. This can drive in implementing new solutions inside their degree of freedom and deliver cost out for both side.

A potential risk is identified because the supplier could push on new proposal inside their capacity and capability, pushing back on new disruptive solutions that can wear away their business and margin.

Both approaches, built to print and built to spec, has been tested to identify advantages and disadvantages and give inside an internal guideline for VM supplier involvement.

Baker Hughes real cases of combination

Case 1… built to specification

Scope of work of this VaVe session is focused on cladding, which refers to components that are attached to the primary structure of a building to form non-structural, external surfaces.

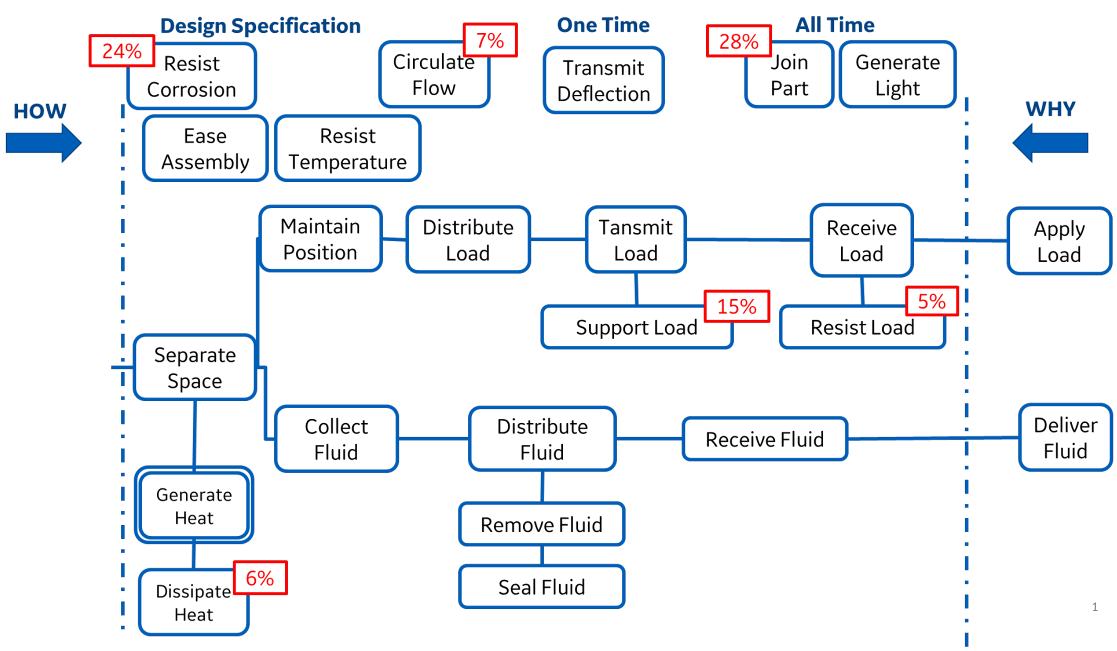
Considering the fact that the project of this particular component is developed with supplier, which owns details about design and production process, we considered strategic decision of inviting supplier as well to this VaVe session.

Thanks also to supplier's contribution, cladding functions have been identified, FAST diagram generated and during creative phase, over 600+ ideas have been generated.

Component name/ Part number	FUNCTIONS	
	Verb	Noun
Louvre Pannellatura parete	PROTECT	ENVIRONMENT
Louvre Pannellatura parete	REMOVE	HEAT
Louvre Pannellatura parete	RESIST	CORROSION
Louvre Pannellatura parete	SEPARATE	SPACE
Louvre Pannellatura parete	RESIST	LOAD
Louvre Pannellatura parete	PROVIDE	LIGHT
Louvre Pannellatura parete	MAINTAIN	POSITION
Louvre Pannellatura parete	ALLOW	DEFLECTION
Louvre Pannellatura parete	EASE	ASSEMBLY
Baraccatura	SUPPORT	LOAD
Baraccatura	RESIST	CORROSION
Baraccatura	JOIN	PART
Baraccatura	RESIST	TEMPERATURE
Baraccatura	TRANSMIT	LOAD
Baraccatura	ALLOW	DEFLECTION
Bulloneria	RESIST	CORROSION
Bulloneria	JOIN	PART

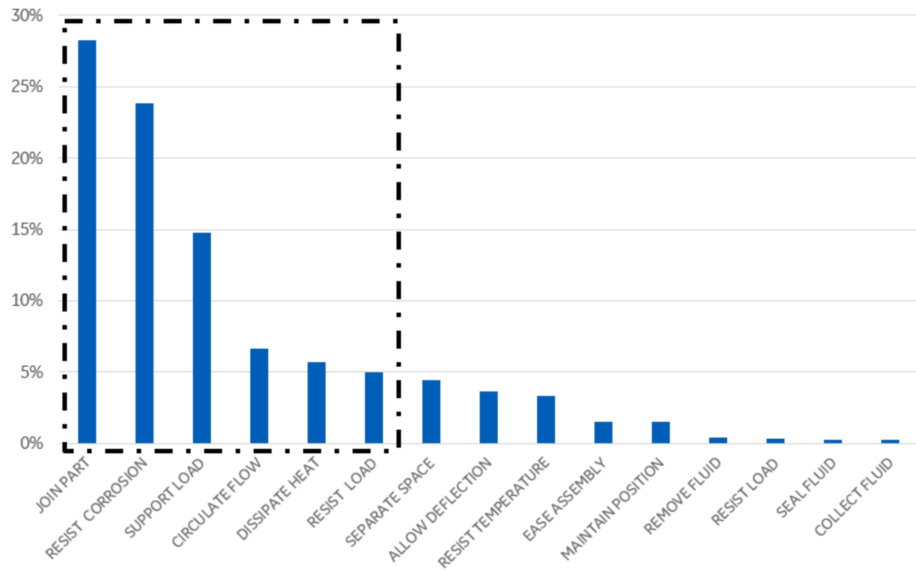
Pannellatura parete	PROTECT	ENVIRONMENT
Pannellatura parete	RESIST	CORROSION
Pannellatura parete	SEPARATE	SPACE
Pannellatura parete	RESIST	LOAD
Pannellatura parete	MAINTAIN	POSITION
Pannellatura parete	EASE	ASSEMBLY
Pannellatura parete	ALLOW	DEFLECTION
Gronde	COLLECT	FLUID
Gronde	RESIST	CORROSION
Gronde	RESIST	LOAD
Gronde	JOIN	PART
Pluviali	REMOVE	FLUID
Pluviali	RESIST	LOAD
Pluviali	RESIST	CORROSION
Pluviali	JOIN	PART
Sealing	RESIST	CORROSION
Sealing	SEAL	FLUID
Sealing	ALLOW	DEFLECTION
Torrino di Ventilazione	CIRCULATE	FLOW

Functions identified for each cladding sub-component



FAST for Cladding

Function	%
JOIN PART	28%
RESIST CORROSION	24%
SUPPORT LOAD	15%
CIRCULATE FLOW	7%
DISSIPATE HEAT	6%
RESIST LOAD	5%
SEPARATE SPACE	4%
ALLOW DEFLECTION	4%
RESIST TEMPERATURE	3%
EASE ASSEMBLY	1%
MAINTAIN POSITION	1%
REMOVE FLUID	0.42%
RESIST LOAD	0.33%
SEAL FLUID	0.28%
COLLECT FLUID	0.24%
PROVIDE LIGHT	0.00%
TRANSMIT LOAD	0.00%



Pareto of Functions Identified

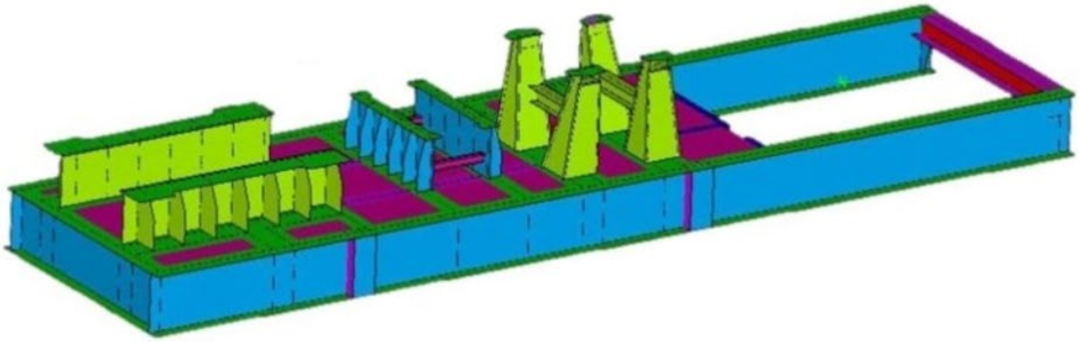
Following four proposals have been deepen analyzed and relative business case presented to leadership for approval and funding. In case of implementation of all the four proposals below, a total saving of 15% would be reached.

- New technology and design for louvre with wings welded and pressed instead of fixed with rivets
- Enlarge roof and open upper area, to ensure natural ventilation avoiding dedicated ventilation tower
- Carbon steel S235JR + HDG versus corrugated sheets for roof and walls with carbon steel + zinc coating
- Support struct reduction related to new louvre design and layout optimization

All the other ideas generated will be deeply analyzed after the workout.

Case 2… built to specification

For the Built-to-Print design we faced a baseplate where Gas Turbine or Electric Motor and their auxiliaries are installed on.



Typical baseplate for EM & auxiliaries

source: https://www.researchgate.net/figure/Rotor-mode-shape-due-to-the-supporting-structures_fig3_282319617

We performed the VAVE workshop internally and the evaluation phase with Suppliers separately (three Suppliers where involved separately) and finally envelop their feedback for each proposal.

The ownership of the design in this case, different from what was done in the Built-to-Spec case, allow us to involve more than one Supplier and moreover to perform should-cost for the baseplate design (performed with a commercial analytic 3D costing tool called LeanCost internally developed and customized) in order to negotiate objectively the benefits of each proposal with each Supplier.

Also, in this case ideas where proposed and evaluated with Suppliers based on their capability. For more disruptive ideas dedicated Manufacturer will be identified.

Conclusions and next steps

Advantages of having supplier on board is, for sure, their deep knowledge on materials, design and production processes used to realize current cladding design.

They also share insight and benchmarking from other products that can have similar functions. Another positive aspect is that the supplier formalizes saving estimation during the workout, so that the business cases of proposals increases in accuracy with respect to standard VaVe.

On the other hand, the presence of supplier sometime and somehow is limiting the possibility of exploring most destructive solution, in particular the ones that are outside supplier’s comfort zone and capability.

The proposal outside supplier’s capability will be further investigated internally and with alternative suppliers, with different capability.

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Value Engineering Supported Software Development for Measuring the Unity Between Players

Ariella Janka Tarjani, Istvan Tarjani and Roland David, JD

Abstract

This study describes the development of a software with the support of value engineering. Using the Value Methodology (VM) in software development has a great perspective for two main reasons. These are the large number of software module developments worldwide and the high level of innovation in software development. The software development industry is currently exploding. With the advancement of the IT sector, software is increasingly needed for more and more purposes. Such rapid development generates increasing difficulties in the labor market, more and more IT professionals are needed everywhere, therefore it is essential to make software development processes more efficient.

The software presented in the paper has no similar predecessor and holds the future of training players in team sports. The study introduces the training tool and its associated software product, addresses the challenges of the software development industry, and how value analysis can contribute to this field. Next, the software is discussed ad a disruptive innovation with its difficulties, and how value analysis can support handling these challenges. Finally, the value analysis project is presented. During the work, the six-step job plan was applied. Each phase, their contribution to the software development and their results are discussed separately.

1. Introduction

The topic is based on a Hungarian invention that can transform professional sports by using a special software created with value engineering. Team Flow Measure is a software solution based on the results of neuroscience (Kotroczo 2019). The software uses EEG data analysis to show how much consistency players have between their brainwaves and teach them how to achieve greater unity.

This product represents a new training technique. It can measure the consistency of a total of four players with headbands and a program running on a laptop. During the exercise, the program gives them different tasks to complete together. Geometric shapes visualize the state of their consciousness on the screen. As they align, the shapes on the monitor get closer to each other. The device, therefore, behaves as a mirror and help them achieve the desired mental unity. Players do not go to the field with the EEG headbands. It has no invasive effect on the brain, it does not manipulate their behavior, it only returns information useful for their training.

Existing EEG systems address the abilities of the individual, but the new device addresses the entire sports team. The main advantage of this new training technique is that it allows players to increase their mental alignment which results in an increased team performance, instead of expanding their physical limits further. After reaching the limits of human performance, the tool opens up further opportunities of development for the team.

The method can also assist coaches and sports psychologists. The product also has a coaching service with artificial intelligence which makes recommendations for suitable team captain, suggests team members, and facilitates player selection. The tool gives coaches and sports psychologists one more method to use and more data to work with, helping them make good decisions for their team.

The influence of psychological factors on sport performance has been scientifically proven (Gyomber 2015). The sports psychology literature typically deals with the mental well-being of athletes, most research studies examine the effects of stress, excitement, motivation, personality and cognitive attributes on sport performance. Research has shown that athletes also need a high level of psychological skills for performing a high level of physical activity. Mental preparation and counseling by sports psychologists help them achieve the appropriate psychological state. Mental preparation is particularly difficult for athletes because they do not receive feedback on their progress and cannot measure their mental performance by conventional tools. Methods for increasing athlete efficiency in the mental field are therefore very useful for them.

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In the early 2000s, in addition to classic software development models, such as the so-called waterfall model, a new methodology, agile, appeared in response to accelerating technological and market demand. This trend and its tools (Scrum, Kanban, eXtreme Programming) are much more focused on the market, on the communication with the customer, and on the feedback (Szabó 2018). Because of the lack of flexibility, previous long-running, iterative, waterfall-like software development models are becoming less and less effective. In recent decades lean management has become a decisive driver of the strategic and operational levels of value creation that underlie agile methodologies.

Agile is a collaborative, constantly evolving, quality-focused development approach. This trend may not be applicable to every company, usually software development teams use it with the appropriate size, headcount, expertise and organizational maturity. A common feature of agile methods is that their applications require a high level of administration and frequent discussions involving both team members and managers.

Value Management can enhance the use of project management and agile methods (Thiry, 2002). It offers techniques for project managers that are not included in traditional or agile toolsets. These tools are primarily intended to support the learning cycle of the integrated program management cycle (Figure 1).

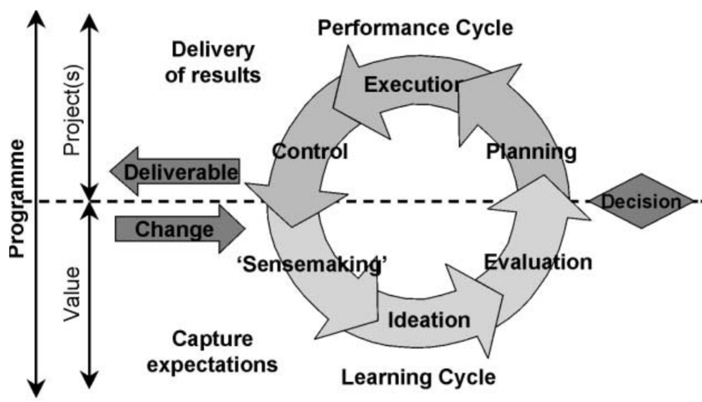

Figure 1. The integrated program management cycle model (Thiry, 2002).

In the learning cycle of the integrated program management model is the processing of inputs, which can be the definition of problems, the understanding of needs, and the interpretation of purpose. These activities may take place during the preparation and information phases of the value study. The second activity of the learning cycle is the creative search for solutions, which is also a highlighted phase of the job plan, so as the third, the evaluation. The Value Management job plan gives a framework for these activities and provides the basis for project management.

In addition to the software development and project management challenges, the project also has to face another challenge, which is its innovative nature. In the literature of technology management innovation is either a new technology or an old one with a new demand to be met (Paap, Katz, 2004). The new demand can either come from existing users or completely new ones. The novelty of the technology or the demand to be met is always considered from the organization's point of view: if it is new to them, it is an innovation, whether there is anything new for others. With the new training device, we cannot talk about existing users or existing needs. Only a few experts in the field of consciousness research may already have an existing need for this new technology.

Therefore, most of the market sees the new training device as a novelty which is something the development team and the marketing need to deal with when designing the product. Disruptive innovations like this break the business model we have followed so far: what we sell, who we sell it to, how we produce it, how we distribute and advertise it and who we compete with. Product development is an interdisciplinary task, all units of the organization should work on it together and the product must ultimately serve the needs of the users, and the organization. Value Management contributes to the success of the product by creating the appropriate team, gathering stakeholder needs at an early stage of development and analyzing the product once again in another mentality.

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Changes in the environment of innovation can create new driving forces, and this product is expected to determine the future of preparation in team sports. It is important to note that it is not a previously existing need that is becoming a driving force here, but a new driving force that does not exist before and is created by the product.

In order to successfully manage disruptive innovations, we need to keep the following points in mind (Paap, Katz, 2004):

- Understand the dynamics of innovation, the emergence of new technologies: there is an unmet need (old or new) that the technology in use is inadequate to meet. Members of our sports teams are already at their physical limit of performance, but the team performance can be enhanced further by strengthening their mental unity.
- When dealing with our customers, do not just pay attention to what they are asking us for! It is even more important to focus on what they need. The value study offers guidelines for collecting and analyzing the stakeholder needs.
- Do not replace any old technology just because it has reached the physical limit of its performance! Physical training will continue to be needed to improve performance!
- However, this does not mean that it is enough to pay attention to the increasing power of our existing technologies to serve the growing driving force! The device will be the first representative of a new technology that can not only meet existing needs, thus increasing team performance, but also enable new driving forces, such as increasing player satisfaction and mental health.

2. Importance of the topic

The importance of the topic is primarily due to the technological innovation, as there is no similar method to use in team sports. The software, using known mental training techniques, programming applications, and psychological techniques, helps players to align and strengthen team unity through mental training. This can increase players' motivation, give them visual feedback on their mental training, and support coaches. The software could revolutionize professional team sports in the coming years.

The software will first be used in the competitive sports and later in a broader market. Just as it contributes to sports performance, it can enhance learning performance, as it is also important for learning to get into an appropriate mental state. In education, you can also fine tune the results of examinations by assessing the mental state of the candidate. It could also be used in corporate management, for example, to improve team performance, group brainstorming, and decision making by increasing mental alignment. It could also provide valuable results in the field of personal mental health.

The application of Value Management in software development is also unique. There are only a few examples in the literature for Value Management based software development. Applying the value methodology give a framework for defining goals, forming a team and collecting detailed information and needs for the project. The development of the software is facilitated by function analysis, which helps the developers to clarify the components of the software and the related communication.

3. Overview of the value study

Pre-Study Activities

The preparation for the value study is of great importance. In the first part of the preparation phase, the subject of the value study and the subject scope must be defined. The subject of this study is the Team Flow Coach & Generator software. Essentially, any product can be analyzed that has function and cost. From an industrial application point of view, it is important to emphasize that both end products and intermediate goods can be analyzed.

In the second part of the preparation phase, objectives and stakeholders need to be defined and the conditions necessary to support the work need to be met. The main goal in this case is to identify features for the development, marketing, and training of these Neuroscience products for sports teams. Partial goals were to offer a complex solution for mentally tuning sports teams, calculating a team-flow index, and exploring missing features.

The development team was established in a startup and consisted of representatives from a variety of fields, as shown in Table 1 and Figure 2.

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Table 1. Members of the team

TEAM Specialty	Position
Management	Executive, owner
Design	External specialist
Marketing, sales	Marketing coordinator
Sports psychology	External specialist
Software development, programming	Technology leader, owner
Sports management (player and coach), measures	External specialist
Finance	Project manager, finance manager
Project administration	Project administrator
Data analysis	External specialist
Programming, data analysis	External specialist
Anthropologist and anthropometry	External specialist
Marketing, sales	Marketing manager
Training	External specialist
CVS expert	External specialist
CVS expert	External specialist

Figure 2. Members of the team

Information Phase

Understanding the topic and the task requires gathering and reviewing relevant information before the work begins. The information required varies slightly depending on the type of value study. Value studies can be:

- Value Analysis (VA) on existing products
- VE (Value Engineering) methodology for new product development.

This work is a Value Engineering as it is the design and development of a non-existent product. However, for each job, information on performance, quality, schedule, cost, and risk related to the subject of the study must be identified, collected, and organized for utilization in the information phase. In connection with this topic, the team collected the following information:

- Project statute,
- Published promotional articles,
- Benchmark information,
- Top athlete reports on group consensus,
- Coach reports on successes, failures,
- Available neurological signal measuring devices and their functional description,
- Group trainings for mental alignment,
- Existing databases,
- Cost data,
- Reference information,

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- Economic requirements, etc.

Function Analysis Phase

Based on the decision of the team, the stakeholders were asked to give a description of their needs. In the group of stakeholders there are everyone who comes across with the project through its lifetime. Stakeholders were either represented by team members in the field or practitioners were involved. From the descriptions collected, the team compiled a list of needs for the project. During the assessment of the needs, the team conducted a series of professional discussions on whether the needs of some stakeholders were already in the list, whether they were outside the scope or were formulated in such way that the team did not want to use the functions expressed in it.

Based on stakeholder interviews, the team compiled a list of a total of 122 needs. The purpose of the analysis of needs is to uncover all the expectations or requirements that stakeholders have for the project throughout its lifetime. The team grouped the needs according to the Stakeholders. During the work, the team ensured the consistency of the needs and analyzed the practicability of each one with the organization's current resources.

The functional model was created after the definition of the functions (Figure 3). The functions are defined according to the needs collected. The functions then were classified and structured in the Customer FAST diagram (Figure 4). The team chose the Customer FAST chart format because its system was the best understood by all team members. When compiling the Customer FAST diagram, the team paid special attention to ensuring that a function does not have too many subordinate functions.

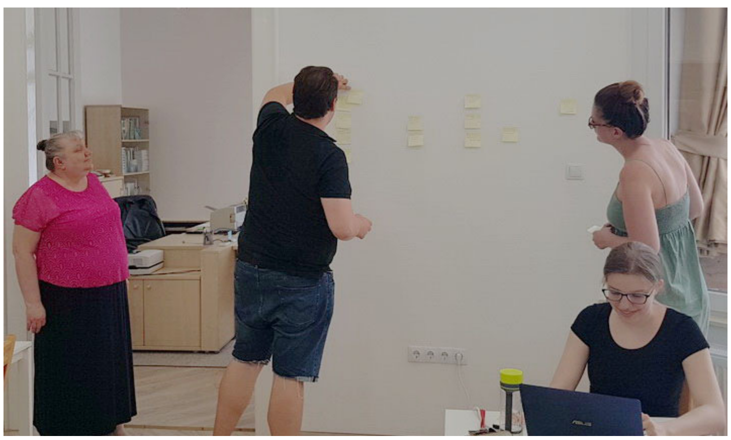

Figure 3. VM function-model – under construction

Based on the evaluation of the functions, the team found missing, under-performed and over-performed functions. Examples of missing functions: Available online, give reward, enhance motivation. Examples of underperforming functions: deliver results, generate intensity, connect devices. There were no over-performed functions.

Figure 4. The whole function-model

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The team reviewed the weaknesses in the function model and pointed out the missing functions for analysis. Using the Evaluation Criteria Matrix, it was estimated how much the customer would spend on each function. Comparing the planned cost of each function and the cost that the buyer intended for the function, the weak points became identifiable. From the cost point of view, two weaknesses have been identified from Figure 5: Motivate people, Improve collaboration.

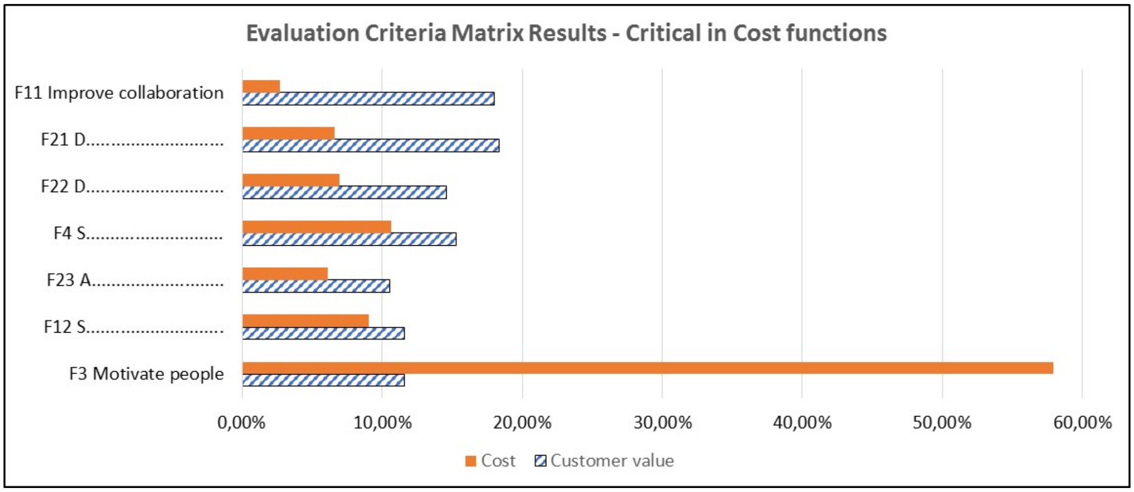

Figure 5. Evaluation Criteria Matrix results

Creative Phase

During the Creative Phase, CVS experts placed great emphasis on creating a creative atmosphere. In a creative environment, people come up with ideas easily and they are helped to develop these ideas further. The collected information base is accessible, team members are open to novelty and to share their ideas, which strengthens their confidence. Brainstorming rules were determined on a rule card distributed to team members. The team organized a Creative Day where each selected weak point was reviewed, and brainstorming was conducted for developing these features to customer-oriented solutions. The results of the brainstorming and the list of ideas were finalized by the team at the end of the day. The team gathered a total of 252 ideas.

Evaluation Phase

The team discarded 2 of the totals of 252 suggestions, merged many, and decided to implement 29 ideas only in version 2.0. Each suggestion was evaluated by all team members individually regarding the estimated time the implementation needs, the estimated cost and the possible impact of the improved feature.

Development Phase

The purpose of the development phase is to develop the “best ideas” identified in the evaluation phase for specific value proposals, recommendations or alternatives that have been technically validated. The impact of individual value proposals should also be quantified. The most important questions and considerations are:

- Does the proposal clearly explain the nature and reason for the proposed modification?
- Does the proposal consider all the impacts on resources (cost of investment, life-cycle costs, schedule, etc.)?
- Does the proposal consider how to implement the change?
- Make sure that all value propositions are fully documented and submitted in a format that allows decision makers to clearly understand all relevant information.

During this phase a total of 10 topic sheets were developed.

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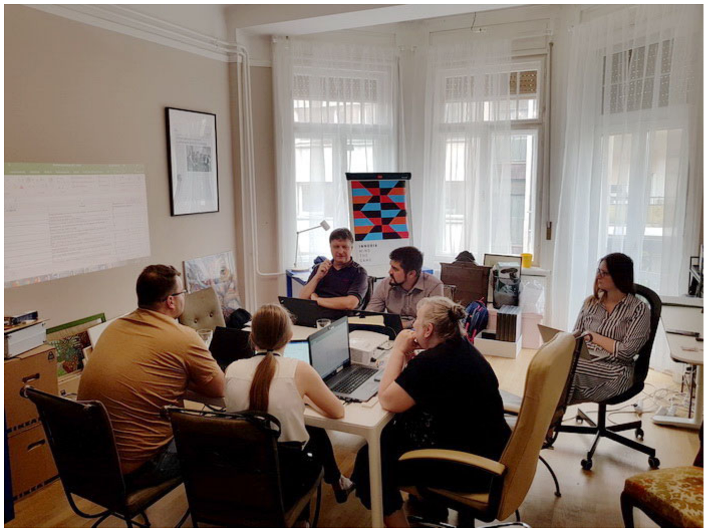

Figure 6. Working in the Development Phase

Presentation Phase

During the presentation phase, the CVS experts prepared the final report of the study and the presentation were delivered to the owner.

4. Results and discussion

The main objective of the study has been accomplished and several non-measurable results have also been achieved. The study was a demonstration to Hungarian start-ups of Value Methodology and how a significant body of knowledge through the application of well-known and widely used methods can enhance innovations. It also strengthened the competence of Hungarian Value Methodology experts and demonstrated the success of applying value engineering. Developing the value engineering study was conducted with a responsible team on a high level of involvement. This contributed to improving team collaboration in the startup and reassess current processes, tasks and opportunities. During the value study employees have been involved in collecting needs, analyzing the functions, brainstorming and evaluating the ideas which enhanced their motivation and the cohesion between them. Thinking in functions gave the team members a new perspective which they can utilize in other tasks as well. Due to the detailed analysis, the decision points during the implementation of the project became foreseeable, thus reducing the risk and the time delay. The study also contributed to specify everyone's task, reducing conflicts in the startup.

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As a self-employed consultant I offer advice and expertise to organizations (mainly SMEs, small and medium-sized enterprises) to help them improve their business performance in terms of operation, profitability, management, structure and strategy.
In my line of work I am involved in several types of analytical and development projects, but generally my responsibilities include:

- conducting research, surveys and interviews to gain understanding of the business,
- analyzing statistics,
- detecting issues and investigating ways to resolve them,
- assessing the advantages and disadvantages of possible strategies,
- compiling and presenting information verbally, visually and in writing,
- making recommendations for improvement,
- implementing agreed solutions,
- managing complex research and development projects,
- conducting innovation management development projects, as a certified IMP³rove Guide (www.improve-innovation.eu, based on the European Innovation Management Standard, CEN/TS 16555, currently becoming part of the ISO),
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Abstract

Nowadays, in a global economy characterized by growing competition, even market leaders struggle to achieve target growth rates through innovation. Product costs are associated with the manufacture of goods or the provision of services. In accounting, the functional classification is the cost classification required for external reporting. We can classify costs different point of view and one of these views can be the function. What the function is and how we can identify, classify and organize the functions. Knowing a product's functions and the cost to produce the functions is imperative to meeting the needs and demands of the customer. The main purpose of function analysis is to identify the greatest opportunity for value improvement. The value management helps companies to recognize hidden reserves for competitiveness and sustainable growth in performance, profitability, efficiency.

Introduction

The main goal of every profitable business is to increase its productivity and efficiency. It is important to increase the production, the revenue, the profit and the expenditure decreasing, but the highest result with the smallest investment is the efficiency. (Szóka, 2018) The advancement of digitization brings new challenges to economists in every area. (Széles, Széles & Papp-Váry, 2018)

In last years, according to Harvard Business Review Research in some industries business models have changed or opportunities to grow revenue aren't what they used to be, which adds to the allure of efficiency for efficiency's sake. We learnt the long term aim is maximalize the profit (shareholder's value) and it has changed. An uncertain global economic situation for example, in 2007 the financial and economic crisis shifted the focus of many enterprises toward costs. Businesses are increasingly coming to the realization that simply cutting costs or perpetually postponing investment cannot help for them. In the end, a business must grow, innovate, and create value to live. (Harvard Business Review Research, 2018)

Accounting cost

The cost appears in an entity's financial statements and an accounting cost is recorded in the ledgers of a business. Accounting cost is the recorded cost of an activity. The place of the accounting cost in the financial statements on the following (Bragg, 2018):

- If an accounting cost has not yet been consumed and is equal to or greater than the capitalization limit of a business, the cost is recorded in the balance sheet.

- If an accounting cost has been consumed, the cost is recorded in the income statement.

The scope of an accounting cost can change, depending on the situation. These are in different case (Bragg, 2018):

- Example 1, a manager wants to know the accounting cost of a product. If this information is needed for a short-term pricing decision, only the variable costs associated with the product need to be included in the accounting cost.

- Example 2, if the information is needed to set a long-term price that will cover the company's overhead costs, the scope of the accounting cost will be broadened to include an allocation of fixed costs.

All types of organization incur different kind of costs for example, business, non-business, manufacturing, retail, and service. In most cases, the kinds of costs are incurred and the way in which these costs are classified depends on the type of organization. (Garrison, Noreen & Brewer, 2006) Nowadays the most of countries use International Financial Reporting Standards (in sort, IFRS) and the international companies use US GAAP. If we compare the IFRS and US GAAP by classification of expenses in the Income Statement there are some differences. No general requirement within US GAAP to classify income statement items by function or nature although there are requirements based on the specific cost incurred (e.g., restructuring charges, shipping costs). In the IFRS, entities may present expenses based on either function or nature (e.g., salaries). However, if function is selected, certain disclosures about the nature of expenses must be included in the notes. (EY, 2018) We can classify costs by function but here is the question how we can identify, classify and organize the functions. It will be the main topic of the next part after the accounting cost.

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According to Garrison, Noreen & Brewer (2006) five different groups have by purpose of cost classification. Basically, costs are recognized as expenses on the income statement in the period that benefits from the cost. Table 1 shows summary of cost classifications. The cost can be product and period cost by preparing external financial statement. Period costs are taken directly to the income statement as expenses in the period in which they are incurred or accrued. They say all costs that are involved in the purchase or manufacture of goods. In the case of manufactured goods, these costs consist of direct materials, direct labor, and manufacturing overhead. Product costs are associated with the manufacture of goods or the provision of services by Hansen & Mowen (2006).

Table 1: Summary of Cost Classifications

Purpose of Cost Classification	Cost Classifications
Preparing external financial statements	- Product costs (inventoriable) - Direct materials - Direct labour - Manufacturing overhead - Period costs (expensed) - Nonmanufacturing costs - Marketing or selling costs - Administrative costs
Predicting cost behavior in response to changes in activity	- Variable cost (proportional to activity) - Fixed cost (constant in total)
Assigning costs to cost objectives such as departments or products	- Direct cost (can be easily traced) - Indirect cost (cannot be easily traced; must be allocated)
Making Decisions	- Differential cost (differs between alternatives) - Sunk cost (past cost not affected by a decision) - Opportunity cost (forgone benefit)
Cost of quality	- Prevention costs - Appraisal costs - Internal failure costs - External failure costs

Source: Garrison, R. H., Noreen E. W. & Brewer P. C. (2006) *Managerial Accounting*. New York, NY: McGraw-Hill International Edition, 47.

According to Hansen & Mowen (2006) the functional classification is the cost classification required for external reporting. In preparing an income statement, production and nonproduction costs are reported. Product costs also called inventoriable costs.

Figure 1 shows the product and periodic costs in the financial statements. The reason for the separation is that production costs are product cost (costs that are inventoried until the units are sold) and the nonproduction costs of marketing and administration are viewed as period costs. Appearance of production costs are in the financial report on the following:

- Production costs attached to the units sold are recognized as an expense (cost of goods sold) on the income statement. Cost of goods sold represents the total cost of merchandise removed from inventory and delivered to customers as a result of sales. It is shown as a separate expense because of its significance and because of the desire to show gross profit as a separate item. (Marshall et al, 2014)

- Production costs attached to units that are not sold are reported as inventory on the balance sheet.

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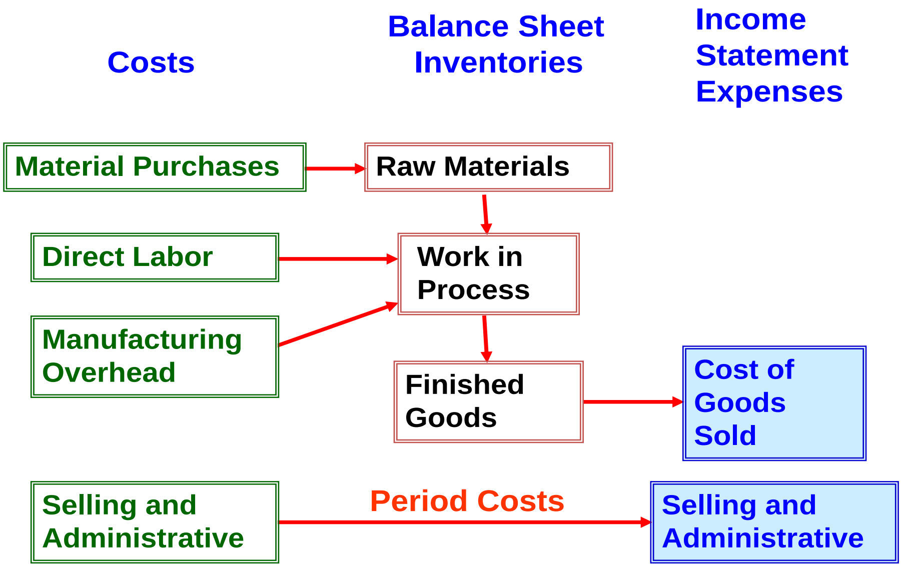
Figure 1: Product and periodic costs in the financial statements



Source: Marshall D., McManus W., Viele D. (2014). *Accounting: What the Numbers Mean*. McGraw-Hill/Irwin

Procurement value drivers

The identification of correct value drivers for procurement should be closely linked to the organization's overall business objectives.

At a company level, high performers are focusing on the execution of one of four design-driver business models:

- Operational excellence
- Product leadership
- Customer relationship management
- Market making

With uncertainty and growth ambitions being a constant in many organizations, it is understandable that the number one priority for 79 percent of CPOs surveyed is reducing costs. This statistic is closely linked to the 48 percent of CPOs wanting to increase cash flow. (Deloitte, 2017)

Economic analysis – Rate of return

An investment economic analysis is undertaken to determine whether an outlay of funds is warranted and/or which of several strategic alternative courses of action is most economical in meeting certain objectives. (Dell'Isola & Kirk, 2003)

To calculate rate of return the return of an investment is divided by the amount of the investment.

The rate of return is the amount you receive after the cost of an initial investment, calculated in the form of a percentage. The percentage can be reflected as a positive, which is considered a gain or profit. This information is very useful in determining whether or not the initial investment you made was a good one. This ratio provides the return on a given investment alternative. All other things being equal, the higher the rate of return, the more profitable the alternative. Higher rates of return are associated with greater risk.

This ratio describes the rate of return management was able to earn on the assets that it had available during the year. An informed judgment about the firm's profitability requires relating net income to the assets used to generate that net income.

According to SAVE the cost-benefit analysis (CBA) a method used to ascertain the soundness of any investment opportunity and provide a basis for making comparisons with other such proposals. All the positives and negatives of the Value Management study subject are first quantified in monetary terms and then adjusted for their time-value to obtain correct estimates for conducting a cost-benefit analysis.

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We have different ratios and these are as follows:

- Return on Investment (ROI): This ratio describes the rate of return management was able to earn on the assets that it had available during the year. An informed judgment about the firm's profitability requires relating net income to the assets used to generate that net income.
- -Return on Equity (ROE): Stockholders are interested in expressing the profits of the firm as a rate of return on the amount of stockholder's equity.
- Return on Assets (ROA): Return on assets (ROA) means an indicator of how profitable a company is relative to its total assets. This ratio gives a manager, investor, or analyst an idea as to how efficient a company's management is at using its assets to generate earnings. ROE and ROA are important components in banking for measuring corporate performance. Return on equity (ROE) helps investors gauge how their investments are generating income, while return on assets (ROA) helps investors measure how management is using its assets or resources to generate more income.
- DuPont Model: Return on Investment is Margin * Turnover. The DuPont model is an expansion of the basic ROI calculation. The developers of the model reasoned that profitability from sales and utilization of assets to generate sales revenue were both important factors to be considered when evaluating profitability. Margin: Emphasizes that from every dollar of sales revenue, some amount must work its way to net income. Turnover: Relates efficiency with which the firm's assets are used in the revenue-generating process.
- Payback period: The payback period refers to the amount of time it takes to recover the cost of an investment, so the payback period is the length of time an investment reaches a breakeven point. A major problem with the payback period is that it ignores cash flows that occur after the project is paid off.

Value Methodology

According to Miles (1989) value analysis and value engineering constitute of function based thinking system to identify and remove all unnecessary cost, on the same time keeping or enhancing all quality in any manufacturing (construction or service). Value Analysis was conceived in the 1940's by Lawrance D. Miles who was a product engineer at General Electric. (Lenzer, 2018)

"Value management (VM) is a proactive, creative, systematic and team-oriented methodology that maximizes the functional value of a project by managing its development from concept to occupancy according to the value requirement of the client." (Gui et al, 2006:1)

According to SAVE International the Value Methodology is „also known as value engineering (VE), value analysis (VA) and value management (VM), so the Value Methodology process can optimize projects, processes and product development in significant ways. Through this process, companies and government agencies regularly:

- decrease costs,
- increase profits,
- improve quality and performance,
- enhance customer satisfaction."

This investigation concentrates on value engineering which is defined as 'A systematic approach to delivering the required functions at lowest cost without detriment to quality, performance and reliability' (Connaughton – Green, 1996).

In essence, new applications of value management continue to emerge – making it a powerful tool for entrepreneurial development. (Jay – Bowen, 2015) This is the most important for enterprises, so they can find a powerful equipment for development. It is important to increase the production, the revenue, the profit and the expenditure decreasing, but the highest result with the smallest investment is the efficiency.

Before we continue logically we should go back to the value definition. First, we have examined the fundamental statements about value methodology and its elements.

What does value mean? How can we calculate it? What is the background for the calculation? These are crucial questions, in case we would like to analyze the value as a definition. According to SAVE International „the value is the reliable performance of functions to meet customer needs at the lowest overall cost."

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In this formula the function can be what the product or service supposed to do and resource (cost) is the expenditure needed to create it.

Cost can often be measured by the amount paid by the customer/user, but function is not easy to measure objectively due to its inherent subjective quality as well as value. Value has been influenced with the customer's/user's purpose, requirements and perception. (Gui et al, 2006)

In our opinion, managers can get into a situation when they hesitate or cannot decide what the acceptable price is for the product or service. According to analysts the cost is easier to measure as part of the value, but we may not share this statement. A lot of different factors can influence the expenditure, these are as follows:

- individual aims;
- user's requirement;
- customer's observation;
- the global economy: for example, the economic and financial crises has influenced our lives and user's price sensitivity;
- different kind of possibilities on the market etc.

Summary

The cost appears in an entity's financial statements and an accounting cost is recorded in the ledgers of a business. Accounting cost is the recorded cost of an activity. The scope of an accounting cost can change, depending on the situation. The functional classification is the cost classification required for external reporting.

The net income is the most important income category at the income statement and the general meeting can describe about dividend part, so which part will be paid to the owners. Rate of return is a universally accepted measure of profitability. It is a ratio, profitability of unequal investments can be compared, and risk-reward relationships can be evaluated. The cost determines the value and the rate of return as well.

The value management significantly helps businesses to recognize hidden reserves for competitiveness and sustainable growth in performance, efficiency, profitability. The companies in the competitive environment can generate significant advantages by using value methodology to identify breakthrough points in development, management, innovation and knowledge capital.

Through this process regularly:

- decrease costs,
- increase profits,
- improve quality and performance,
- enhance customer satisfaction.

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INTRODUCTION OF STRATEGIC VALUE ENGINEERING SYSTEM FOR LARGE-SCALE MEGA HUB AIRPORT CONSTRUCTION PROJECT

-Focusing on Incheon International Airport Passenger Terminal 2-

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Biography

Surname : Kim

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Nationality : Republic of Korea

Jong-Hyeon Kim obtained the CVS qualification in March 2010, and as the director of VE at Incheon International Airport (IIA), he made a great contribution to VE activation and development through systematic introduction of advanced value engineering and continuous VE process improvement activities. In addition, as a PM of airport construction projects in IIA, Iraq, Indonesia and Turkey for the past 25 years, he has successfully completed all the tasks through creative execution techniques of VE and Agile leadership.

In particular, during the 25-years construction period of IIA, he supervised VE for approximately 90 units of projects, resulting in a budget reduction worth 327 million USD (total operating cost 15.5 Billion USD), an average function improvement of 22.3%, and a value improvement of 32.1%.

Abstract

The large-scale mega hub airport is a gateway to comprehensive evaluation of the country's culture, art, economy, technology, etc. Integrated management by the best project management professional organization is required for the successful execution of the airport construction project composed of complex construction types. In particular, the systematic introduction and application of Value Engineering should secure the economic feasibility of the project and secure quality competitiveness through function and value improvement. For the strategic promotion of VE, IIA established a sustainable development system by operating an organization dedicated to VE, establishing guidelines and manuals, forming a pool of experts in each field (private and public institutions), activating the Value Engineering Change Proposal, organizing VE competitions open to the general public, strengthening VE performance verification, supporting VE video conferencing, diversifying VE operating techniques and establishing a database.

1. IIA Construction Project and VE

The aviation transport industry has rapidly changed due to deregulation, opening the sky, intensifying market concentration due to M&As between airlines, increasing the role of low-cost carriers, strategic alliances among global airlines, and expanding the air transportation market followed by the rise of the Chinese economy. In addition, various business strategies are being reinforced to preoccupy competitiveness with competitive airports.

Integrated management by the best project management professional organization is required for the successful execution of the airport construction project composed of the most advanced complex construction types. In particular, the systematic introduction and application of Value Engineering should secure the economic feasibility of the project, and secure quality competitiveness through function and value improvement.

The value engineering technique, which is the main decision-making tool of project owners and project implementers, is to secure the necessary functions of the facility with a minimum life cycle cost. Experts in various fields review the economic feasibility of design content and the feasibility of field application by function and alternative. Currently, it is actively applied in all industries including the domestic airport construction business.

For the construction of IIA, a step-by-step construction plan was established according to the air traffic demand and comprehensive development plan. It was implemented as in Fig.1.

Figure 1. Status of Phase-by-Step Construction and Major Operating Facilities at IIA

2. VE STRATEGY AND INNOVATION

The IIA development project is a mega project with a project period of 372 months and a total project cost of 15.5 billion USD from 1992 to the end of 2024. Through this, IIA became a hub airport in Northeast Asia that connects the world, and it is the only airport in the world to achieve the No. 1 record for 12 consecutive years (2005-2016) in the World Airport Service Assessment (ASQ), the world's most prestigious airport service assessment.

In order to secure economic feasibility, maximize functionality, and value for the IIA development project, IIAC has been organizing in-house “VE Awards” open to internal and external experts, and through the awards, excellent proposers are given the right to participate in the annual “SAVE Value Summit” and many other educational benefits.

In addition, a pool of VE experts is organized by organizing specialized groups for each business and specialized field, and a more systematic and efficient VE is performed by establishing a technical cooperation system between related public corporation.

In particular, through VE, it was possible to improve the function, value, landscape, structure, safety, and quality by performing more systematically reviewing the economic feasibility of the design.

Through the establishment of a technical cooperation system and strategic VE promotion between related public corporations, as shown in Figure 2, remarkable VE promotion results were achieved. In recognition of these achievements, IIA received the national VE award from the Minister of Land, Infrastructure and Transport in 2019.

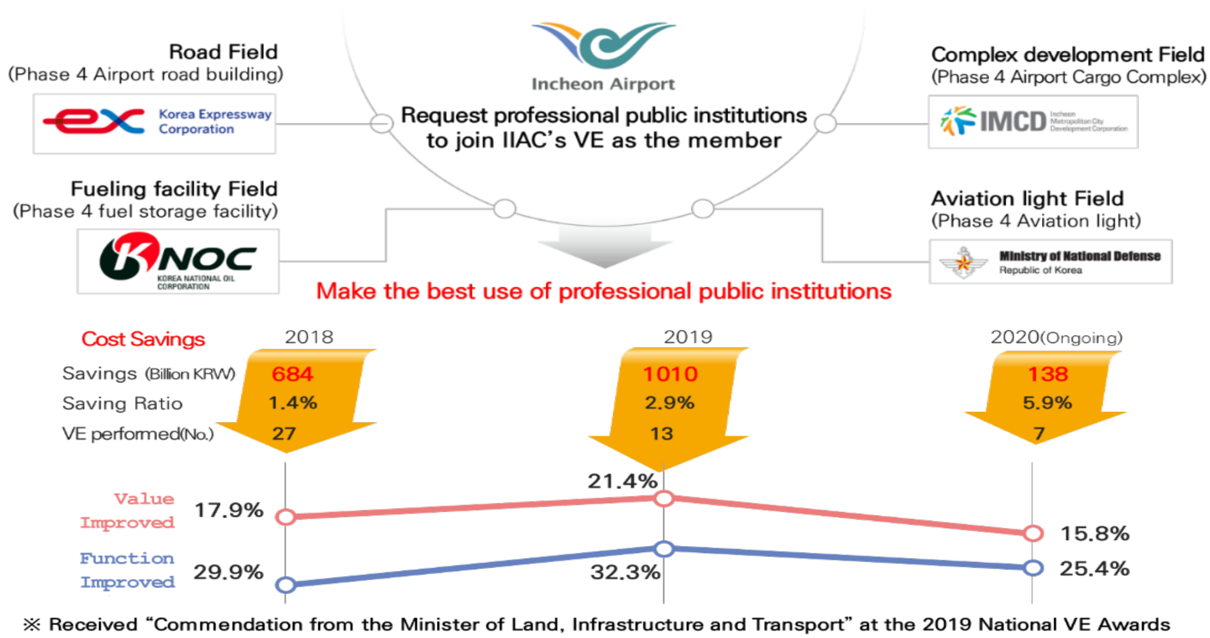

Figure 2. Achievements using a pool of VE experts

In order to improve VE efficiently and continuously, the process has been improved, and the VE Databank System that can continuously accumulate and utilize numerous ideas and results generated according to the results of VE performance has been established and operated, and is actively used for subsequent VE work.

As shown in Figure 3, the VE promotion for the IIA development project is carried out thoroughly in accordance with the detailed procedure for each VE process, starting from the VE contest and building the VE result database, which is the end stage.

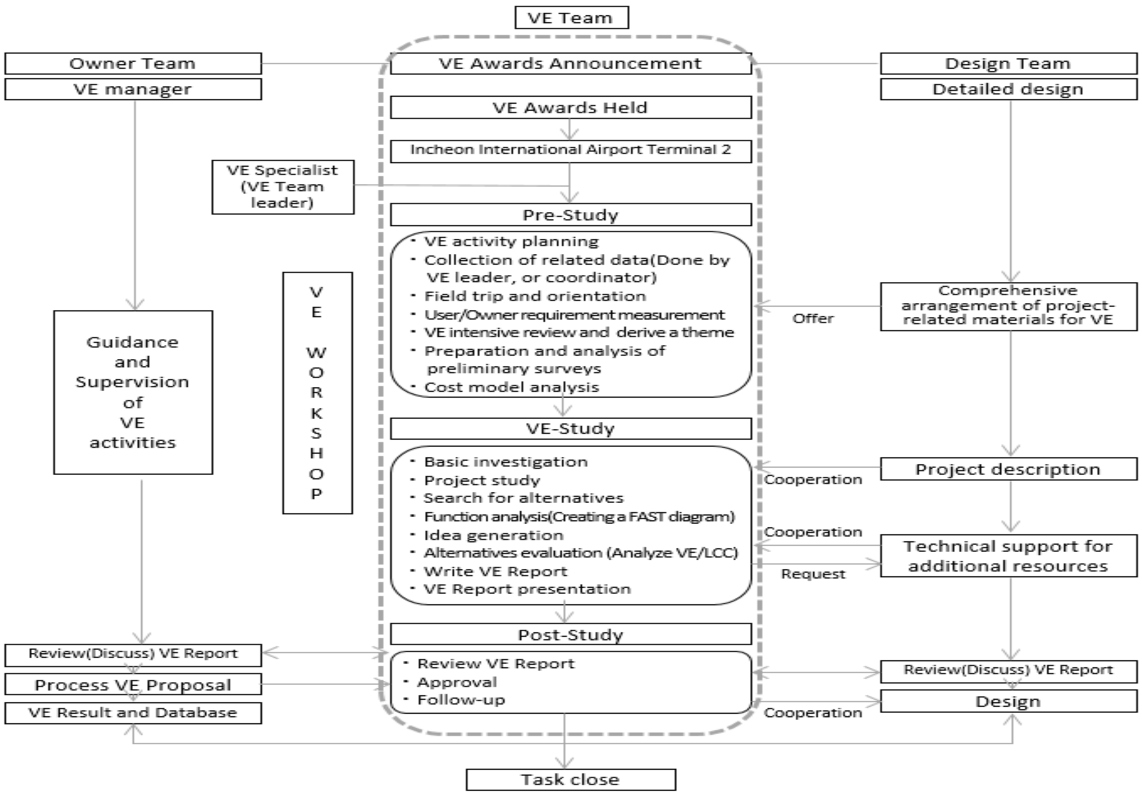

Figure 3. VE Process

In addition, the project cost for design VE application is lowered from 8.8 million USD or more to 4.4 million USD or more, and the scope is extended to mid- to long-term facility improvement projects.

Figure 4 shows the improvement of the VE implementation process to secure the appropriateness of the business plan and budget for the facility improvement project due to the aging of the airport.

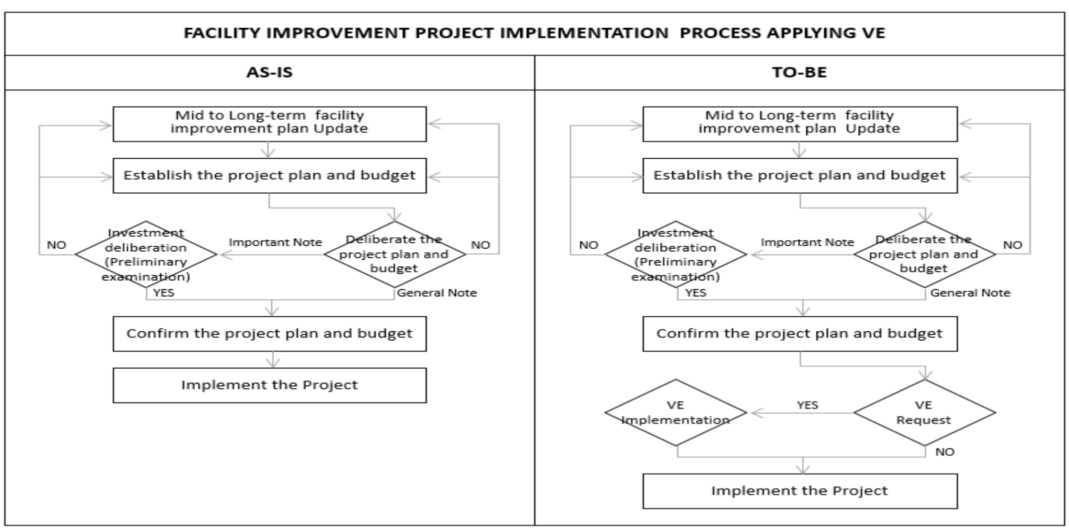

Figure 4. VE Process for facility improvement project due to deterioration of airport

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IIA is carrying out expansion projects in stages according to the mid- to long-term comprehensive development plan, and is promoting VE to secure economic feasibility for the total project cost and to secure appropriateness for design and construction. VE is being implemented to identify cases that need further improvement as shown in Fig. 5.

	AS-IS	TO-BE
VE Object	• Construction expenses over 8.8 million USD	• Construction and Maintenance expenses over 4.4 million USD
VE Times	• 1 time for schematic design or construction document	• 1 time for schematic design and construction document each
VE Standard	• Insufficient VE Standard • The same VE technique regardless of scale of construction	• Establish VE work process (Standard Model) • Classify VE techniques by scale of construction
Cost Criteria	• Cost based on estimate • Examine cost for professional field is low	• Establish VE Cost Criteria • Clarify and actualize the cost
Professionals Capability	• Insufficient external professionals pool • Strengthen internal professional's Capability	• Build up external VE professionals pool by • VE training for internal VE professionals

Figure 5. Strategic VE improvements case

3. Effects Of Airport Construction Project VE Implementation Timing

Large-scale airport construction projects may appear differently depending on factors such as characteristics, scale, and environment and, it is common that for more than 80% of the project details and cost factors is determined at the design stage.

Therefore, it is most effective to carry out VE activities when the schematic design of the new airport construction project has reached the 70% level or when the construction documents has been 50~70%. Fig. 6 shows the relationship between input cost and performance according to the timing of VE implementation.

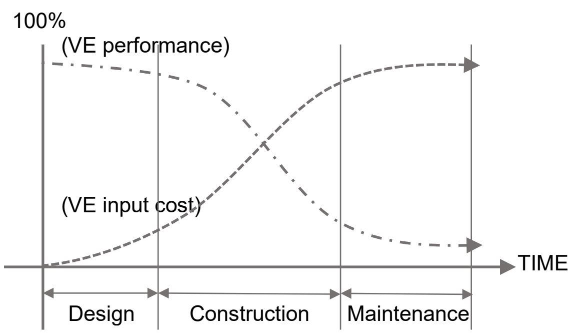

Figure 6. VE performance related with implementation timing

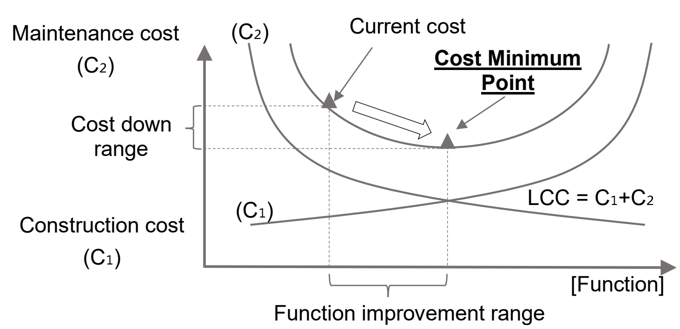

Figure 7. Performance expected area of VE from LCC perspective

In addition, the construction cost of an airport construction project is the sum of the design and construction phases, and the sum of these production cost and maintenance cost is LCC. In terms of LCC, the expected performance area of the VE is shown in Fig. 7.

The VE of the airport construction project aims to find a point where current LCC (the sum of construction cost and maintenance cost) can be minimized. At this point cost minimization and function improvement can be achieved.

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4. Innovative Implementation Of IIA Terminal 2 Design VE And Process Improvement

In this paper, focusing on the execution result of the VE, for the construction documents stage of IIA Terminal 2 Expansion Project, we will examine the strategic approaches such as budget reduction, function improvement, structural safety and quality assurance of public construction projects.

4.1 VE Organization

In order to facilitate the smooth implementation of VE for the IIA construction project, a dedicated department composed of experts is in operation, and the VE team composition of a unit project constitutes a VE TF (Task Force) team in consideration of the characteristics and scale of the project. The composed VE TF team performs tasks based on field-specific expertise and VE techniques for VE target projects conducted at the airport under the direction of a VE leader. The detailed composition is shown in Fig. 8.

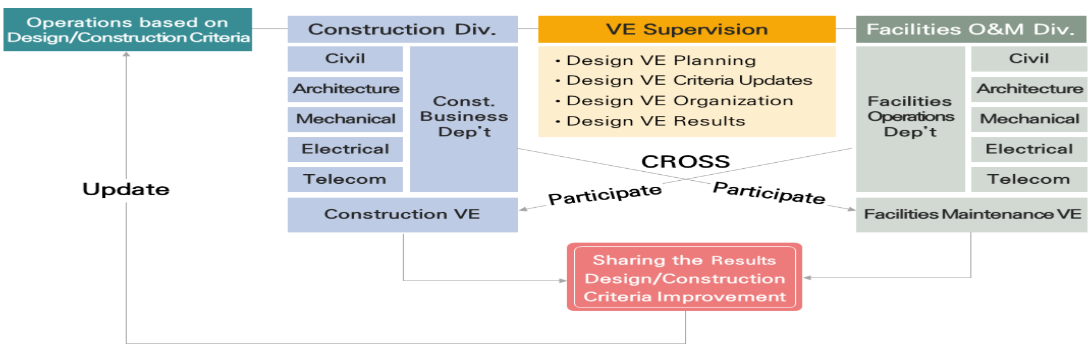

Figure 8. Composition of VE propulsion organization at IIA

4.2 Preparation Phase

The main purpose of the VE preparation stage is to establish a cooperative system of related organizations for smooth VE performance through reviewing the general contents of the analysis target and reviewing the main items for VE performance.

Such preparation steps consist of pre-task meeting and VE performance plan preparation, VE performance plan report and notification, design document distribution, VE orientation and field trip, related data collection and content analysis, and workshop preparation. Details are seen in Fig. 9.

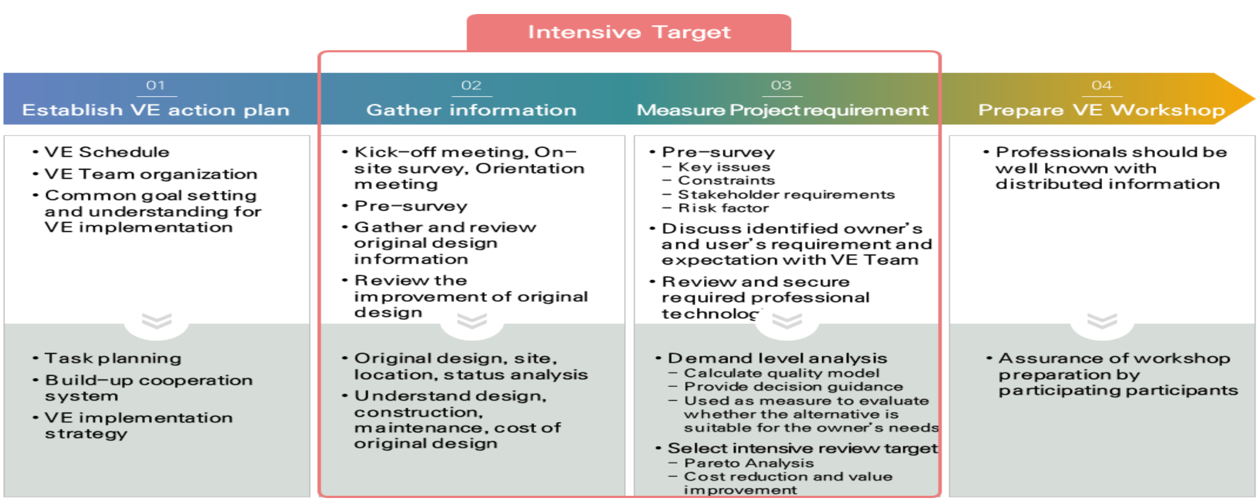

Figure 9. VE Readiness Phase Process

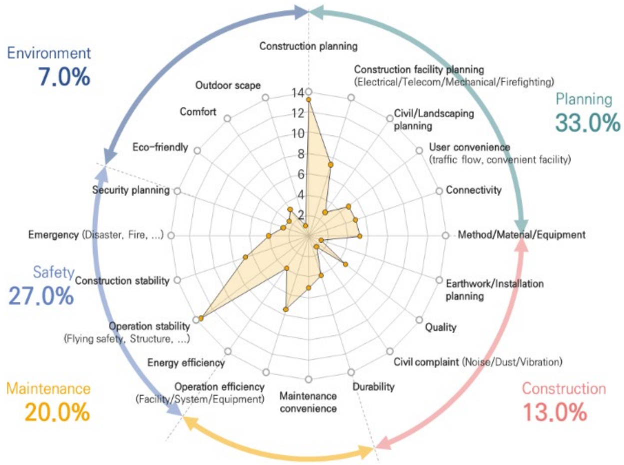

Figure 10. VE quality model

Through preliminary on-site surveys and expert advice, the user/client requirements are organized into a schematic quality model as shown in Fig. 10, and items for function improvement are selected by reflecting the results of understanding the needs and expectations of stakeholders for project performance.

As a result of the quality model analysis, economic feasibility, convenience, eco-friendliness, maintainability, safety, and energy efficiency were identified as key items, and the selected items were continuously used in VE target field selection, function evaluation, idea creation and evaluation.

4.3 Analysis Phase

The analysis step uses the VE Job process on the detailed schedule of IIA's standard VE workshop[Fig.11] based on information collected in advance. Through this, it consists of a total of six steps: Gathering information, function analysis, idea generation, idea evaluation, alternative generation, reporting and presenting. Details of each step are as follows.

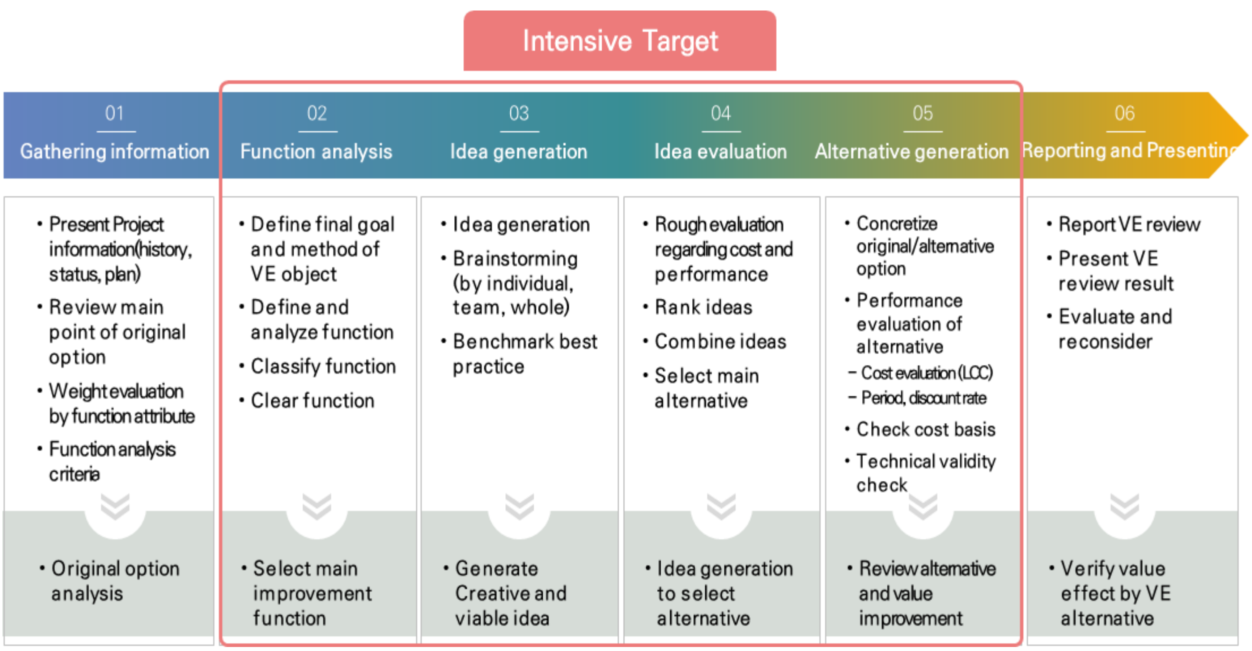

Figure 11. VE Analysis stage process

4.4 Implementation Phase

In accordance with IIA's VE manuals and procedures, an implementation meeting is held during the VE workshop, and the final VE report including detailed LCC analysis is sent to the project team for reflection in the original design. The following Fig. 12 is the VE implementation stage process.

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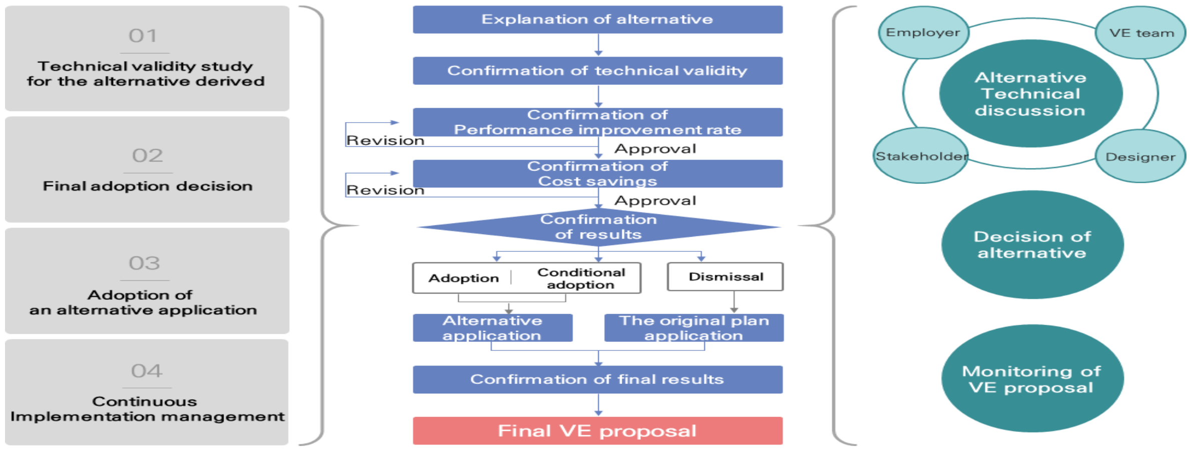


Figure 12. VE Implementation stage process

4.5 VE Results

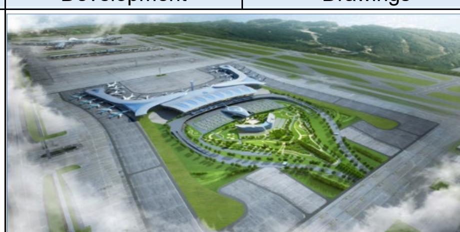
Item	**Terminal 2**(Phase 3)		**Terminal 2 Expansion**(Phase 4)	
	Design Development	Construction Drawings	Design Development	Construction Drawings
Image				
Design Period	July 25th, 2011~July 24th, 2015		Aug. 25th, 2017~Dec. 31st, 2020	
Scale	Gross floor area : 384,336㎡ Number of levels : 2BLs, 5GLs Maximum height : 40m Passenger capacity : 23mil. PAX		Gross floor area : +347,000㎡ Number of levels : 2BLs, 5GLs Maximum height : 40m Passenger capacity : +29mil. PAX	
Total Project Cost	2.04billion USD		2.33billion USD	
VE Period	July 25th, 2012 ~ Sep. 25th, 2012	Feb. 17th, 2014 ~ March 12th, 2014	Aug. 21st, 2018 ~ Sep. 12th, 2018	Nov. 11th, 2019 ~ Dec. 10th, 2019
Economics	▼56 million USD (2.03%)	▼7.9 million USD (1.14%)	▼2.1 million USD (0.1%)	▼11.6 million USD (0.6%)
Functional Improvement	▲6.09%	▲16.6%	▲27.8%	▲19.2%
Value Improvement	▲6.64%	▲31.2%	▲28.6%	▲20.6%

Figure 13. Results of design VE for Terminal 2

5. Future VE Innovation Tasks For The Airport Construction Project

In order to successfully promote VE for the airport construction project, it is necessary to implement such policies as: operation a dedicated VE organization, institutionalizing compensation for technology development, organizing a pool of experts by field (private and public institutions), encouraging Value Engineering Change Proposal, inviting the general public to VE contests, strengthening VE performance verification, fostering VE experts and introducing certification systems, doing research on diversification of VE operation techniques (e.g. a databank). In addition, continuous efforts and support from the government-industrial academia are required for the establishment and activation of the creative VE system in the public and private sector.

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DEVELOPMENT OF A STRATEGIC HUMAN RESOURCE UTILIZATION METHOD "SEE THEORETICAL METHODOLOGY" THROUGH FUNCTION ANALYSIS

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Biography

Noriko Murakami is the president of Legend Consulting Company Limited, a management consultancy firm for companies and human resources development consultation, focusing on organizational and leadership development. She has also been involved in entrepreneurial development and support at an administrative agency in Japan since 2015, and her achievements have earned her the prize "Sogyo-Kiun-Jousei-Shou (award for fostering the nation's interest and understanding of business startups in order to increase the opening rate) 30th year of the Heisei period" from Japan's Ministry of Economy, Trade and Industry in 2019. She has been learning the Value Methodology (VM) since 2013 at the Functional Approach Institute Company Limited in Japan and has qualified as a "Functional Approach Consultant". She provides consulting for companies in various industries and business entities applying VM, and also VM education to businesspeople.

Abstract

The Japanese government has positioned the industrial human resource strategy as an important issue, and Japanese companies are aware of the importance of human resource strategy. The reason is that the efficient use of human resources brings about a significant improvement in productivity. Consequent upon the backdrop of drastic changes in the employment environment, organizations and individuals are currently under great pressure to change their consciousness of how to utilize their abilities and demonstrate their abilities.

However, the lifetime employment system has become dominant in Japanese companies since the high economic growth period after the war in Japan. While the conventional long-term human resource management remains persistent from the personnel evaluation system, personnel flow, and human resource development, the current situation is that employment and evaluation systems are just partially reviewed or changed.

In this paper, the purpose and ideal form of human resource management are clearly shown through function analysis. The author establishes a strategic and efficient method for utilizing human resources and proposes it as SEE Theoretical Methodology. Furthermore, the evaluation guideline with the index for standardization and practice of the SEE Theoretical Methodology is presented, and its effectiveness is discussed.

Keywords: SEE Theory, SEE Theoretical Methodology, Productivity improvement, Human resource strategy, Human resource utilization, Human resource management, Human resource utilization method

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Introduction

Against the backdrop of rapid technological innovation and intensifying competition, the Japanese government has taken various measures to improve industrial productivity in a short period. The human resource strategy is directly linked to productivity improvement and plays a central role, and is deeply involved in promoting diversity management and work style reform. However, it is not easy for Japanese companies to escape from utilizing human resources based on the lifetime employment system that has taken root in Japanese society for a long time after the war. Since the survey results[1)] show that many Japanese companies have realized that they cannot effectively utilize human resources, human resource management is currently an urgent and important issue among the Japanese companies' management issues.

While involved in corporate organizational development and human resource development, the author developed and proposed the diversity strategy tool "Diversity Standard" through the function analysis in the previous paper.[2)] In this paper, the author will further develop the elements related to productivity improvement and demonstrate the human resource management system through function analysis. Furthermore, a strategic and efficient method of utilizing human resources will be proposed that is effective for the human resource strategy to improve the organizations' productivity.

Current Situation and Issues of Productivity Improvement and Human Resource Strategy in Japan

Current Situation

Many top management say, "people, goods, money, and information. The most important management resource is people." Regardless of the company's size, Japanese companies have placed value on "human resources" and emphasized the acquisition, training, and management of them. The traditional approach by typical Japanese companies has been to establish evaluation criteria based on the lifetime employment system, secure the lives of employees in seniority, give grades, and ensure organizational harmony.

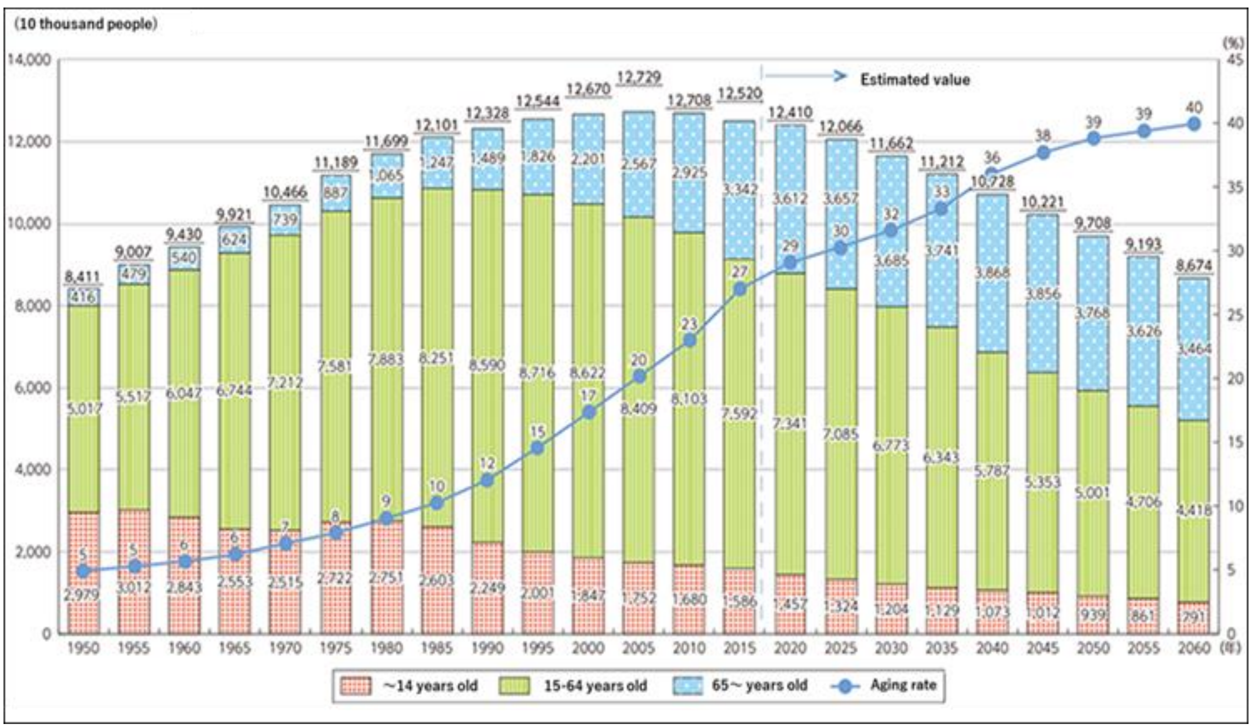

Figure 1: Population Projections of Japan

(2017 White Paper Information and Communications in Japan)

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However, with the rapid social changes, economic changes, and technological innovations in recent years, the approach has no choice but to change. It is clearly shown that the working population will continue to decline due to the declining birthrate and aging population, which is a serious issue in Japan (Figure 1). In addition, many companies face management crises under the current severe economic conditions, chased by the intensification of global competition. Besides being required to incorporate technological innovation and work to improve productivity, securing IT human resources, which is far behind overseas, is also a major issue for Japan.

Under these circumstances, Japanese companies are currently exhausted by being involved in the war for talent, struggling to secure excellent human resources and prevent the outflow of them. They face the opposite situation of utilizing human resources to improve productivity. It is challenging to secure excellent human resources even if they spend money on recruitment and the human resources that they have carefully trained, flow out of the organizations.

Issues

In the face of intensifying competition, diversification of customers, and drastic changes in the socio-economic external environment, what kind of human resource management should companies promote? Companies should adopt the following steps to promote human resource management: First is to secure diverse and talented human resources. The second is to provide a workplace where employees can work lively. The third is to ensure employees to be innovative and productive. These bring effective for management. However, most companies do not have clues about how such an ideal form can be realized.

In Japan, various measures are being taken under the initiative of the government to promote productivity improvement. However, many Japanese companies are at the mercy of the main keywords that appear one after another, such as Managing Diversity, Promotion of Women's Participation and Advancement in the Workplace, Work Style Reform, Productivity Improvement, and Digital Transformation (DX). The current situation is that they are being swayed by the business crisis issues in front of them without understanding the essential significance of those keywords or without making essential efforts.

Human resource management is involved in all the issues hidden in the series of main keywords mentioned above. This is the reason why human resource management is an issue that is directly linked to management strategy.

Conversely, it has been reported that the personnel department in charge of human resource management, often do not participate in the decision-making of management strategy in most of the Japanese companies[1)]. This is the essential issue of human resource management that the industry currently faces in Japan.

The human resource utilization is not commensurate with the human resource management. It is crucial for companies to position human resource management as a management strategy and work on it. There is no doubt that the personnel evaluation system is an essential factor in human resource management. Moreover, in the future of human resource management, it is inevitable to go beyond the conventional management work such as evaluation and determination of rewards and grades, to work on the organization and individuals effectively, and to make strategic approach for human resource development and organizational development.

It is necessary to shift from the attitude of conservatively protecting "people" to the attitude of strategically utilizing "people". Even though the phrase "people, goods, money, and information. The most important management resource is people." has not changed, the time has come to reconsider how to place importance on people.

Function Analysis of Human Resource Management

Relationship Between Productivity Improvement and Human Resource Management

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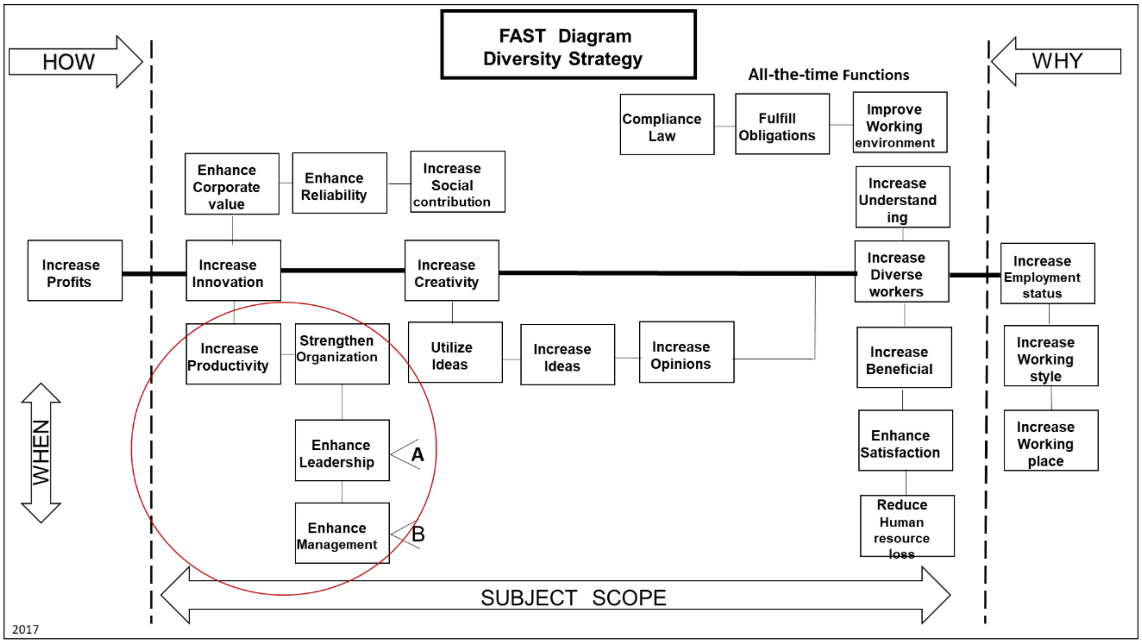

Figure 2: FAST Diagram "Diversity Strategy" (Noriko MURAKAMI, 2017)

Let us clarify the relationship between productivity improvement and human resource management. The author has developed a diversity strategy tool "Diversity Standard" through function analysis (Figure 2) to lead management results efficiently[2)]. The diversity strategy is an organizational strategy to ensure the diversity management's realization for enhancing competitiveness and improving management results. The developed Diversity Standard includes "increase productivity" as an essential requirement. It also demonstrates that productivity improvement is associated with many human resource management requirements, such as development of human resource ability for enhancing leadership and highly transparent personnel evaluation system. Human resource management is deeply involved in productivity improvement for management strategy.

Function Analysis of Human Resource Management

No	component	Verb	Noun	function type	No	component	Verb	Noun	function type
1	Acquisition	Acquire	Huma-resources	Secondary	4	Allocation	Develop	Human-resource-ability	Secondary
2	Cultivation	Procure	Basic-skills	Secondary	5	Exit	Replacing	Human-resources	Lower-order
		Compensate	Insufficient-basic-skills	Unwanted	6	Treatmnt	Strengthen	Control	Secondary
		Bring out	Ability	Secondary			Increase	Motivation	Secondary
		Improve	Ability	Secondary	7	Remuneration	Fulfill	Labor-contract	All-the-time
		Add	Ability	Secondary			Enable	Management-continuity	All-the-time
		Increase	Productivity	Highr-order	8	organizational - development	Increase	Profits	Subject Objective
3	Evaluation	Obtain	Basis-for-allocation	Secondary			Enhance	Corporate-culture	Secondary
		Increase	Reward-fairness	Secondary			Produce	Leaders	Higher-order
		Promote	Self-awareness	Secondary			Realize	Corporate-philosophy	Subject Objective
		Strengthen	Control	Secondary			Utilize	Human-resouces	Basic
4	Allocation	Increase	Contribution	Secondary			Increase	Appropriateness-for-allocation	Secondary

Figure 3: Random function identification

It is indispensable to guide an efficient and strategic human resource utilization method as a management strategy without sticking to human resource management. Diversity Standard, however, did not focus on a specific method for strategic human resource utilization.

Therefore, the author further developed Diversity Standard and conducted a function analysis of human resource management to clearly understand the essence of human resource management and derive a

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useful method for utilizing human resources. The targeted company is listed in the First Section of the Tokyo Stock Exchange, and is about 70 years after its foundation, which has approximately 300 employees on a non-consolidated basis and approximately 900 employees on a consolidated basis. It is a typical model of a current Japanese company, which has not been able to get out of the post-war lifetime employment system.

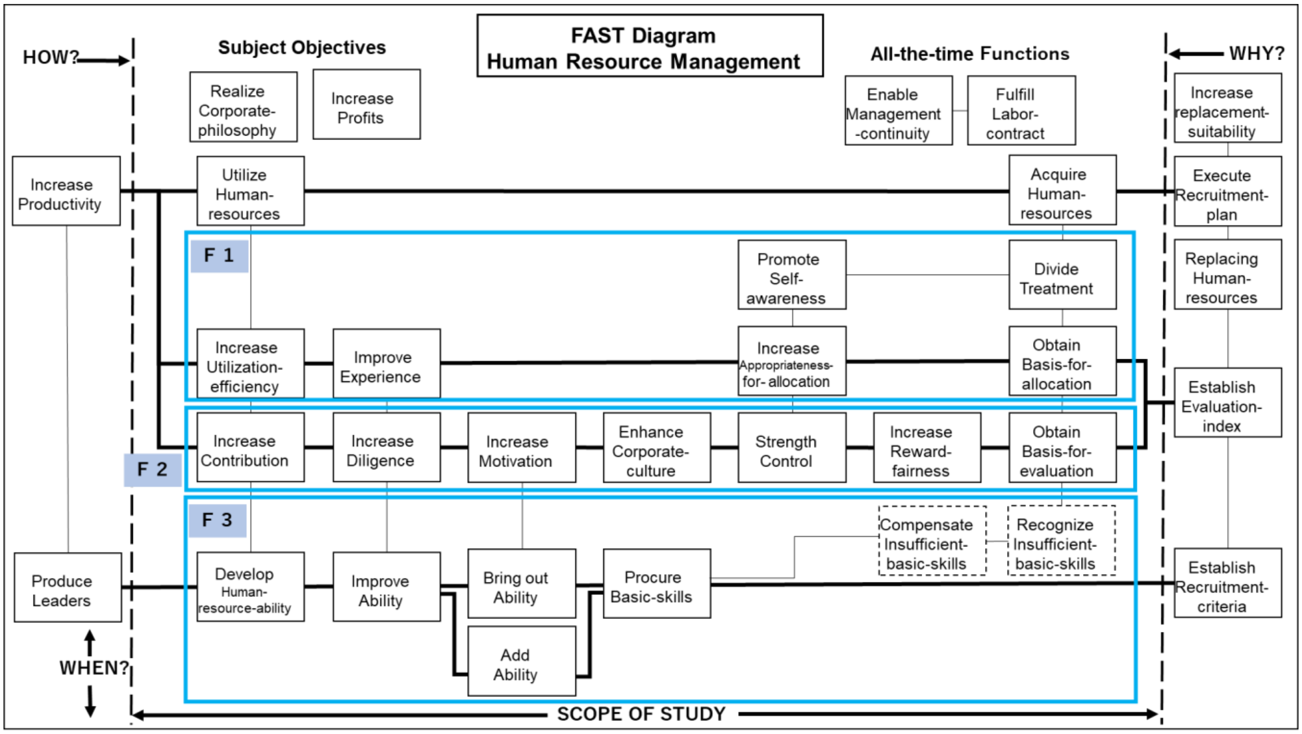

Figure 4: FAST Diagram "Human Resource Management"

After defining the functions from the components: "acquisition", "cultivation", "evaluation", "allocation", "exit", "treatment", "remuneration", and "organizational development" (Figure 3), a Function Analysis System Technique (FAST) diagram is created and modeled in Figure 4.

Scope of Study was defined from *Acquire Human-resources* to *Utilize Human-resources* whereas establishing evaluation system criteria, human resource recruitment criteria, and recruitment plan based on appropriate values for human resource replacement were excluded from the Scope. The analysis focused on how to utilize human resources and lead to *Increase Productivity* after acquiring human resources.

The FAST diagram demonstrated that *Increase Utilization-efficiency*, *Increase Contribution*, and *Develop Human-resource-ability* must be achieved at the same time when *Utilize Human-resources*. These functions are from the perspective of organization.

As a means of achieving each function, *Improve Experience*, *Improve Diligence*, and *Improve Ability* of employees are required. These functions are still from the perspective of the organization; however, it can be recognized that they are strongly based on the internal elements of the employees' perspective. The important points are how employee experience value, awareness of contribution to the organization, and self-actualization by improving their abilities can be achieved. It is worthy to note that these must be achieved at the same time. If any of these functions are missing, *Utilize Human-resources* will be either difficult to achieve or the degree of human resource utilization will decrease.

In addition, it was also reported that *Develop Human-resource-ability* is to *Produce Leaders*, and a condition for achieving *Increase Productivity* at the same time. Organizations aim to continue life while increasing productivity and producing the next generation of leaders.

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Traditionally, in Japanese companies, the remuneration system, human resource allocation, and human resource cultivation system have been managed as their respective efforts. However, from now on, they should be considered as a human resource strategy rather than human resource management, and promotion of comprehensive approach linked to the management strategy will be essential.

Human Resource Strategy for Productivity Improvement

The FAST diagram, shown in Figure 4 above presented the system of human resource management. How should we utilize the acquired human resources to improve productivity? The ideal form of human resource management shall be clarified, and a method that will lead to concrete actions for the utilization of human resources shall be established in the sequel.

Essential Requirements and Focus of Approach for Human Resource Management

First, the ideal form of human resource management that leads to productivity improvement will be clarified. The author has set the function areas of F1 to F3 by placing key functions as *Increase Utilization-efficiency*, *Increase Contribution*, and *Develop Human-resource-ability* (Figure 4). As a result, each key function was defined as three essential requirements for utilizing human resources.

The functions existing in each function area will be utilized as approach to achieve the key functions and regarded as a useful index for evaluating the achievement level of essential requirements.

Furthermore, to narrow down the focus of the approach to be conducted by the organization, the functions existing in each of the F1 to F3 function areas were extracted and organized as the “focus of approach” for the organization (Figure 5).

KF	Essential Requirements	Focus of Approach
F 1	Increase Utilization-efficiency	Right people, Right place
F 2	Increase Contribution-degree	Rewarding, Motivation
		Corporate culture
		Control
		Fair reward
F 3	Develop Human-resource-ability	Improvement of Ability
		Standardization for Basic-skills

Figure 5: Essential Requirements and Focus of Approach

In the F3 function area, there is an unwanted-function, *Compensate Insufficient-basic-skills*. It is particularly important to note that resources should not be invested for the unwanted-function. However, targeted company invested 4,480,000 yen per year, which is about 15% of the annual F3 resource of 29,968,000 yen. This is not the story limited to the targeted company. In most Japanese companies, training to improve basic abilities such as “prospective employee training” or “new employee training” is customarily conducted. However, such fundamental abilities should be already prepared before adoption. Recruitment standards should be clearly established, and personnel recruitment should be thoroughly implemented in line with the standards. The Japanese government advocates “Basic Skills for Working Adults in 100-years Life Society”[3)] and recommends and promotes awareness and acquisition of basic skills for working adults at each stage before entering society[4)]. Companies and individuals must thoroughly recognize that basic ability is not what companies should grant at their costs.

Development of SEE Theory and SEE Theoretical Methodology

Human resource management's essential requirements to increase productivity and the organization's approach have been clarified.

The author visualized an ideal form of human resource management (Figure 6) by integrating the essential requirements and the main approach presented in Figure 5 together with the important viewpoints obtained by the function analysis of human resource management. This has been named as SEE Theory. Human resource management is composed of three elements that are related to each other: “utilization efficiency,” “contribution,” and “ability development.” By simultaneously raising the achievement level of these three elements that include perspectives of both organizations and employees, it will be possible to improve productivity and produce leaders who will lead the next generation.

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The organizational perspective factor ("Company Centered") and the employee perspective factor ("People Centered") of the three elements are two sides of the same coin. "Utilization efficiency" for organization is "Improve Experience" or "employee experience" for employees. "Contribution degree" is "Increase Diligence" or "employee engagement". "Ability development" is "Improve Ability" or "self-actualization". SEE Theory, standing for "Self-actualization", "employee experience", and "employee engagement", reflects how the relationships between organizations and employees influence and contribute to each other.

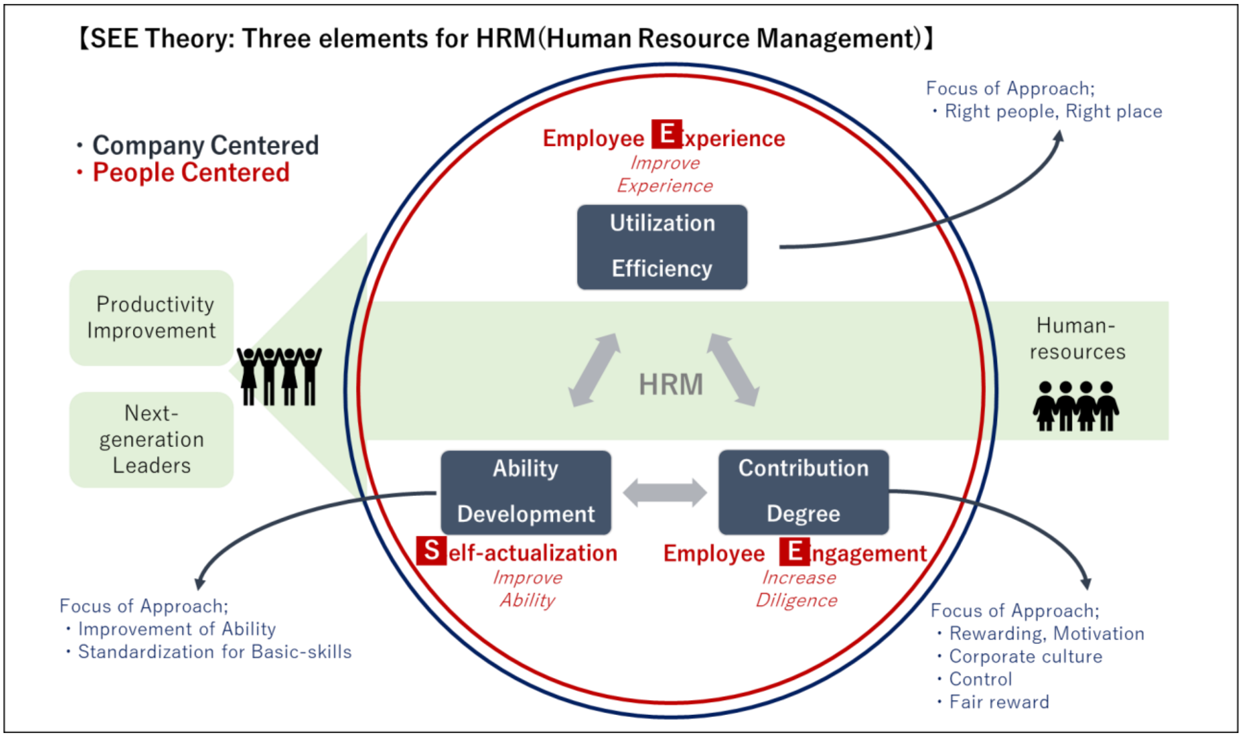

Figure 6: SEE Theory

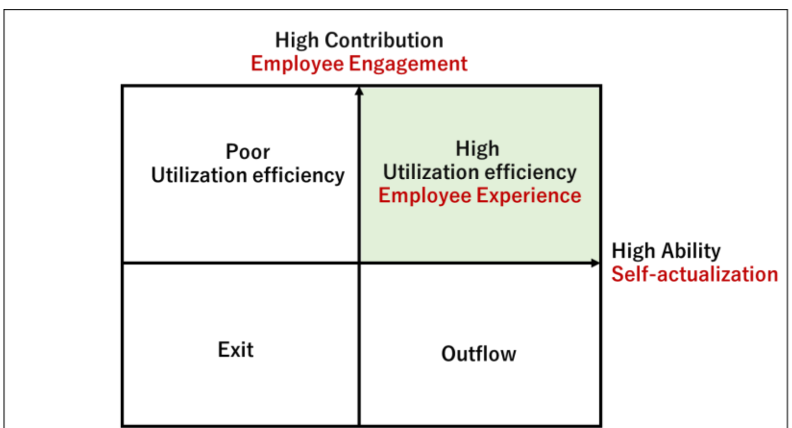

Figure7: Correlation Diagram Between Contribution Degree and Ability Development

In addition, the degree of contribution and ability development are factors that correlate with each other and have a large effect on utilization efficiency. These are also factors that are greatly involved in the outflow of human resources. The author created a correlation diagram of them (Figure 7).

In many Japanese companies, highly qualified personnel trained in-house investing time and money leave the company, or excellent personnel hired at the expense of the company leave the company shortly after joining. This falls under the "outflow" area shown in Figure 7. Even if their ability is high, they forsake the organization and outflow if their contribution is low.

Japan ranks last[5] for job satisfaction and happiness on "Global Job Satisfaction Ranking" by Indeed, the world's largest recruiting site, and ranks 132nd[6] out of 139 countries for the percentage of engaged employees according to Gallup's report. These results highlight the low employee engagement, which is a factor for contribution as a critical issue for Japanese companies in human resource utilization.

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SEE Theory is the composition of human resource management built with three elements that are related to each other: “utilization efficiency,” “contribution,” and “ability development.” By executing these three elements’ simultaneous improvement based on the SEE Theory, productivity improvement and production of leaders who led the next generation will become possible. This approach to utilizing human resources is defined as SEE Theoretical Methodology.

Standardization and Index of SEE Theoretical Methodology “SEE Theoretical Three -element Evaluation Guideline”

Element	Index	0 10 20 30 40 50 60 70 80 90 100		
UE	Right people, Right place	Unacceptable	Neither	Satisfactory
CD	Fulfillment to job	Dissatisfied	Neither	Satisfied
	Expectations for corporate growth	not at all	Neither	very much
	Expectations for self-growth	not at all	Neither	very much
	Empathy for corporate philosophy	not at all	Neither	very much
	Empathy for the employment system	not at all	Neither	very much
	Satisfaction with the work environment	Dissatisfied	Neither	Satisfied
	Consent to the reward	Unacceptable	Neither	Satisfactory
Comprehensive	Average			
AD	Self-improvement	not at all	Neither	very much
	Absolute evaluation	poor	Neither	high
Comprehensive	Average			
※UE; Utilization Efficiency, CD; Contribution Degree, AD; Ability Development				

Figure 8: SEE Theoretical Three-element Evaluation Guideline

SEE Theory has clarified what human resource management should be. To standardize SEE Theoretical Methodology, which is a human resource strategy and an approach to realize the ideal human resource management, and to lead a reliable result, the author created SEE Theoretical Three-element Evaluation Guideline together with the index (Figure 8). It is an employee-centered guideline since the internal factors of the employees have strong influences.

Among the evaluation items for the degree of contribution, “fulfillment to job”, “expectations for corporate growth”, and “expectations for self-growth” correspond to “rewarding or motivation” of the focused approach. “Empathy for corporate philosophy” corresponds to “corporate culture”, whereas “empathy for the employment system” and “satisfaction with the work environment” correspond to “control”.

Self-improvement evaluation and absolute evaluation of skills are placed as the evaluation items for ability development. The author also created “Essential Skill Evaluation Guideline for Ability Development” that contributes to grasping the skills to be strengthened and establishing educational programs and can obtain numerical indicators for each skill; however, it shall be omitted in this paper.

SEE Theoretical Three-element Evaluation Guideline can be practiced as an employee survey, and evaluation items can be added.

Advantages of Utilizing SEE Theoretical Three-element Evaluation Guideline

The first advantage is that the degree of achievement of the three elements from the employees’ perspective can be obtained numerically. With the provided evaluation index, measuring the degree of achievement has become possible. It also enables us to grasp the current value and set the target value, by which improvement activities can be effectively executed.

The second advantage is that the index value can be obtained efficiently. Recently, the number of employee engagement survey services is increasing, which can also be utilized; however, as most survey services merely present comprehensive evaluations or presenting too many items, whereas it is difficult to lead concrete actions for improvement. SEE Theoretical Three-element Evaluation Guideline was created based on the functions obtained from the FAST diagram and has essential focus; therefore, it can be an efficient survey tool and index.

Points to Note When Using SEE Theoretical Three-element Evaluation Guideline

We should note that the three elements; "utilization efficiency," "contribution," and "ability development" must be improved at the same time. As shown in Figure 8, even if only the ability is improved or only the degree of contribution is increased, it cannot be said that the utilization efficiency is improved, whereas it is hard to achieve productivity improvement. Using the evaluation, it is necessary to accurately recognize which elements are lacking in the company and which are to be prioritized, and promote them. The three elements must interact with each other and improve in a balanced manner.

In this chapter, SEE Theoretical Methodology was standardized by positioning the SEE Theoretical Three-element Evaluation Guideline as an inevitable achievement index. In addition, after narrowing the focus and enabling evaluation of the items to be achieved, it also contributes to clarifying the points to be improved, increasing the accuracy of priorities, concrete planning and executing, and efficient promoting.

Conclusion

In this paper, through the function analysis of human resource management, the purpose and ideal form of human resource management are clarified and SEE Theory was named and presented. SEE Theory is a composition of human resource management composed of three related elements: utilization efficiency, contribution, and ability development.

SEE Theoretical Methodology was proposed which is a human resource utilization method based on the SEE Theory. SEE Theoretical Methodology aims for productivity improvement and producing leaders who will lead the next generation. This methodology is a strategic and efficient method to utilize human resources, and it promotes the simultaneous improvement of the three elements: utilization efficiency, contribution, and ability development.

Furthermore, to standardize and substantially develop the SEE Theoretical Methodology, SEE Theoretical Three-element Evaluation Guideline was created. To improve ability development, utilization efficiency, and contribution in a balanced manner, obtained evaluation index and indicators that clearly grasp the issues will greatly contribute to improvement activities and the reliable execution of the plan-do-check-act cycle.

It is an urgent task for Japanese companies to promote human resource management as an initiative linked to management strategy rather than a straightforward personnel management. Value creation for the future through the utilization of human resources begins from there. SEE Theory is an important viewpoint for that purpose, and the SEE Theoretical Methodology is extremely useful for substantial approach.

In Japan, the era in which organizations only protect individuals as in the past is over. The era demonstrated by SEE Theory has arrived, in which organizations and individuals respect each other, contribute to each other, and grow together to improve productivity, achieve management results, and realize management principles. Function analysis of human resource management has contributed significantly to the elucidation of the mechanism for that purpose and has made it possible to improve useful organizational improvement. It also finds great potential for Value Methodology application in this field.

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Effective VM Application to Multi-Store Retail Companies

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Abstract

Ever since their emergence in Japan, multi-store retail companies, with an aim to support a richer life of the public, have been striving to open more stores throughout the country, by achieving their purchase cost reduction and organizational efficiency, based on the Chain Store theory. Since the turn of the 21st century, however, many of them have had a difficulty in achieving their customers' satisfaction due to ever-increasing changes as time went on. The main problem lies in the fact that the headquarters of these companies are ordering each store to do its business operations more efficiently and then each store ends up with just passively executing the directions from the headquarters as top priority. This causes a dilemma between following these orders and satisfying customers, which often leads to a general lower service quality and more customer turnover. To solve such a problem, the author would like to suggest an effective VE application for multi-store operations, which was obtained through functional analysis. By presenting a successful case, he also shows an effective way for a multi-store retail company to increase each store's morale and enhance its active operations, while improving the overall efficiency and maintaining their brand image.

Keywords: multi-store retail companies, headquarters/store sharing, 4-Meeting Functional Approach, store independence, service VM

Introduction

As of April, 2020, Higuchi Group, which this author works for, owns and operates 4 business departments with a total of 64 stores in Japan's southernmost main island named Kyushu. Many of our stores center in Nagasaki City, the capital of Nagasaki Prefecture in Kyushu, where our headquarters are located. Roughly speaking, our operations are divided into two: headquarters and stores. We have been running multi-store business, based on the Chain Store theory.

The Chain Store theory was introduced in Japan in the 1960's, with an aim at achieving a richer life of the public. Since its inception there, the theory has been adopted by many companies with their ambitious intents to develop multi-store retail businesses.

Since the turn of the 21st century, however, the Chain Store theory has become obsolete, reaching to the point where it cannot match the ever-changing needs of the times. The primary reason lies in that its excessive emphasis on work efficiency and productivity might have led to eliminating creativity and flexibility at a store level. As a result, store employees have ended up with a heavier emphasis on conducting their assigned tasks rather than improving customer satisfaction than their customer-centered approach.

This paper presents a case study on VM application to Higuchi Group and its effectiveness. Its purpose is for each store to be able to actively satisfy its customers, while executing orders from its headquarters to achieve the company-wide efficiency and to maintain the company's brand image.

Background of the study

Just as any other type of company, customer satisfaction depends largely on how well this author's multi-store retail company operates its business. No matter how good its headquarters' policy may sound, it would be impossible to gain expected customer satisfaction unless each store achieves it as they initially intended to do. This chapter describes issues with this company, from the standpoint of the relationships between the headquarters and the store.

Issues with the multi-store company

There lies a kind of dilemma in a multi-store operation. If organizational conformity is emphasized, store employees may execute their assigned task monotonously: Their work would diverge from their original ‘customer-centered’ manual. In the meantime, if store independence/work motivation and its delegation of authority are heavily emphasized, its efficiency and brand conformity may be lost, which leads to less customer-friendliness or more customer management cost.

Indeed, it is extremely difficult to balance management efficiency and customer satisfaction. This company should prioritize customer satisfaction and this awareness should be kept among not only headquarters staff, but also store employees. To this aim, this company should draw a clear line between headquarters tasks and store tasks and give the optimally-balanced delegation of authority to each store.

VM application to issues with the multi-store retail company

To cope with these issues, this company should actively apply VM, for its ‘User Priority principle’, ‘Team Design principle’, and ‘Change-by-Creation principle’, as tools for company problem-solving activities.

When it is implemented only in the headquarters, however, VM cannot satisfy the ever-changing demand of local customers at each store in a timely manner. Nor can each store improve its efficiency and maintain its brand image with their VM alone.

Considering the relations of headquarters/store VM implementation, the author thought that by devising such relations functionally, this company could solve its aforementioned issues. To begin with, he conducts a functional analysis on business operations of this company and clarifies functions to achieve. Moreover, to ensure their achievements, he shows the best application type out of three by comparison. Finally, he describes its effectiveness and points to consider.

Functional analysis of the multi-store retail company’s business operations

Functional area

The area of functional analysis is this multi-store retail company’s business operations.

Defining and diagramming the function

To analyze this multi-store retail company’s business operations, it is very important to understand the achievements of their necessary functions. To this aim, this author thought that it would be useful to define the functions of stores and the headquarters and clarify their mechanisms.

He set components as ‘A: stores’ and ‘B: headquarters’, as these are units of active organizations for this multi-store retail company: therein, component: ‘B: headquarters’ includes top management, general sales department in charge of stores, management staff department, etc. He defined each function from the components and diagrammed them in a FAST (**Figure 1**).

As shown in **Figure 1**, its functional area were set as the following five: <<Enhance customer-sympathy>>, <<Give use-comfort>>, <<Increase convenience>>, and <<Gain local-trust>>, and <<Extend company-activity-period>>. The FAST in **Figure 1** represents this company’s work as a mechanism, when its activity purposes/intentions are diagrammed as functions. Through this FAST, the stores’ following of the work manual and the headquarters’ building of the work system were clarified for <<giving use-comfort>> and <<gaining customer-support>>, but not for efficiency and low costs.

This author thinks that it is the nature of this multi-store retail company. This company who has put too much emphasis on efficiency should reconsider the true intentions and purposes for their ongoing business operations and organizations. By doing so, its activities can satisfy the function:

<<Enrich local-life>> as it originally should.

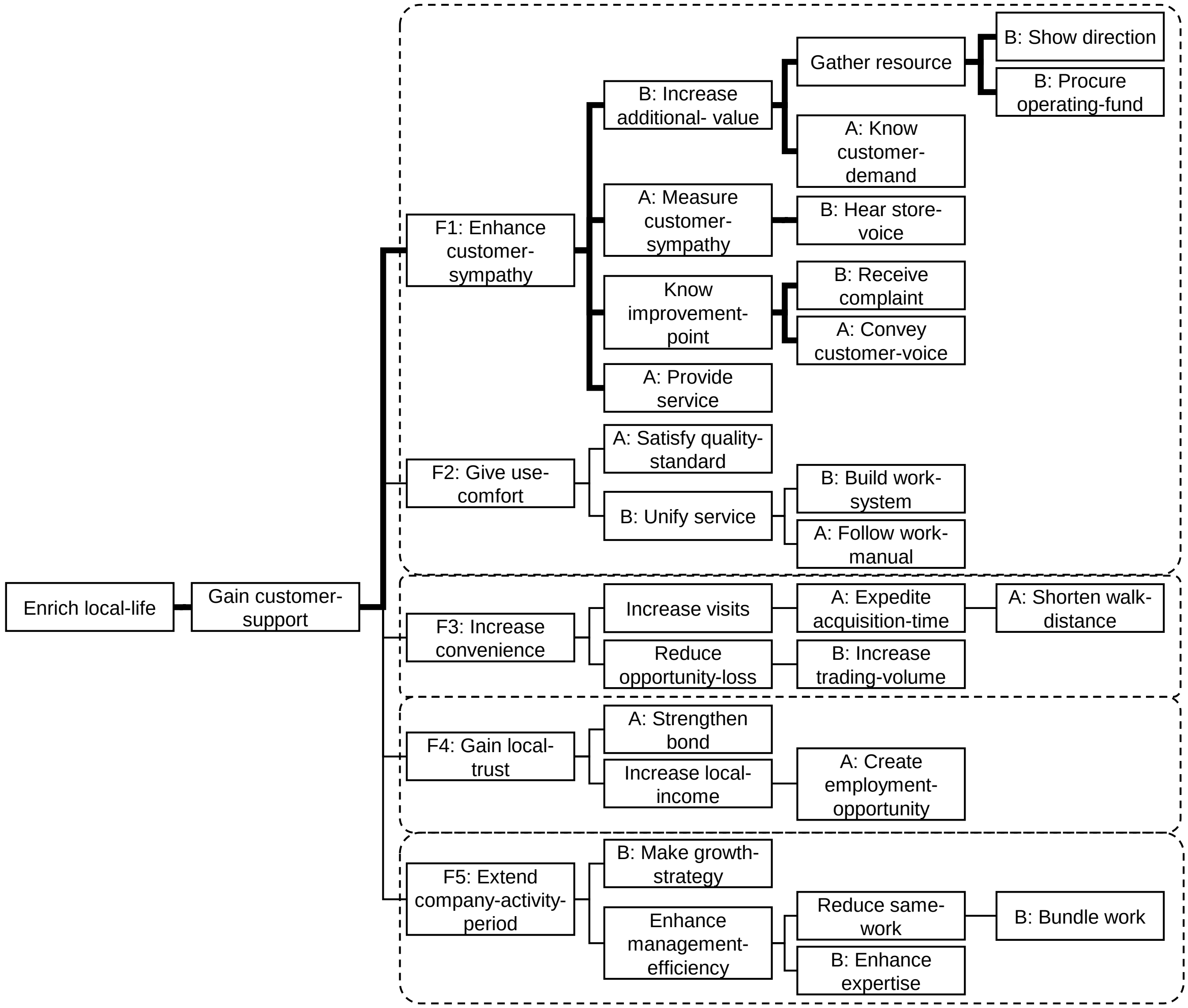

Figure 1: FAST

Three effective application types for the multi-store retail company

Through the FAST, functions that this multi-store retail company should achieve were made clear. Then, to ensure their achievements, this author describes how the company should apply VM. Considering the company's brand conformity (demanded from the headquarters) and the store independence to meet customers' needs (demanded from the stores), he applied 4-Meeting Functional Approach [1)]. This approach made it possible to have effective communications between the stores and the headquarters for a shorter period.

Setting VM application types

To conduct VM on this company, this author classified possible VM applications into three types.

Headquarters-initiative type

As the current stores lacks staff with VM expertise, the headquarters has an initiative to conduct 4-Meeting Functional Approach and then order their decisions to each store. This type is defined as the 'headquarters-initiative type'.

Headquarters/store-sharing type

4-Meeting Functional Approach that the headquarters and the stores would share is defined as the 'headquarters/store-sharing type' (this author's first choice). The headquarters define the function, as it has staff with VM expertise. To define and diagram the function requires expertise and whether VM activities are good or bad depends largely on it. Before the headquarters evaluate the function, they give each store detailed explanations on FAST.

After the function has been evaluated at the headquarters, then the stores conduct VM on their own, as they know well what their customers demand and can increase VM accuracy.

The headquarters and stores collaborate for evaluating alternatives: Two members from each side are to be selected (total: four members). All of them should have sufficient knowledge of VM. Through collaborative work, this style aims at the headquarters' increasing efficiency and maintaining a band image as well as the store's operating business with customer-centered motto and independence.

Store-independence type

4-Meeting Functional Approach is defined as the 'store-independence type'.

Cost analysis by each VM application type

This author defined the total cost as total standard hours – the summation of each hours in each step: therein, the number of pachinko (or slot machine) stores is 26 (**Figure 2**). Numbers with 'brackets' in **Figure 2** represent standard hours per person (H), those without brackets represent hours in each step, and steps without any numbers had not been implemented. Each step for each application type was calculated by multiplying the number of members and with that of headquarters/stores, and then by multiplying those results with standard hours per person.

The standard hours for the headquarters/store-sharing type differ from those of 'a-Meeting Functional Approach' in the following three points: 1) in the 'Information gathering for the subject' step, they require 52 (H) with the participation of 4 members from all the 26 stores (4 x 0.5H); 2) in the 'Diagramming of function' step, they also require 52 (H) with the participation of 4 members from all the 26 stores (4 x 0.5H); and 3) in the 'Evaluation of alternatives' step, they require 52 (H) with the participation of 2 members from the headquarters and 2 member representatives from all the 26 stores (0.5 (H) x 4 people x 26 stores).

The implementation of each type is 1 time for the 'headquarters-initiative' type, 26 times (store number) for the 'headquarters/store-sharing' type (for both the 'Diagramming of function' and 'Evaluation of alternatives' steps), and 26 times (store number) for the 'store-independence' type.

Basic step	Headquarters-initiative type (current)		Headquarters/store-sharing type		Store-independence type	
	Headquarters	Store	Headquarters	Store	Headquarters	Store
Number of members	4	0	4	4	0	4
Number of headquarters and stores	1	0	1	26	0	26
Information gathering for the subject	(1.0) 4	0	(1.0) 4	(0.5) 52	0	(1.0) 104

Definition of function	(1.0) 4	0	(1.0) 4	0	0	(1.0) 104
Diagramming of function	(2.0) 8	0	(2.0) 8	(0.5) 52	0	(2.0) 208
Cost analysis by functional area	(0.25) 1	0	0	(0.25) 26	0	(0.25) 26
Evaluation of function	(0.5) 2	0	0	(0.5) 52	0	(0.5) 52
Selection of the functional area	(0.25) 1	0	0	(0.25) 26	0	(0.25) 26
Idea generation	(0.75) 3	0	0	(0.75) 78	0	(0.75) 78
Evaluation of ideas	(0.25) 1	0	0	(0.25) 26	0	(0.25) 26
Developing of ideas	(1.0) 4	0	0	(1.0) 104	0	(1.0) 104
Evaluation of alternatives	(1.0) 4	0	(1.0) 52	(0.5) 52	0	(1.0) 104
Sub-total	32	0	68	468	0	832
Total	32		536		832	

Figure 2: Standard total time for each type

As shown in the lowest row in **Figure 2**, the total hours (as cost) are: 32 hours for the 'headquarters-initiative' type, 536 hours for the 'headquarters/store-sharing' type, and 832 hours for the 'store-independence' type. The first type requires the least cost, but it may create the lowest accuracy in achieving the functions and provide a service below the customer expectation standard. The following sections evaluate the achievements of the functions for each type, to see if they are up to the customer expectation standard.

Evaluation of each VM application type

This author shows which VM application type is the most effective for the said multi-store retail company (**Figure 3**).

Functional area	Importance coefficient	Customer expectation standard		Headquarters initiative type		Headquarters/ store sharing type		Store independence type	
		PR	Worth	PR	Worth	PR	Worth	PR	Worth
F1: Enhance customer-sympathy	0.47	3	142	2	95	4	189	4	189

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F2: Give use-comfort	0.16	3	47	4	63	4	63	3	47
F3: Increase convenience	0.16	3	47	3	47	4	63	4	63
F4: Gain local-trust	0.16	3	47	3	47	5	79	5	79
F5: Extend company-activity-period	0.05	3	16	4	21	4	21	3	16
Total	1.00		300		274		416		395

Figure 3: Worth of each VM application type by *PR (performance rating)

He evaluated the achievements of the functions by each VM application type through 'performance rating', an easy-to-use method suitable for evaluating the function of service. Therein, as 'customer satisfaction' and 'service' indexes for this method, this author used the corresponding ratings from the store's customer survey. Also, he used the statistics for the store's customer visit frequency and local share from the company's own analysis results. Furthermore, he set a business duration as that of the current brand store. All things considered, he evaluated the function of each VM application type through the DARE system, a method to compare the relative importance of each functional area.

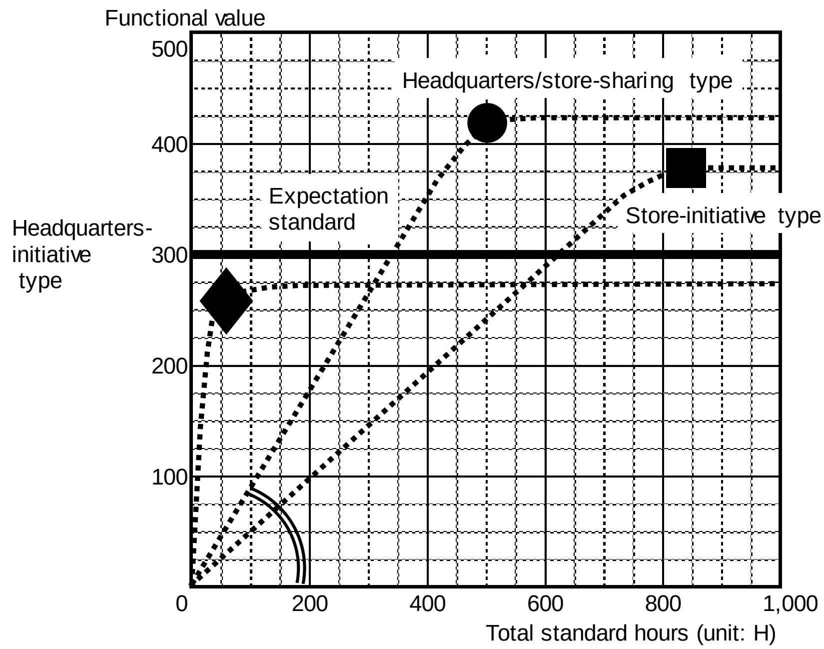

Figure 4: Graph of the relations between total standard hours and functional value

This author clarified the cost and functional values for the three VM application types. To easily visualize their relations, he made a graph (**Figure 4**): therein, the cost was plotted on its horizontal axis and the functional value was plotted on its vertical axis. This graph proved that the 'headquarters/store-sharing' type was the best choice, as the 'headquarter-initiative' type went below the customer expectation standard, while the 'headquarters/store-sharing' type satisfied it and cost less than the 'store-independence' type.

Points to consider and effectiveness

Points to consider

The transition from the 'Definition of function' step to the 'Evaluation of function' required a takeover from the headquarters to each store. The most important thing in this takeover was to gain a deep understanding of the theme's mechanism. One needed to increase one's awareness to functions to achieve, free from one's five senses or biases.

In the 'Alternative development' step, the headquarters and stores collaboratively evaluated ideas generated by the stores, before proposing the final alternative. Ideas generated by the stores alone might not have met the headquarters' brand or mid-/long-term strategies. It was important for them together to make such a final arrangement in the 'Evaluation of alternatives' step.

Effectiveness

The 'headquarters/store-sharing' type has the following two advantages. The first advantage lies in that this type increased morale at stores; this differed greatly from the conventional ‘headquarters-initiative’ type. Each store became more active to satisfy their customers, rather than do assigned task as top priority under the ‘headquarters-initiative’ type. To solve such an issue with the ‘headquarters-initiative’ type, this ‘headquarters/store-sharing’ type turned out to be very effective. Through the ‘4-Meeting Functional Approach’, store members became able to understand their purposes as the corresponding functions and the current values of their means. Further, they became more independent and responsible for generating ideas. Such change in their awareness made a difference in their business operations, which would lead to attracting more customers.

The second advantage lies in that the ‘headquarters/store-sharing’ type requires only the minimal headquarters’ direction. Contrarily, the ‘store-independence’ type has a danger that it may become so independent that they would lose efficiency for multi-store management or brand conformity that local customers are comfortable with. To solve such an issue, this ‘headquarters/store-sharing’ type adopted the theme for improvement from the headquarters, and the both sides could even evaluate alternatives in the final step.

From all of these, this ‘headquarters/store-sharing’ type proved ideal – a hybrid of the other two types, taking their good points.

Implementation at store

This author implemented the ‘headquarters/store-sharing’ type in all of the company’s 26 pachinko (or slot machines) stores and 21 restaurants.

Measures against COVID-19 at pachinko (or slot machine) store

Since its outbreak in China in January 2020, COVID-19 has widespread throughout most of the world. As the first case was reported in the Kyushu Region on February 20th, 2020, this company needed to take a preventative measure against COVID-19 for all its 26 pachinko (or slot machine) stores in a timely manner.

Implementation

This author defined and diagrammed the function and made a FAST (**Figure 5**). Function <<Control poor-brand-image>> was set from the headquarters’ request. He gave detail explanation of the FAST to the headquarters’ leaders and they understood the theme well and gained a stimulation for creative thinking. Then, he finished developing an alternative as a step towards taking an infection-prevention measure for customers at all stores.

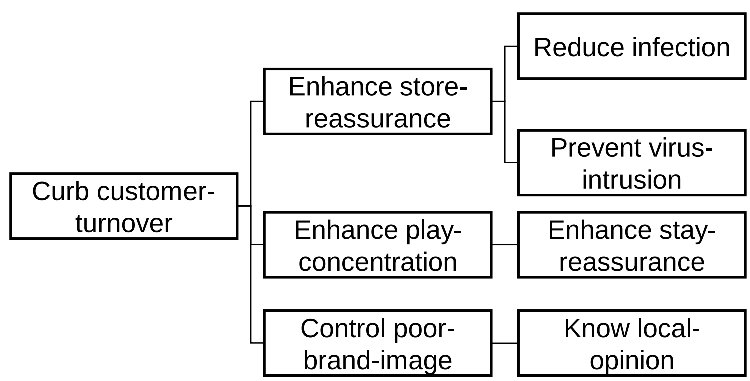

Figure 5: FAST

Results and issues

The ‘headquarters/store-sharing’ type made each store behave more actively for improvement. It enabled store customer service staff to share information and act as a whole team. From these verifications, this type proved effective.

One drawback of the type lay in that VM expert staff were not deployed equally among the stores, which bore a difference in activity evaluation. For that, this author thinks that such an issue would be solved if only the company increases the number of training for ‘4-Meeting Functional Approach’ as a part of the company’s education system or learning opportunities.

Measure against customer turnover at restaurant

As another case study, this author implemented the ‘headquarters/store-sharing’ type throughout all of the company’s 21 restaurants. The theme was to retain customers by providing impressive

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service or conveying heartful gratitude.

Implementation

For the restaurants, this author made a FAST by setting their current jobs as components (**Figure 6)**. COVID-19 made it difficult for them to achieve the function <<Strengthen bond>>. Considering this point, a headquarters leader asked all 21 restaurant managers to generate ideas for keeping the function <<Retain customer>> and enhancing the functions <<Enhance hospitality>> and <<Brighten mood>>. As a result, each store became able to generate ideas and share their ideas through their group SNS.

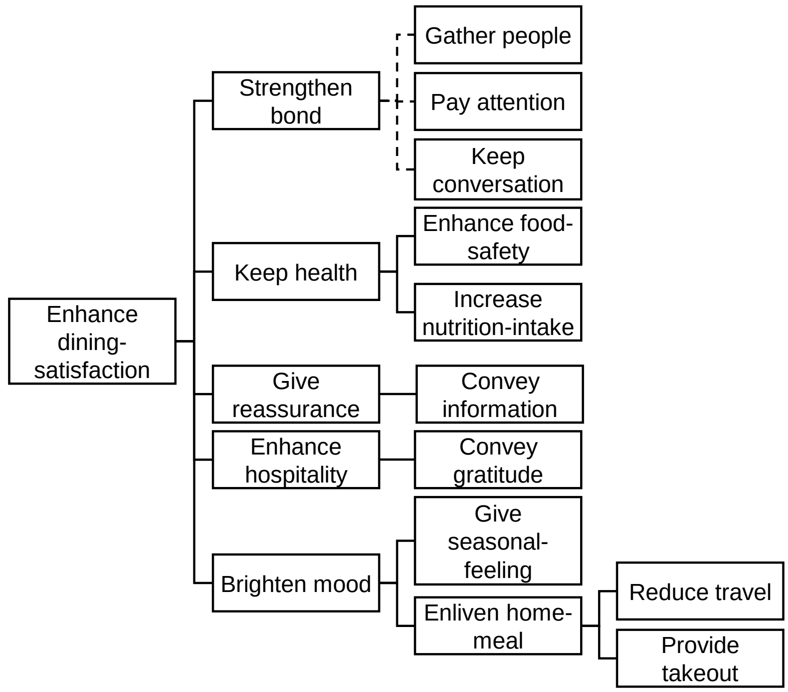

Figure 6: FAST

Results and issues

The 'headquarters/store-sharing' type made each restaurant gain a deep understanding of each function and active for better change through creative thinking. Before this type's implementation, these restaurants tended to simply do tasks assigned from the headquarters. After its implementation, however, they became more independent to do their activities for improvement with their team design thinking. This author believed that this attitude change would contribute positively to their future business operations. The issue with the 'headquarters/store-sharing' type was the same as that with the pachinko (slot machine) stores.

Future issue to address

One future issue with this company lies in that there is a shortage of VM expert staff at each store, even though VM expert leaders and members from the headquarters conduct '4-Meeting Functional Approach' collaboratively with store staff. To bear more satisfactory results, this company should develop more VM expert staff. Low VM skills at store may lead to insufficient and time-consuming VM Job Plan. In addition, they may not become up to the task. To cope with this issue, this author is planning to hold '4-Meeting Functional Approach' training on a regular basis and thus develop VM leaders at each store.

Conclusion

This author has proven that the 'headquarters/store-sharing' type was very effective for enhancing store independence at his company. In the recent past these stores tended to emphasize efficiency and conformity too much, thereby resulting in lower customer satisfaction. At present, however, they seem enjoying doing their own improvement activities with customer satisfaction as top priority.

Herein, the most important thing lies in that a company needs to create employees' independence. To this aim, the 'headquarters/store-sharing' type would be very effective. This author firmly believes that any other multi-store retail company with these issues can use this 'headquarters/store-sharing' type to help improve customer satisfaction as well as sales.

Note: 1) 4-Meeting Functional Approach: Simplified VM, named '4-Meeting Functional Approach'. Following VM Job Plan, it is used for having 4 meetings (each takes 2 hours). It usually takes 8 hours in total.

PROPOSING 'TIME INTEGRATION METHOD' TO QUANTIFY EVER-CHANGING VALUE WITH TIME – THROUGH THREE CASE STUDIES

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Biography

Hisaya Yokota is a Certified Value Specialist both by the SAVE International, USA and by the Society of Japanese Value Engineering and also is a Professional Engineer, Japan (P. E. Jp), certified by the Institution of Professional Engineers, Japan. He has been a leading VM Consultant over the past 23 years, has promoted the application of Design-phased VM to public works projects for the Ministry of Land, Infrastructure, Transport and Tourism, the Urban Renaissance Agency, Prefectures, Cities, Towns, and Villages, etc. He has conducted approximately 90 Design-phased VM Studies, creating a total savings of about 200 billion JPY in cost reductions. In 2010, after having worked as Director of the Value Engineering Center at Pacific Consultants Company Limited, he started the Functional Approach Institute Company Limited in Tokyo whereas President and Chief Executive Officer, offers business management strategies, project consulting services, and VM education.

Abstract

This paper proposes a new concept of "value that every value specialist around the world is already aware of." Its most critical point lies in how we can possibly grasp ever-changing value as times go by. Only after he had conducted numerous studies on the service industry, did the author notice this very "nature" of value, which differs from that in the manufacturing industry. Above all, its performance may vary significantly. The author had endeavored formulating this ever-changing performance into a numerical model through logical approaches and did finally succeed in doing so. Subsequently, he established a practical method – "Time Integration Method" – in job plans, in hope that it would be of immense help to a great many value specialists.

Keywords: service, quantification of performance, Life Cycle Value, Time Integration Value, Time Integration Method

INTRODUCTION

Value methodology (VM), since its inception in 1947, is widespread in various industries. Ranging from manufacturing, to begin with, through to service. Over the past two decades, this author has studied functional approach (FA) – a principle of VM, and thus has established a versatile methodology. Now he is endeavoring to disseminate its application to virtually every industry.

In July 2020, the VM Guide was published and in it it clearly described as the scope of VM application "Product, Process, Project, Organization and, above all, Service". It was, in this guide, for the first time that Service was officially documented as part of VM application scope. As a cowriter and a leading advocate, this author was honored to have contributed his writing to this guide.

There is no doubt that VM will be widely applied to the service industry. In response to the needs of each service, it would be necessary to develop techniques accordingly. This author has faced many cases where service's performance was changing as time passed. As described earlier, service is very unstable and difficult to grasp.

In this paper, this author summarizes the main characteristics and ever-changing "service" performance, diagrams and formulates them into a numerical formula, through several actual studies. He also shows job

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plans and sheets for applying this formula.

Features and Issues of Service

Simultaneity and time flow of service

In service, generally, its production and provision which take place simultaneously. In short, service possess its 'simultaneity' feature. In this regard, service differs substantially from products, for products can be provided some time after its production. This is one of service's features (**Figure 1**)[2]. Unlike products, service is destined to be produced and provided at the same time under the very nose of its customers.

There are exceptions: Some services can be kept beforehand, such as space renting, information, and security services. These can be kept before use.

Positioning them in a time flow, however, such services are considered in the middle of their production. Assume that there is one information service that is available for its members all through the year. Each member can gain a particular amount of information: This service produces and provides a bit of information on a regular basis – daily, weekly, monthly, or yearly (**Figure 2**).

Therefore when evaluating service, one needs to consider its feature of simultaneity. Its focal point lies in how service should be produced and provided in a time flow. The author thought that it should be quantified and visualized.

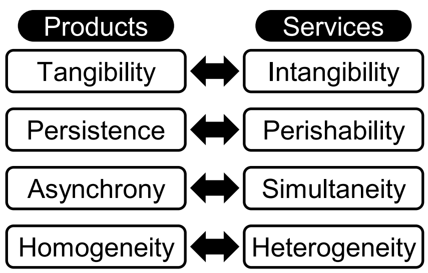

Figure 1: Service features

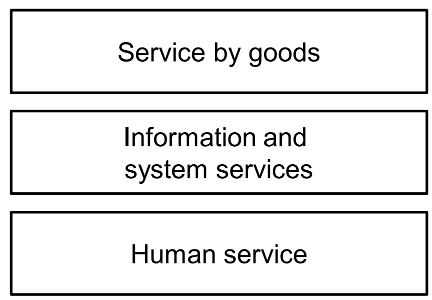

Figure 2: Types of Service

Heterogeneity and repeat effect of service

Service should never be evaluated as to whether it simply has been done or not. A service should not be judged on whether it's in progress or how many/much time(s) it has been done.

Service should be evaluated, based on its performance. What or how much performance it has given users determines said service's evaluation. In other words, service varies according to how its user perceives it. This is 'heterogeneity' of service (**Figure 1**).

Moreover, service varies by its timing. Its performance depends on how often or at what timing service is provided. Its repeat effect can be generated when service is repeated at the right time.

Given such issues, service is difficult to evaluate. Accordingly, this author thought that a new concept and technique would be necessary to take into good account of its heterogeneity and repeat effect. He discusses his concept in the following chapter.

Proposing Time Integration Method to Evaluate Service Performance

Concept of time change

To begin with, the author made a hypothesis that service performance would change as time passes. In other words, service may not always produce its performance as originally designed. Let us assume that there is a home security service. Its function is *Enhance safety*, but its performance is maximized during the 'leave' and 'sleep' hours.

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This author hit on an idea to make a graph of the relationship between time and performance: herein, time and performance are plotted on its x and y axis respectively (**Figure 3**). By doing so, one can easily see what performance is made at a particular point of time. Also, one can set its desirable performance when designing a service.

It is by no means an easy task to quantify these, for service has its intangibility and perishability as well as its simultaneity and heterogeneity. In other words, one cannot directly measure its performance. To do so, it is necessary to gain users' sense, according to each services' performance. Therein lies an issue with accuracy and reliability.

By taking this fully into account, the author proposes making a graph of average performances in each time division. By widening and narrowing time divisions, one can adjust performance accuracy and reliability (**Figure 4**).

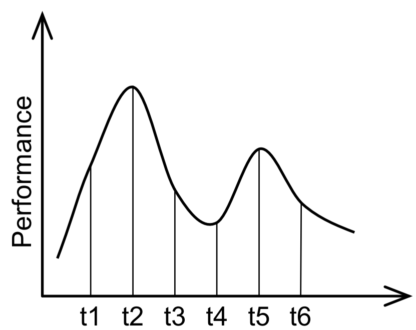

Figure 3: Performance curve

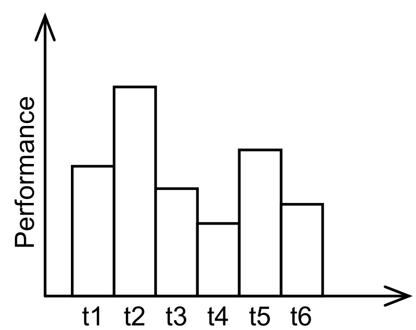

Figure 4: Performance changes

Time Integration Method

This author attempted to quantify service's performance, which is changing with time. To begin with, he made a function formula with time as its variable (**Formula 1**), for one can easily calculate it with such a simple formula.

$$Performance = \int_{Beginning}^{Ending} f(t)dt \qquad \text{...... Formula 1}$$

However, it turned out rather difficult to do so, as described in the previous section. Thus, the author decided to calculate its performance with summation of performances in all time divisions. It would be better to divide the entire service period equally into several time divisions. Smaller time divisions increase calculation accuracy, but the number of time divisions depends on each case.

Furthermore, this author plugged the value gained by **Formula 2** into Life Cycle Value Formula, which in 2019 he devised to quantify the value of service's life cycle. In his SAVE paper in 2019[4)], he described the difference between the potential value and the performance value and presented their formulas. Service's performance value can be calculated by **Formula 3**.

$$Performance = \sum_{t=1}^{n} Performance_t \qquad \text{...... Formula 2}$$

$$V = \frac{Performance}{Resources} = \frac{Potential}{Resources} \times \frac{Performance}{Potential} \qquad \text{...... Formula 3}$$

This formula uses a concept of 'potential'. 'Potential' is defined as the maximum performance that a service can originally make. Based on this concept, its service provider can design service to maximize its potential.

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In reality, however, any service cannot always make its performance at 100%. Through **Formula 2**, the author attempted to quantify service's potential: wherein, each unit of time is the same for a definite duration (**Formula 3**).

As a result, this author found out that service value for a particular period can be quantified by dividing the summation of performances in each unit of time with the total potentials (**Formula 4**).

$$\sum_{t=1}^{n} \mathrm{V_t} = V_{Potentianl} \times \frac{\sum_{t=1}^{n} Performance_t}{\sum_{t=1}^{n} Potential_t} \qquad \text{...... Formula 4}$$

He has named 'Time Integration Value' to the value gained by Formula 4 and 'Time Integration Method' to improvement of service value with Time Integration Value.

VERIFICATION THROUGH SEVERAL CASES

Cases with the value of employees

Let us assume that one needs to quantify the value of employees at a service business. It is a restaurant with 8 full-time employees and its business hours are from 10 a.m. to 2 p.m. It allocates the necessary number of employees for each business hour. Performance of each employee is counted as 10 points to the maximum. Also, workload for each employee is counted as 10 points to the full (**Figure 5**).

Time	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	Sum.
Potential	40	40	80	80	80	80	80	80	560
Performance	20	30	40	60	80	80	60	40	410
PP Rate	50%	75%	50%	75%	100%	100%	75%	50%	73%

Figure 5: Potential Performance Table

Gained through the table are 560 points as the total potentials and 410 points as the total performances. By dividing these, 73% is gained. This can interpret that this restaurant's actual performance is only 73% of its potential. In other words, there is 137% (reciprocal of 73) room for improvement at the restaurant.

The restaurant has had an issue with human resource use. It lies in how much loss per day it can reduce. To do so, the manager has had a difficulty in standardizing its workload and allocating its employees (**Figure 6**).

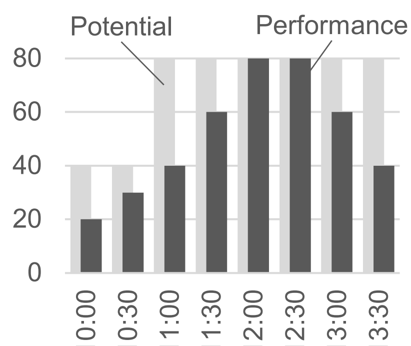

Figure 6: Human Resource

In general, those companies whose workload vary by day or season tend to have the same issue with workload standardization. This restaurant hires only full-time employees, not part-timers.

It is critical for stores' or businesses' to value how they can improve their employees' performance. Time Integration Method enables them to quantitatively evaluate their employees' performance for their various measures.

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Case with the value of passenger cars in Japan

As of May 2020, the total number of cars in Japan was 61.8 million (**Figure 7**). Such being the case, this author calculated how much of their performance was being made through Time Integration Method.

To start, he calculated the potential of the passenger cars: wherein, their maximum potential is gained with their full use. It is 262,800 kilometers if they run at the speed of 30 kilometers per hour for 24 hours a day throughout the year. This value is a theoretical value, which excludes time for filling gasoline/electricity and maintenance.

Then, he calculated their performance. The total mileage of all the passenger cars in 2020 was 660.7 billion kilometers. By dividing this mileage with 61.8 million (passenger cars' number), the mileage per passenger car is 10,691 kilometers.

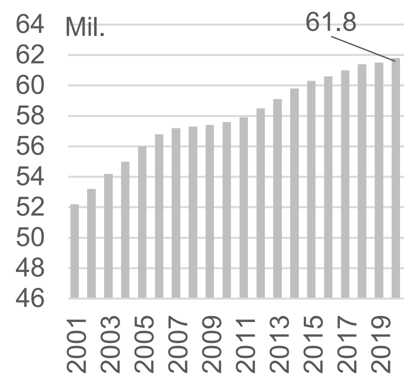

Figure 7: Number of Cars

Thus, their performance (time integration value) has turned out to be only 4.1%, for a one passenger car in Japan runs only 10,691 kilometers on average, while its potential is 262,800 kilometers.

As a result, it is projected that the passenger cars' time integration value can be enhanced with wide use of self-driving technology and car sharing. In other words, the total number of passenger cars in Japan is projected to decrease, as their time integration value improves.

Case with advertising effects on viewers' memory

It goes without saying that an advertising's effect depends largely on how long advertising is retained in its viewers' memory. By nature, humans can temporarily remember what they see or hear. At the same time, they start to forget it as time passes. For advertising, therefore, it is effective to let them recall it until its viewers forget it completely.

Hermann Ebbinghaus succeeded in expressing forgetting of one's memory as a function formula (**Formula 5**)[1)]. This formula is referred to as the 'forgetting curve', and it indicates that one's memory is exponentially forgetting as time passes. This author has calculated t's (time) integration value through his Time Integration Method.

$$b = 100 \times \frac{1.84}{(\log_{10} t)^{1.25} + 1.84}$$ ...... **Formula 5**

$$Performance = \int_0^{600} \frac{1.84}{(\log_{10} t)^{1.25} + 1.84} dt$$ ...... **Formula 6**

First, this author 'time-integrated' **Formula 5**: wherein, t is minute. Let t be 10 hours, and then t ranges from 0 minutes to 600 minutes. Thus, he gained **Formula 6**.

Through Formula 6, he calculated how much of memory one retains for 10 hours. It turned out that one retains 33.9% memory after 600 minutes (= 23,734). That is to say, 33.9% is advertising's performance.

On the other hand, the potential of one's memory for advertising is 60,000, gained by multiplying 100% with 600 minutes. Thus, the time integration value of advertising has turned out only 39.6% (**Figure 8**).

In other words, time integration value for advertising can be regained to 100%, if it is repeated within the given duration. Advertising, as an

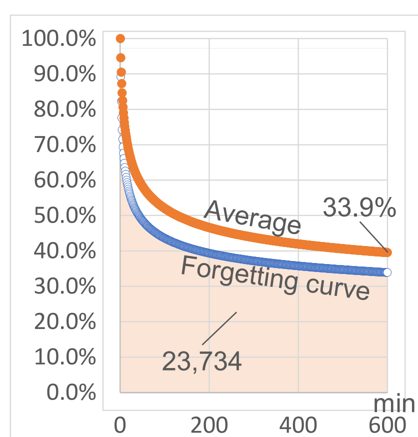

Figure 8: Forgetting curve

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intelligible service, can change its value, depending on how it is exposed to its target viewers within the given duration.

USE OF TIME INTEGRATION METHOD FOR VM STUDIES

Unit time summation sheet

The author devised a sheet needed to conduct "time integration". By plotting "performance" in each unit time on the sheet, one can calculate "performance/potential" rates to use for "time integration value" for a particular duration.

To begin with, the target duration should be divided equally into several "unit time" slots. Fill time in the top row of the table (**Figure 9** (1)). Next, calculate "potential": Fill necessary values in the appropriate row (**Figure 9** (2)) and then fill in calculation results (**Figure 9** (3)). The summation of calculation results should be filled in the last column (**Figure 9** (4)).

For "performance", record its values in each "unit time" (**Figure 9** (5)). Then, fill in their average value (**Figure 9** (6)). The summation of each average value should be filled in the last column (**Figure 9** (7)). Finally, "performance/potential" rates can be calculated by dividing the total performance value with the total potential value (**Figure 9** (8)).

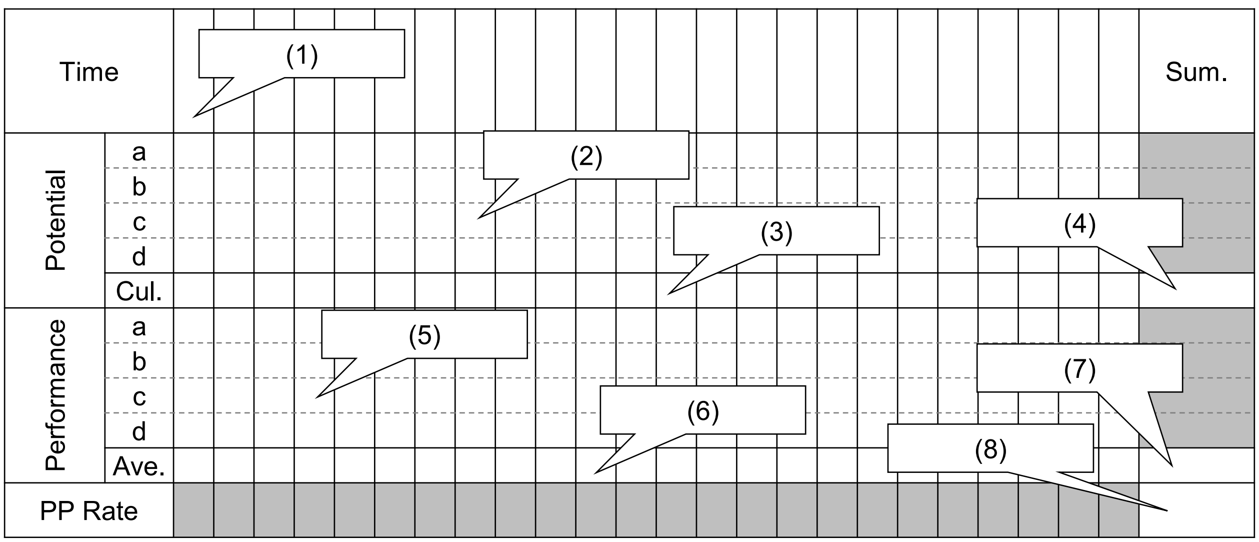

Figure 9: Potential Performance Sheet

By using this sheet, one can provide numerical evidence for improvement. It is versatile as one can easily expand the number of items needed to meet one's needs. Note that this sheet is unnecessary for cases where potential or performance can be obtained as a whole or easily by formulas.

Time Integration Method and Job Plan

The following explains where (or in which phase) in the Job Plan one should use Time Integration Method. As described earlier, this author has added time to the existing value formulas. Thus, it is ideal to use Time Integration Method in phases where one analyzes or evaluates value (**Figure 10**).

More specifically, it is in the 'Function Analysis' phase where one can represent ever-changing functions as time integration rates. To shorten work time, one can represent it by gradual divisions. For example, one can describe over 75% as "excellent", 75-50% as "good", 50-25% as "passing", and under 25% as "failing", as shown in **Figure 11**: FAST of "Thank you very much"[3].

#1 Preparation
#2 Information
#3 Function Analysis
#4 Creativity
#5 Evaluation
#6 Development
#7 Presentation
#8 Implementation

Figure 10: VM Job Plan

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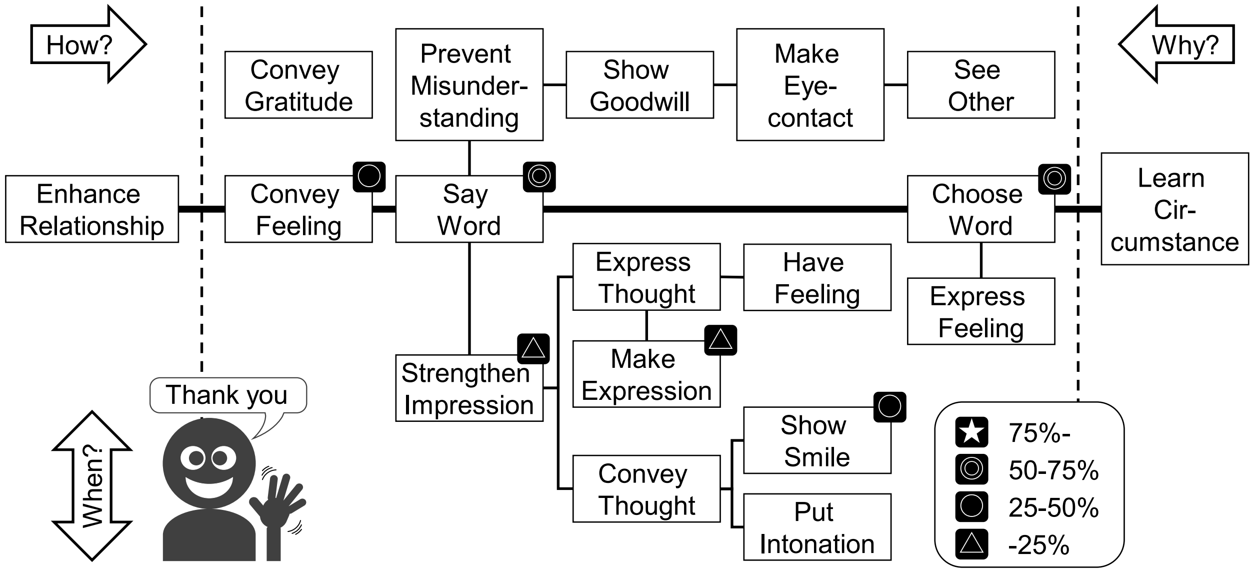

Figure 11: Mark Sample for FAST of 'Thank you very much'
(Hisaya Yokota, 2019, "Life Cycle Value and Its Evaluation")

Another area in the Job Plan to use Time Integration Method is the 'Evaluation' phase. The reason is that one can easily identify an area for improvement in the FAST and then can find a solution to value improvement. Also, by focusing on improving time integration value, one can make all the better alternatives when refining generated ideas.

Time Integration Method can also be used in many other phases in VM Job Plan, such as 'Information', 'Development', and 'Presentation'.

CONCLUSION

This paper has introduced Time Integration Method. This author has described the concept and formula to quantify time change of performance, which frequently occurs in the service industry. He has also proposed the sheet and timing to be used for VM Job Plan.

Through this Time Integration Method, one can satisfy one's customers more. This method can also be applied not only to service, but also to products and organizations.

People have tended to focus only on a point of production/selling time for products/services. They have thought that they can make improvement if only these go well.

However, the author does think that any product/service should be evaluated through their life cycle for their value. Ultimately, it is value specialists' duty to provide value products/services.

This author sincerely hopes that this paper will be of great help to many value specialists.

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Proposing ‘Function Layout Matrix’ Method for Optimizing the Office Design

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Higuchi Group

Abstract

This study proposes a new method to design one’s office with a special focus on its important functions. It enables one to visualize cost allocation for each area of one’s office, based on its ideal functional achievement. The office’s function changes as its company grows. This can be interpreted that the office does exist for its company’s growth, not just for its employees. In response to this, its layout should be modified along with its company’s growth. By understanding what phase one’s company’s growth stands in and by altering its office layout accordingly, one can achieve the growth of one’s company more effectively and efficiently.

Keywords: layout, individual, team, concentration, interaction, Function Layout Matrix (FLM), five phases of growth

Introduction

Virtually every company has a particular kind of office, as it serves as an essential function for them. However, people have often neglected one fundamental: What is the office for?

Every workday, people go to their office. Even though they have been relocated to a different section/department, they are quite often assigned an identical office. By and large, this has been a practice with the office layout in Japan. People have taken for granted that their office layout needs not to be altered once it has been determined.

However, this author has considered this practice as ineffective and inefficient. Therefore, he has conducted studies to find out what the ideal office layout should be, through analysis of its important functions.

New issues with office design along with its company’s growth

Ever-changing office functions

There are an ever-increasing number of companies around the world: For instance, 100 different companies may have 100 different formats for their offices, such as face-to-face or round-desk offices. Some even have cafeterias, gyms, and nurseries.

These programs have been created in response to the times. The present era, abundant in PCs and smartphones, has made people alter how they work, which differs greatly from the previous eras. Accordingly, this change has been taking place within the office’s functions.

Even though it is subject to work environment change, each company has each different circumstance by nature. These two do not necessarily correspond to each other. In fact, some companies remain the same in how they operate their business, even after they have introduced the latest technology.

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Under these circumstances, the office layout should be modified in correspondence with change in its company. Companies should design their office, not by imitating the latest fad but by satisfying their ever-changing needs.

One's stereotype and other factors to hinder improvement for the office design

In office design, the most important aspect lies in how companies can achieve the most desirable work environment for their employees. Nonetheless, people has accepted the 'unchanged' office as 'easiest to work in': They work at the same desk, using the same PC.

In reality, however, things are changing day by day. Just seeking work comfortability might lead to stunted growth of the company. In the first place, employees are supposed to help grow their company. Thus, their office should undergo change, associated with its company's growth.

One major drawback is that it would take much time and cost to change the office layout. Also, it would affect all departments and their employees. Having said that, nothing would change for the better, if one does nothing about it. One should change one's office in response to the times. By doing so, ultimately, one should change how they work for their company's growth.

Diagramming the function of the office design

FAST of the office

Up to the present time, a vast majority have supported the idea that 'the "unchanged" office is easy and efficient to work in'. Indeed, it may sound right but nothing remains unchanged for the better.

Thus, this author attempted to analyze the function of the office through FAST. He used the office layout of his company's headquarter as the scope of analysis. Based on this layout, he defined its use purpose by each named zone (Figure 1).

The first thing that the office designer does is to determine where each component zone should be placed. Accordingly, this author diagrammed functions of these component zones. The results are shown in Figure 2: There are six functions – F1 <<Strengthen departmental-bond>>, F2 <<Increase interdepartmental-interaction>>, F3 <<Extend concentration-time>>, F4 <<Reduce nonwork-time>>, F5 <<Shorten clerical-time>>, and F6 <<Keep company-image>>.

Component	Name	Use purpose
A	Rest zone	Place where employees eat/drink or relax
B	Reception zone	Place where employees receive visitors
C	Meeting zone	Place for meetings
D	Director zone	Place where the managing director works
E	Business zone	Place where employees do business
F	Work zone	Please where office supplies are stored and employees can do simple work

Figure 1: Components of the office

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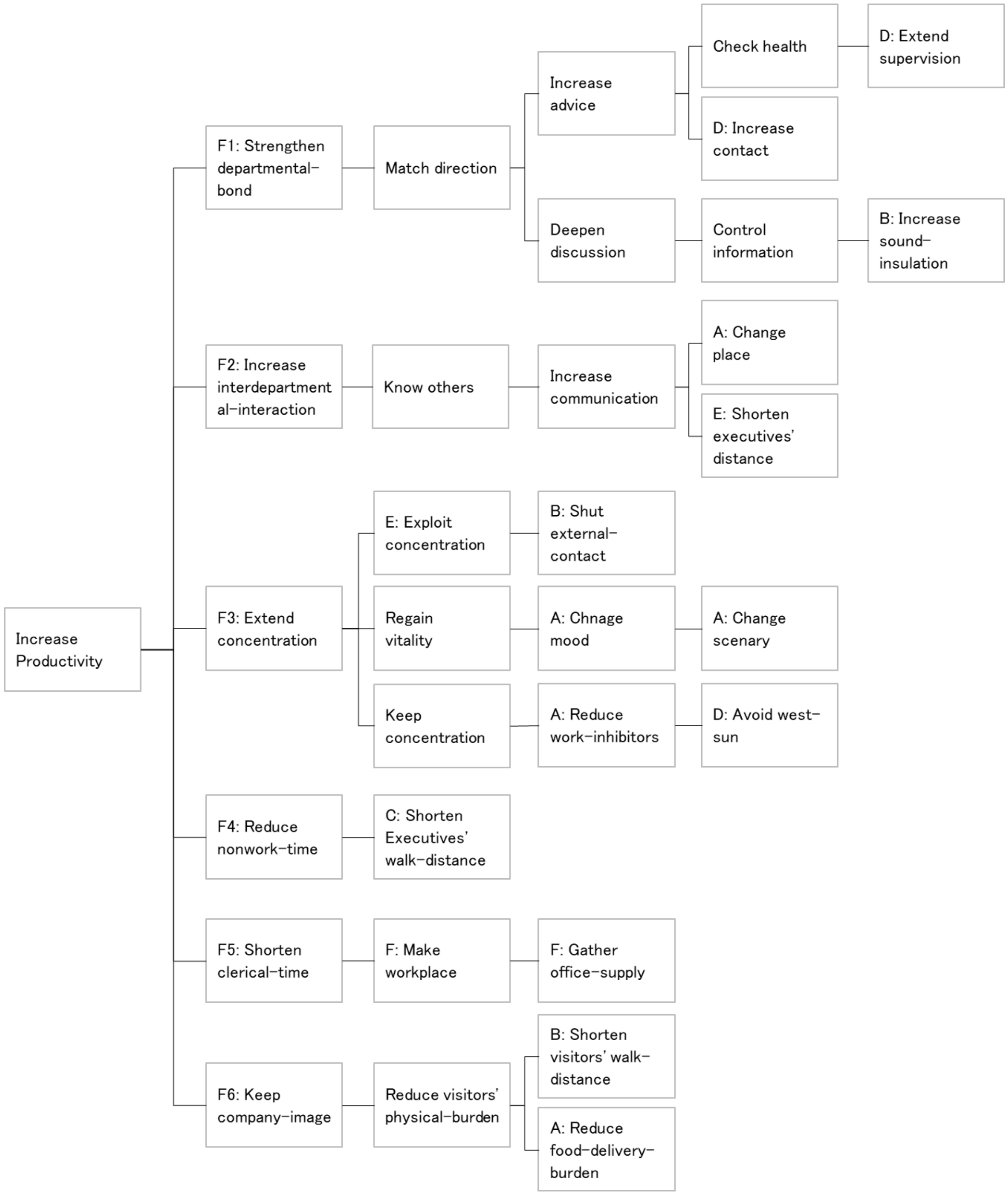

Figure 2: FAST

Three key functions for the office

FAST made clear what functions the office should have. Each key function is inevitable for the office layout.

Furthermore, this author described critical functions from each key functions. Users of the office are defined as the company's employees. They use their office for their company's growth. Thus, they function as components highly associated with the company's growth and should be considered critical functions of the office.

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From the above concept, this author narrowed the six functions down to three as critical functions, as F4 and F 5 are for the employees and F 6 is a secondary function for the office: F1 <<Strengthen departmental-bond>>, F2 <<Increase interdepartmental-interaction>>, and F3 <<Extend concentration-time>>. These are truly important functions for the company’s growth. The ideal office can be designed by a layout that can achieve these three. Therefore, one should generate ideas based on these functions, when designing an office.

Organization’s life cycle and proposing Function Layout Matrix (FLM)

Conversion of key functions into matrix

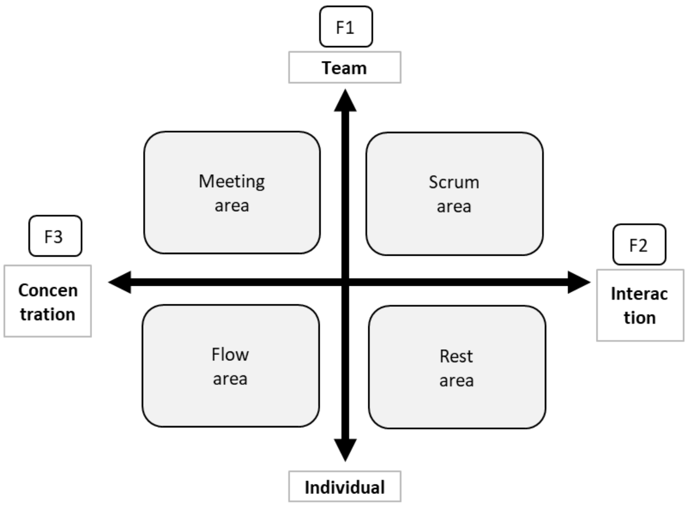

Figure 3: FLM

This author studied how the three key functions are related with one another. The first focal point was the relations between F2 and F3: If concentration time is extended (F3), interdepartmental interactions cannot be increased (F2). Also, he noticed that the opposite of F1 <<Strengthen departmental-bond>> is individual ability.

From these results, this author made a visual matrix, where ‘team’ and ‘individual’ are plotted on its vertical axis and ‘concentration’ and ‘interaction’ on its horizontal axis. Moreover, he discovered that in the matrix, there are four areas divided by its vertical and horizontal axes: an area prioritizing ‘team’ and ‘interaction’, an area prioritizing ‘team’ and ‘concentration’, an area prioritizing ‘individual’ and ‘interaction’, and an area prioritizing ‘individual’ and ‘concentration’.

This author has named the resulting table ‘Function Layout Matrix’, referred to as FLM hereinafter (Figure 3). Also, he has named an area where a team interacts ‘scrum area’, an area where a team concentrate ‘meeting area’, an area where individuals interact ‘rest area’, and an area where individuals concentrate ‘flow area’, respectively.

Organizational growth and four areas of the office

The office should be modified, according to change in companies’ circumstances. A company’s life cycle ranges from its inception through to its maturity. Thus, how one should change one’s office depends on one’s company’s circumstances.

Taking these fully into account, this author came up with an idea that the office should change according to its company’s size and maturity. For instance, a start-up company has a small size and not yet a considerable amount of maturity. Thus, its office should be determined accordingly.

Therein, the author paid attention to ‘five phases of growth [1]’ proposed by Larry E. Greiner who authored *Evolution and Revolution as Organizations Grow*. As five phases of the company, Grainer advocated ‘Phase 1: Growth through Creativity’, ‘Phase 2: Growth through Direction’, ‘Phase 3: Growth through Delegation’, ‘Phase 4: Growth through Coordination’, and ‘Phase 5: Growth through Collaboration’.

By combining Greiner’s concept, this author discovered relationships among his four areas of the office. To achieve the growth through Creativity in Phase 1, one should design an office layout to prioritize individuals/interactions, for Creativity can be generated through individual communications.

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To achieve the growth through Direction in Phase 2, however, one should design an office layout to enhance the concentration of 'capable' individuals, for this is the phase where the company grows under the Direction of 'capable' managers. As for Phases 3 and 4, one should design an office layout to prioritize the team and its concentration, as these are the phases where the company grows through Delegation and Coordination.

In the last Phase 5 one should prioritize team/interactions, as this is the phase where the company grows through Collaboration. These were the author's findings of relations between FLM's four areas and Greiner's 'five phases of growth'.

Diagram of the relations between FLM and 'five phases of growth'

In his 'five phases of growth', Grainer also described 'revolution' to overcome crises that each phase ends with: 'Leadership Crisis', 'Autonomy Crisis', 'Control Crisis', 'Red-Tape Crisis', and 'Internal Growth Crisis'. These crises, which a company should overcome to grow to the next phase, arise when each phase ends. Thus, this author proposes modifying one's office layout before each crisis occurs.

This author has successfully diagrammed the relations between FLM and the timings of an office's layout change (Figure 4). Through this diagram, one can modify one's office layout according to one's company's sizes and maturity.

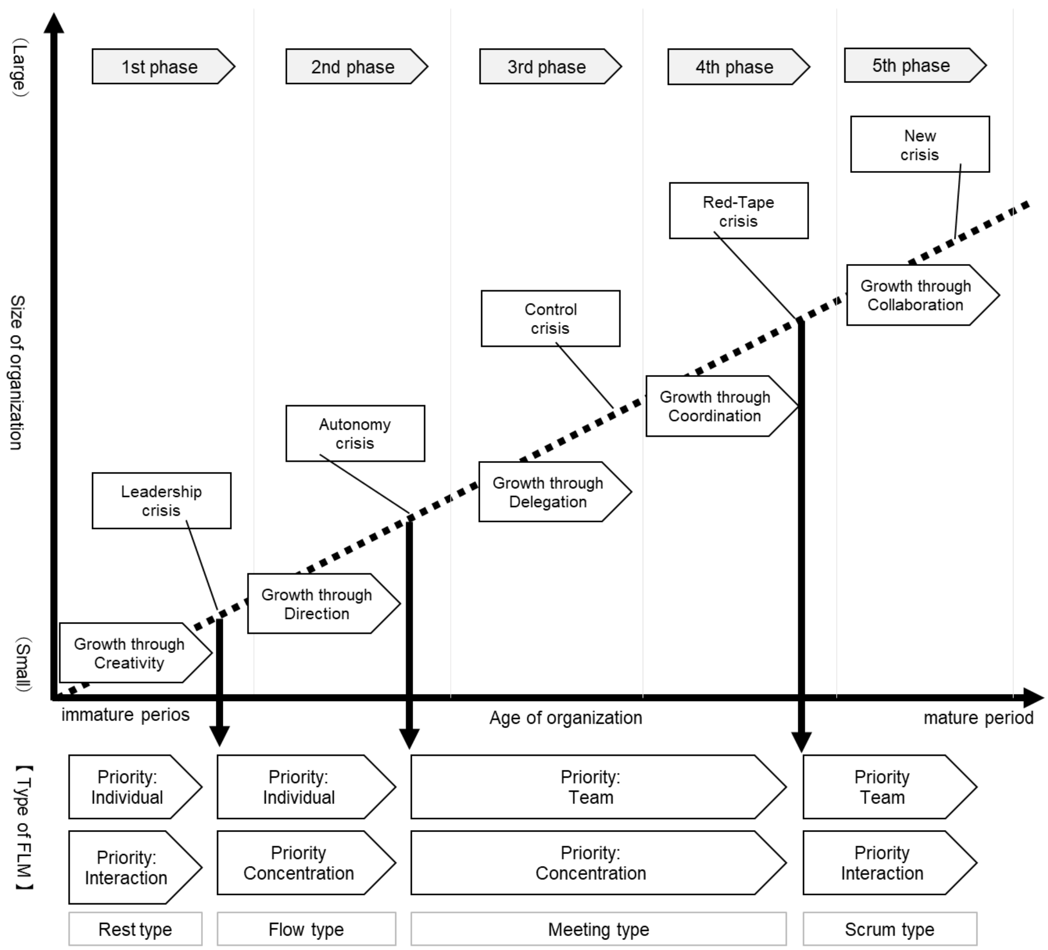

Figure 4: Evolution phases and FLM types

Figure 4 shows an example of the optimal office layout through each phase of a company's evolution. By altering one's office layout before each crisis occurs, one can help one's company grow and overcome each crisis.

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Case with FLM application to an office relocation

An office's layout before its relocation

Higuchi Group, a company that the author works for, decided to relocate its head office in May, 2021. Its relocation will be the first time for 28 years. Management asked this author to apply VM to a new office layout in response to the times.

He set 'office layout after relocation' as the VM subject for improvement, called project members, and held workshops for four days. Then, he verified the current, head office layout. The problem with the current office layout lies in that there are partitions between face-to-face desks and each department, which leads to fewer opportunities for communication (Figure 5).

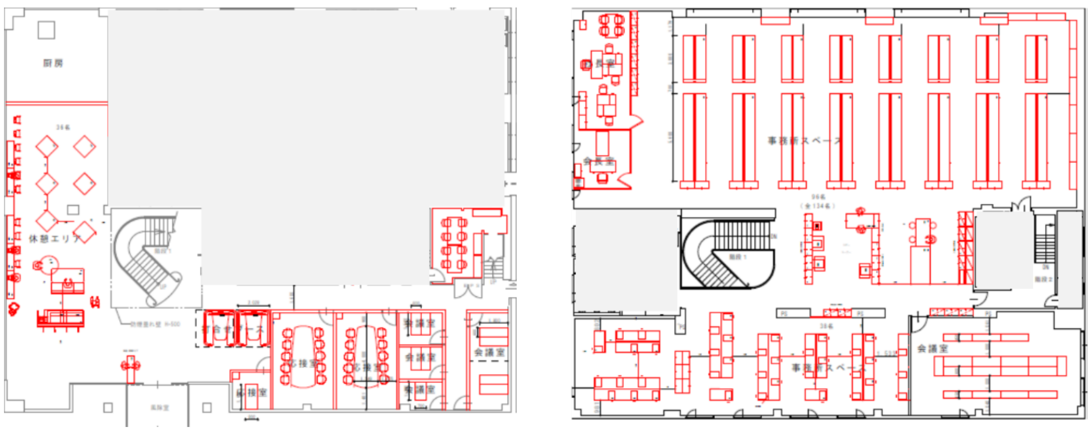

Figure 5: Current office layout (left: 1st floor; right: 2nd floor)

FLM evaluation and points for improvement

Through FLM, this author evaluated the importance of three key functions by DARE. He shared the company's requirements with other members and evaluated the importance of each function collaboratively (Figure 6).

Key function	Relative weighted coefficient (R)	Absolute weighted coefficient (K)	Weighted coefficient (W)
F1 Strengthen departmental-bond	1.5	2.25	47.4
F2 Increase interdepartmental-interaction	1.5	1.5	31.6
F3 Extend concentration-time		1	21.1
Total		4.8	100.0

Figure 6: Importance of the key function

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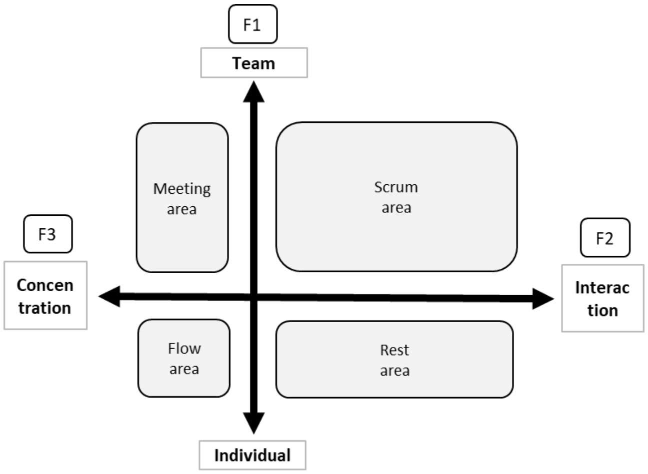

Figure 7: FLM evaluation

Then, this author determined the importance of each key function on FLM axes, together with his members: They first determined the F2 and F3 importance on a graph's vertical axis, and second, the F1 importance on its horizontal axis. They found that 'interaction' is more important than 'concentration' on the horizontal axis; and 'team' is more important than 'individual' on the vertical axis (Figure 7).

From those results, they determined how much each of the four areas should be allotted in the entire floor: a 'scrum area' was most suitable based on the FLM evaluation. The 'scrum' type indicated that the company should grow towards Phase 5, so it turned out to be perfect considering the company's size and maturity at that time.

It meant that the company should spend most money on its 'scrum area' but least on its 'flow area'. Through idea generation, this author and his members came up with as many as 340 ideas, focusing on F1 <<Strengthen departmental-bond>> and F2 <<Increase interdepartmental-interaction>>.

Modified office layout

Figure 8 shows the resulting layout (right), gained through FLM on the current layout (left).

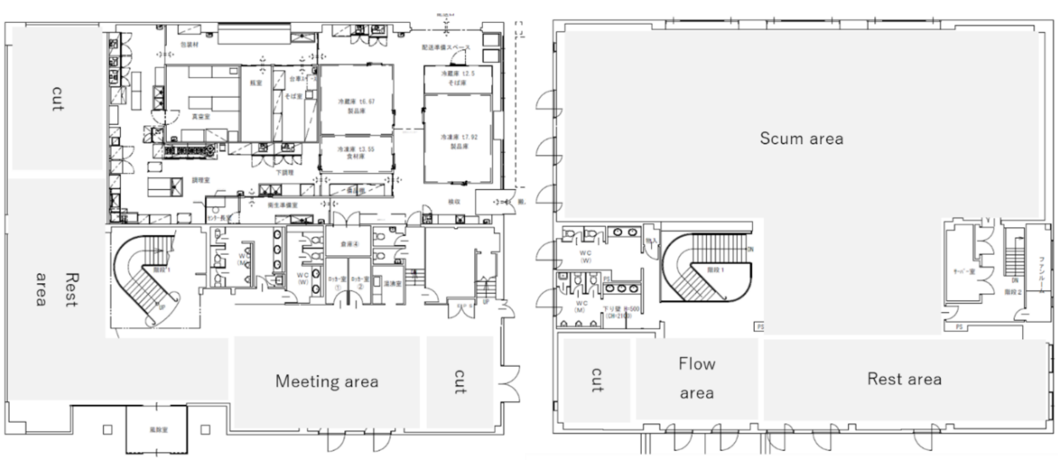

Figure 8: Layout of the four areas

From the generated ideas, this author selected and arrange components suitable for each area, and arranged desks to achieve each function. Thus, he altered the layout (Figure 9).

To achieve F1 <<Strengthen departmental-bond>>, the author devised a 'windmill-style' desk arrangement. This arrangement can reduce distances between members and increase one's visibility with other members.

Additionally, to achieve F2 <<Increase interdepartmental-interaction>>, he removed all partitions among departments and arranged one department next to another department. Also, he arranged the 'rest zone' adjacent to the 'business zone' so that employees could interact easily.

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Moreover, to achieve F3 <<Extend concentration-time>>, he created a new, ‘concentration zone’ where several ‘concentration rooms’ are provided (each room should be used for one person only). Though its area is small, an employee can concentrate on work in this room with partitions on its both sides.

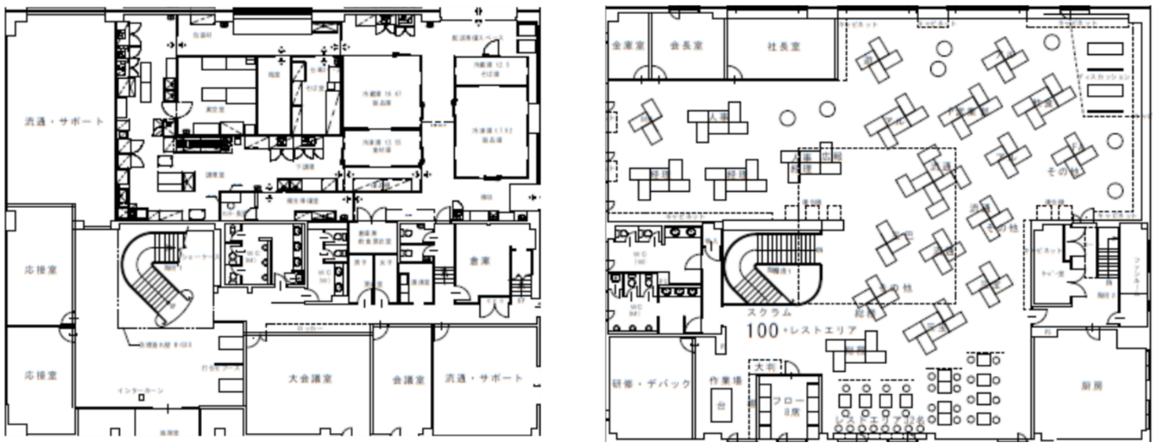

Figure 9: Altered layout

Effects of FLM

Through FLM, this author became able to develop ideas, which provided the opportunity for his members to evaluate them collaboratively. Also, this method enabled them to significantly shorten their idea development. Usually, it would take great time when determining an office layout – for what purpose each zone should have or where and for how large it should be.

Moreover, this author applied ‘five phases of growth’ as a verification of FLM evaluation results and proved it correct. It enabled his other members to be assured of their evaluation and go to the next step with a clear mind. Therefore, FLM can make it possible for any company to design its ideal office layout.

Conclusion

Through the given study, this author has proposed FLM – how one should design one’s office layout effectively and efficiently. For a company’s evolution, functions necessary for its growth should correspond with functions for its employees to satisfy.

Change in recent times has become faster and ever greater. In most cases, however, companies do not necessarily grow along with this change. One should always observe one’s company to find out where in the five phases it stands and how its office layout should be.

Ultimately, one should consider the role of one’s office for the growth of one’s company. The company growth should be more emphasized than a work environment that is friendly to employees. To do so, the company should share with its employees where in the five growth phases it stands.

If the company’s vision matches that of its employees, then each employee can learn how they should behave. This leads to a more employee-friendly office.

Note: [1)] Larry E. Greiner, 1979, “Five Phases of Evolution: Evolution and Revolution as Organizations Grow”, Harvard Business Review

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Application of "Multiple Cost Analysis" as a Human Resources Development Method for Middle Management and Its Measures

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Biography

Tomohisa Kakiyama joined Higuchi Co., Ltd. in 2000 and was engaged in store operations in the Food and Drink Division. After moving to the Human Resources Department in 2005, he was engaged in recruitment and education. He is currently engaged in the design of overall personnel systems such as compensation systems and evaluation systems. Since 2018, he has been studying VM theory from Mr. Hisaya Yokota, a certified value specialist at SAVE International in the United States.

Abstract

This paper presents "multiple cost analysis" – a VE application for developing 'middle management' by three key functions: 'work performance', 'work environment', and 'work motive'. The paper also describes a case study and its effect. There are many cases where VE subjects bear multiple costs: These multiple costs have variable composition ratios and influences. Considering these components, this author has developed a method for proposing effective alternatives for developing 'middle management'.

Keywords: work performance, work environment, work motive, multiple cost analysis

Introduction

'Middle management' is a VE subject in this paper. It is defined as 'a group of employees in a company who are in charge of departments or sections, but not the whole company': namely, 'department manager (*bochou*)', '*deputy department manager* (jichou)', and '*section manager* (kachou)' in Japan.

Virtually every company in Japan has a common theme: How can they develop their middle management? A Japanese portal site named *Nihon no jinjibu* (HR department of Japan) points out that one of the problems with the current middle management in Japan lies in the fact that 'without having learned skills that any middle management must have, they become middle managers, and they do whatever they want to do'. In fact, it is widely recognized that this is the case with many Japanese companies.

One thing to clarify here is that the fact that 'Japanese companies have not developed their middle management well' is just a result. They should make it clear how they can develop their middle management well.

Current middle management development in Japan

Japanese companies should check to see how they develop their middle management. In Japan, the word ‘human resources development’ is generally associated with physical trainings such as seminars, workshops, or books to name just a few. Common practice is that many Japanese companies hire a trainer within their budget allowance and if it does not work, then they will replace him/her with another.

It is estimated that these companies allocate more budget for training their middle management than for any other training. However, few companies are presumed to gain the satisfactory results through this common practice.

Compositions for higher performance

In *NikkeiBizPlus* (volume 12 in 2019), Takako Nakahara from Instructional Design Company states that the multiplication of three components – ‘work performance’, ‘work environment’, and ‘work motive’ – equals performance. The first ‘work performance’ means one’s skills, which also include one’s knowledge. The second ‘work environment’ means external elements such as bench marks, indicators, or one’s boss. The third ‘work motive’ means one’s motivation for work.

Nakahara also points out that many Japanese companies focus only on ‘work performance’ out of the three components through their trainings, while performance are produced from 20% of ‘work performance’ and 80% of ‘work environment’ and ‘work motive’ combined. This tendency holds true to middle management training.

Necessity for multiple cost analysis

One may analyze multiple costs that are borne when the ‘output’ changes for multiple causes. The multiple causes in this context means multiple causes to influence middle management performance.

In most cases, one analyzes multiple causes from a one-cost perspective, such as cost, time, and area. However, in a case where such said cost has little influence, it implies that there will be little room for improvement. For example, if one inputs money on a function that is uninfluenced, though it may be a small amount, it will end up as a waste of money.

Indeed, it would be difficult to analyze cost with one indicator, when the whole cost consists of variable costs. Such being the case, one needs to analyze multiple costs for VE theme where its performance function is relatively clear and yet it is difficult to set its scope in detail.

Gathering information and defining functions for the VM subject

Under these circumstances, this author analyzed multiple costs in VM Job Plan for ‘middle management’ as a theme for improvement. As components, he set ‘roles of middle management’ from ‘*The current issues with middle managers and their measures*’ reported by Japan Business Federation in 2012. Subsequently, he defined the function of ‘middle managers’ **(Figure 1)**.

Component		Definition of function
Item	Description	
A: Information	・Gather information in/outside the company and analyze it	Gather fact
		Add comment

	・Convey necessary information to top management	Convey information
	・Understand messages from top management and communicate it to subordinates onsite	Change expression
	・Show team clear direction to move on	Show direction
	・Negotiate with domestic/overseas group companies and share information with them	Solidify relation
B: Business Operations	・Process daily work and solve problems	Solve problem
	・Promote new business/projects and create innovations	Make plan
		Make judgement
	・Respond to globalized management	Research market
C: Interpersonal Relations	・Train each subordinate based on their strengths and weaknesses	Teach work
		Know subordinate
		Develop HR
		Determine work
		Determine action
	・Enhance morale towards work	Enhance morale
	・Create such a workplace as subordinates can collaborate	Build relation
	・make early detections of interpersonal problems and make their early solutions	Solve problem
	・Strengthen people concerned (in/outside company and build a network of people	Solidify relation
D: Compliance	・Manage personal information properly	Avoid leakage
	・Take measures against leakage of intercompany/confidential information	
	・Manage work hours properly	Know subordinate
	・Comply with labor laws	Obey law

Figure 1: Components and definitions of each function

Diagramming of the function for 'middle management'

This author diagrammed a FAST **(Figure 2)**, based on each function defined in Figure 1. Note that alphabets A through D in Figure 2 correspond to those in Figure 1. By diagramming each function, he set seven functions as the third-level function: F1 <<Reduce loss>>, F2 <<Enhance customer-satisfaction>>, F3 <<Improve company-image>>, F4 <<Improve progress>>, F5 <<Build collaboration>>, F6 <<Develop HR>>, and F7 <<Develop individual-independence>>.

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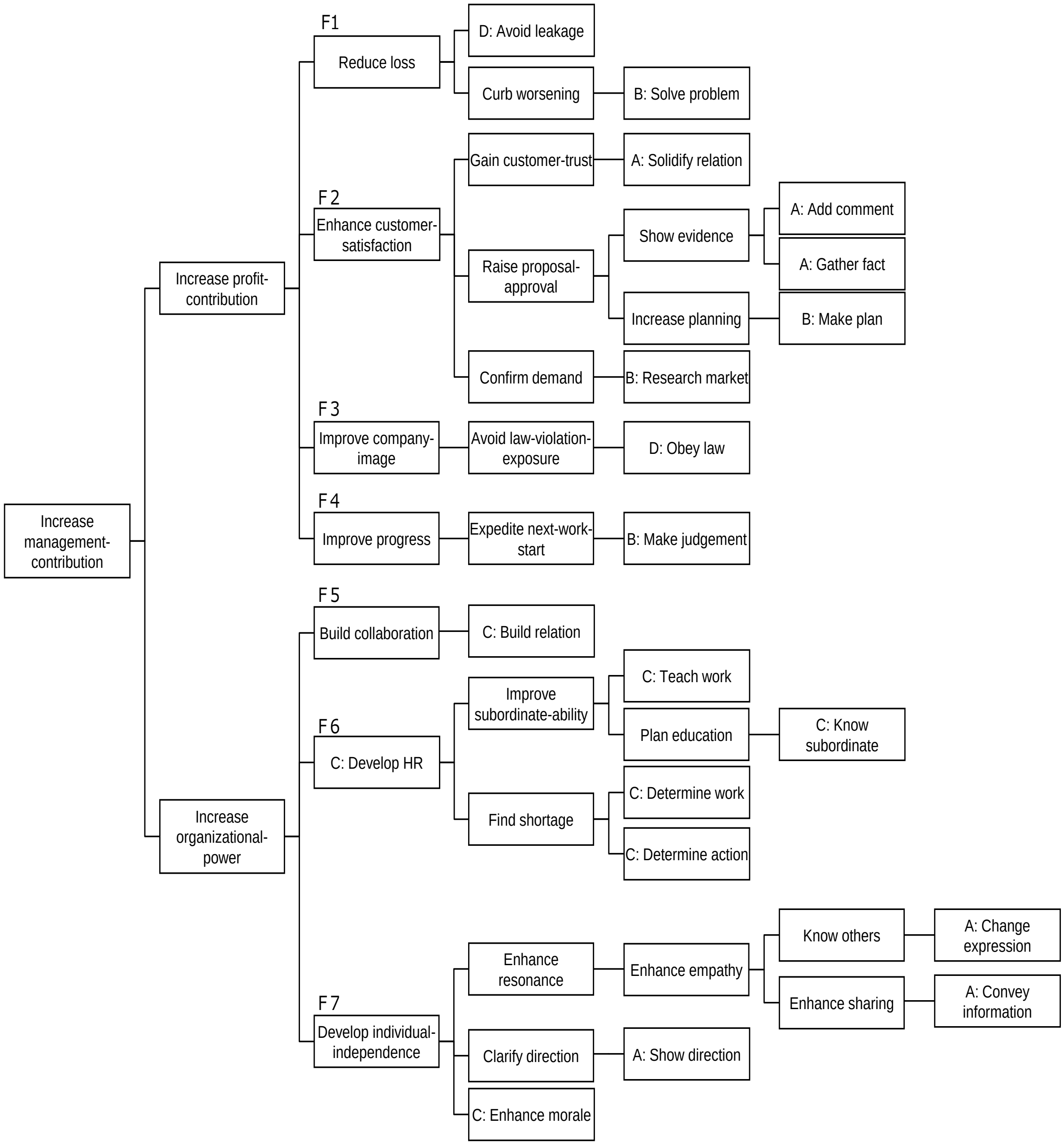

Figure 2: FAST

Multiple cost analysis

Based on the diagrammed functions, the author analyzed multiple costs in terms of ‘work performance’, ‘work environment’, and ‘work motive’. As each of the three has a broad meaning, he set ‘work performance’ as ‘skill training hour ratio’, ‘work environment’ as ‘evaluation item ratio’, and ‘work motive’ as ‘incentive ratio’, and analyzed the current cost.

Herein, one needs to consider each cost’s influence on functions and its composition when analyzing multiple costs. One can multiply each cost’s influence on functions with cost and reflect each influence: herein, one should set each composition so that 10% of ‘work performance’ can equal 10% of ‘work environment’.

Composition of each cost through multiple cost analysis

The author set the whole cost as 100% and then divided it for each component. Let us assume that many Japanese companies input 80% of their cost on 'work performance' and input 10% on the other two respectively **(Figure 3).**

	View	Composition ratio	Information	Business operations	Interpersonal relations	Compliance
①	Work performance	80%	4	10	4	2
②	Work environment	10%	2.5	35	7.5	5
③	Work motive	10%	0	28.5	1.5	0

Figure 3: Cost for each component based on its composition ratio

Influence of each cost gained through multiple cost analysis

One needs to consider that each cost influences functions. In some cases, companies input cost on a function that is not influenced by doing so. In the worst scenario, they do not gain either function or performance.

Generally, it is difficult to calculate how much influence each cost has on functions. However, this author used the statistics released by Takako Nakahara in chapter 3 that the influence of 'work performance' on one's performance is 20%. Given that, he set the remaining two – 'work environment' and 'work motive' – as 40% each.

The author multiplied costs for each component with their contribution ratio and then set them by each function. Furthermore, he multiplied the gained values with their each influence **(Figure 4).**

	Work performance	Work environment	Work motive
F1: Reduce loss	1.8	0.8	0.6
F2: Enhance customer-satisfaction	2.6	1.1	2.3
F3: Improve company-image	1.8	0.5	0.4
F4: Improve progress	3.0	0.8	0.2
F5: Build collaboration	0.8	0.2	0.4
F6: Develop HR	5.3	0.4	0.1
F7: Develop individual-independence	1.0	0.2	0.1

Figure 4: Cost for each function based on its influence

Setting target cost through multiple cost analysis

The author calculated target cost through DARE and gained **Figure 5.** Therein, he set the target cost for each multiple cost as the gained values were calculated by multiple cost analysis.

Functional area	Relative importance coefficient	Absolute importance coefficient	Importance coefficient	Target cost
F1: Reduce loss	1	1.5	20.7%	20.7
F2: Enhance customer-satisfaction	2	1.5	20.7%	20.7
F3: Improve company-image	1.5	0.75	10.3%	10.3
F4: Improve progress	0.5	0.5	6.9%	6.9
F5: Build collaboration	1	1	13.8%	13.8
F6: Develop HR	1	1	13.8%	13.8
F7: Develop individual-independence		1	13.8%	13.8

Figure 5: Importance coefficients and target costs

Given that the composition ratio of each target cost is the same as that of its influence, this author calculated each composition ratio and influence of 'work performance', 'work environment', and 'work motive' as 20%, 40%, and 40% respectively **(Figure6).**

	Work performance	Work environment	Work motive
F1: Reduce loss	0.8	3.3	3.3
F2: Enhance customer-satisfaction	0.8	3.3	3.3
F3: Improve company-image	0.4	1.7	1.7
F4: Improve progress	0.3	1.1	1.1
F5: Build collaboration	0.6	2.2	2.2
F6: Develop HR	0.6	2.2	2.2
F7: Develop individual-independence	0.6	2.2	2.2

Figure 6: Target costs based on their composition ratios and influences

Advantages of multiple cost analysis

One advantage of using multiple cost analysis lies in that one does not fail to oversee where cost should really be input. **Figure 7** shows a case with 'work performance' alone, in terms of training hour ratio.

	Current cost	Current function Value	Current value	Target cost	Target function value	Target value
F1: Reduce loss	11.0	104.0	9.5	20.7	104.0	5.0
F2: Enhance customer-satisfaction	16.0	62.0	3.9	20.7	104.0	5.0
F3: Improve company-image	11.0	31.0	2.8	10.3	52.0	5.0
F4: Improve progress	19.0	7.0	0.4	6.9	35.0	5.1
F5: Build collaboration	5.0	14.0	0.4	13.8	69.0	5.0
F6: Develop HR	33.0	14.0	0.4	13.8	69.0	5.0
F7: Develop individual-independence	5.0	14.0	2.8	13.8	69.0	5.0

Figure 7: Value evaluated without using multiple cost analysis

Both the current/target function values were gained through performance rating. The indexes of F1 through F7 were set as 'expense appropriate rate', 'customer number achievement rate', 'customer number achievement rate', 'task achievement rate', 'man-hour production rate', 'sales/ordinary income rate', and 'man-hour production rate' respectively.

In Figure 1, one often sets F4 as a VE subject, as this function has the lowest current value. Subsequently, one tries to generate ideas for lowering the training hour ratio and increase its function. However, it will not be effective, for in this case the influence of 'work performance' on function is only 20%. Such being the case, one may oversee costs that should really be input and their input amount.

Through multiple cost analysis, contrarily, one can easily compare the current cost in **Figure 4** with the target cost in **Figure 6**. By doing so, one can notice that there is a range where cost should be input, not just by lowering costs related to 'work performance'.

Application of multiple cost analysis

From this case study, multiple cost analysis has proven effective. Usually, cost comes with function. Thus, the range of cost and function should be set as the same.

However, the range of function may become broad in such a case as 'human performance'. In this case, one should not focus only on one cost, but should consider cost from multiple components. Therefore, it is useful to consider multiple costs for a case with a broad function range.

To do so in reality, however, is difficult, as each cost has a variable index and are difficult to analyze. For that, one can use multiple cost analysis by analyzing multiple current costs in terms of their composition ratios and influence on functions.

As a hypothetical case study, this author has conducted a multiple cost analysis on the theme 'middle management development'. To improve its value, he did so in terms of three components: 'work performance', 'work environment', and 'work motive'.

Each of the three costs has a different index, composition ratio, and influence on function. By setting composition ratios and influences for each, he was able to analyze these multiple costs.

For such a theme as 'human resource development', often times, one tends to analyze only one cost for training as 'work performance'. By adding the remaining two components, however, one can analyze its true costs, understand where cost should be input, and ultimately develop an effective alternative.

Points to consider Multiple Cost Analysis

Multiple cost analysis can be applied only to cases where there is a difference in composition among multiple costs or there is a difference in influence among functions. Prior to using multiple cost analysis, one needs to understand that there is/are another/other area(s) where cost should be input. Having said that, multiple cost analysis is instrumental to the case where one cannot improve value even though cost has been input. The reason behind this is that the current cost analysis can only help improve the function range with great cost input.

However, multiple cost analysis is difficult to use for *mono* or tangible products, for their functional scope can be defined in detail. In comparison, this method is easy to use for *koto* or intangible services.

For multiple cost analysis, 'middle management development' is a suitable subject for VE study, as its theme 'human performance' is *koto* and it is difficult to define its broad range of function. One should be aware that multiple cost analysis can be applied only to cases where there is a difference in composition among multiple costs or there is a difference in influence among functions.

Conclusion

This paper has showed that multiple cost analysis can be used in the current cost analysis step in VM Job Plan. There are many cases where multiple components have been input in 'direct human performance'. Also, this holds true to one's group/company.

This author belongs to the HR department, which is directly associated with human performance. He has been thinking of how one or one's group/company is related to input on them, in VM terms. He has generated a good idea for how a company should train and develop its middle management, in terms of three components: 'work performance', 'work environment', and 'work motive'. Also, he has made it clear that cost should also be input on 'work environment' and 'work motive', not just on 'work performance' or training hours, which is a widely practiced approach. The author sincerely hopes that his applied multiple cost analysis will be useful to not only human resources development, but also many other subjects for improvement.

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ORGANIZATIONAL IMPROVEMENT OF INDIVIDUAL KNOWLEDGE WITH FAST AND TRIZ TECHNIQUES

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ABSTRACT

The challenge facing our manufacturing industry is to digitize and systematize high-quality data at the manufacturing site and knowledge of individuals depending on their ability, to systematize them into knowledge assets and to reconstruct a new " *Genbaryoku* (problem finding and solving capabilities at the manufacturing site)". The authors are working on to convert the information at the manufacturing site and the knowledge of individuals depending on their ability into explicit knowledge and to transform such knowledge into knowledge assets as work process information. Naturally, this work process information must be available for organizational improvement activities. In this paper, a method of generating improvement ideas from work process information through FAST diagrams and TRIZ techniques is proposed with the aim of organizationally improving knowledge of individuals depending on their ability. In addition, the verification results of these case studies are reported.

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KOICHI AKAGI PE, CVS

Chief Manager, Takasago Production Design Department, Mitsubishi Power, Ltd.
Consultant of Society of Japanese Value Engineering.
After five years of experience in the development and design of jet engines, he engaged in development and design of heavy-duty gas turbines for power generation at Mitsubishi Heavy Industries. After six years in the manufacturing department managerial position, he promoted company-wide deployment of VE at the Technical Headquarters. In 2016, Takasago Production Design Department was established to realize the organizational knowledge creation of manufacturing.

1. Necessity of Improvement of Individual Knowledge at Site

Improvement activities in the Japanese manufacturing industry have long been dependent on the knowledge of individuals based on their ability. We have praised this as "*Genbaryoku*", which is problem finding and solving capabilities at the manufacturing site. In fact, the dependence on the knowledge of individuals based on their ability could produce significant results until not long ago. However, the environment surrounding manufacturing site has been changing with fewer workers due to low birth rate and with advances in ICT.

In the 2018 Manufacturing White Paper issued by the Ministry of Economy, Trade and Industry, the reconstruction of new *Genbaryoku*, such as the ability to digitize and systematize high-quality data and personal knowledge and having those as asset in organizations, is mentioned regarding the challenges and prospects facing the manufacturing industry in Japan, "Maintenance and improvement of strong *Genbaryoku* (labor shortages, quality control) and "Creation and maximization of added value" [1]. Therefore, the authors are working on activities to organizationally improve the knowledge of individuals of the field works.

2. Work Process Information

The concept of SECI Model is applied to organizationally improve the knowledge of individuals regarding field works based on their experience. This Model is to generate the knowledge continuously and organizationally by mutually converting tacit knowledge within the individual into explicit knowledge within the organization [2]. In the mutual conversion of tacit knowledge and explicit knowledge, there are following conversion modes; socialization, externalization, combination, and internalization. Specifically, the work process information is prepared to convert the tacit knowledge including the knowledge of individuals based on their experience into explicit knowledge (externalization). Next, organizational improvements are made using engineering management techniques based on this work process information (combination).

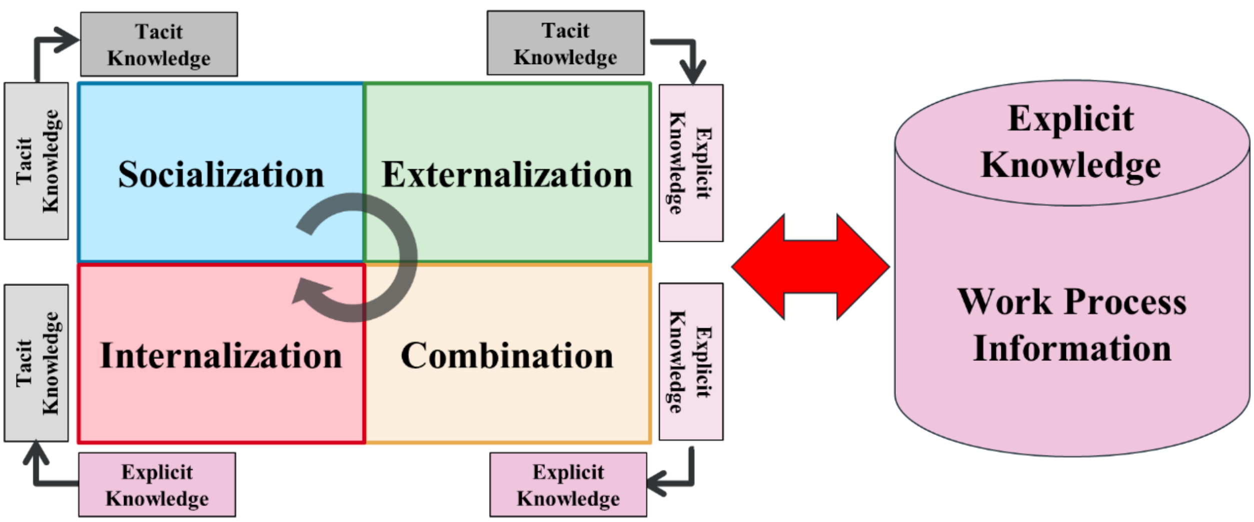

Figure 1: Concept of SECI Model and Work Process Information
Prepared by authors with reference to [2]

In order to utilize the engineering management technique, the work process information is organized as shown in **Figure 2**. The first information is the element work process, which is obtained by subdividing work process into the smallest unit that completes the work process, and the information visualized where each element work process lies in the overall manufacturing flow. The next is the information to visualize the individual knowledge required for the worker for each element work process. The authors have newly established four items to evaluate the degree of dependence on individual abilities regarding the individual knowledge; the worker's judgement level, the skill level, the quality level, and the safety level during the work process. Furthermore, the authors have established three levels for these four evaluation

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items according to the Dreyfus Model; Level 1 for novice, Level 2 for advanced beginner, and Level 3 for competent [3]. The final information is the information to visualize the necessary information for the improvement activity, such as “work time” and “value of process” to be used for LEAN, 4Ms (Man, Machine, Material, Method) and ”function of process” to be used for VE.

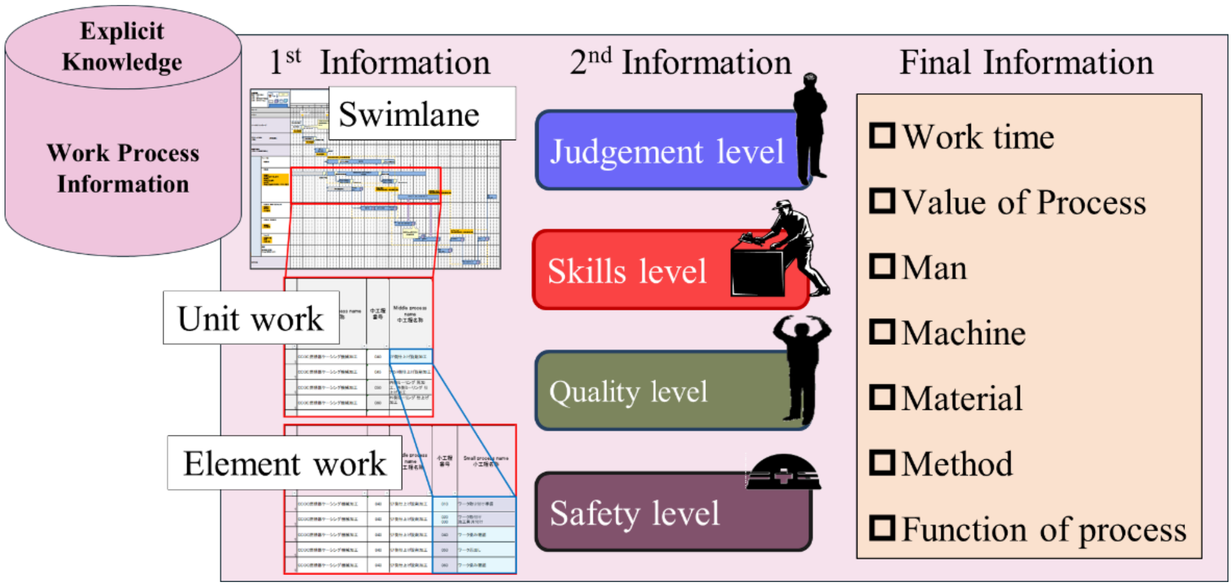

Figure 2: Organizing Work Process Information

3. Workflow of Improvement Using Work Process Information

The workflow of improvement using work process information is shown in **Figure 3**.

1. Selection of target component
2. Creation of Work Process Information
3. Creation and Utilization of FAST Diagram
4. Generation of Improvement Ideas with the TRIZ Contradiction Matrix and Invention Principles
5. Generation of Disruptive Improvement Ideas by Leveraging Trend of Technological Evolution

Figure 3: Workflow of Improvement Using Work Process Information

Taylor points out that the division of a given work process into its proper elementary units (element work process) before beginning the time study, calls for considerable skill and good judgement [4]. Therefore, the authors set up a specialized team to create work process information. The team members created the work process information by recording the worker's motion, analyzing the video based on interviews with the worker, and linking each element work process to the following 13 information; 1: Unit work process,, 2: Element work process, 3: The degree of dependence on individual ability (Judgment), 4: The degree of dependence on individual ability (Skills), 5: The degree of dependence on individual ability (Quality), 6:

Degree of dependence on individual ability (Safety), 7: Work time, 8: Value of process, 9: Man, 10: Machine, 11: Material, 12: Method, and 13: Functions of process.

This allows to convert the tacit knowledge, which is owned by workers only including individual knowledge (information 3 through 6), into explicit knowledge that can be used for organizational improvement activities.

Rains cites "Essential to the success of the Value Analysis function-based creative-problem solving system is what has been called the CHANGE OF VIEWPOINT" as the view of the functional analysis of Fowler [5]. The authors also consider the functional analysis using FAST diagrams as “a method which allows to clarify the previously hidden issues from a new perspective". Therefore, the value of work and the degree of dependence on individual ability (Skills) of work process information are also expressed on the FAST diagram. Specifically, the value of work is distinguished by the frame color and line type, and the degree of dependence on individual ability (Skills) is distinguished by the fill color. For the evaluation of the value of work, however, LEAN technique is applied [6].

There are several techniques for idea generation. However, TRIZ technique is applied in this research since two types of improvement ideas with different objectives can be generated. One is the generation of effective improvement ideas in a short time with a problem-solving approach related to technical contradiction. The other is the generation of disruptive improvement ideas that anticipate the future by leveraging trend of technological evolution.

4. Practical Case

Improvement activity was conducted to the target component using the work process information shown in **Figure 3**. The details are shown below.

4.1 Selection of target component

Mitsubishi Power Ltd. manufactures power generation equipment and power generation systems, which are the core of Mitsubishi Heavy Industries' sales. Its global market share of heavy-duty gas turbines, which are its main products, was No. 1 in 2018. A component shown in **Figure 4** of this heavy-duty gas turbine is selected as a target component. During operation, this component is exposed to a combustion gas of 1000°C or more. Therefore, since the material is a special superalloy and needs to be cooled by air, it is necessary to process the narrow and long holes with strict positional accuracy. Since these holes cannot be machined by cutting or processing, electric discharge machining, which can remove the material by discharging electricity and melting metal, is performed. More than 1000 pieces of this components are manufactured every year. However, displacement of the hole position has occurred in several pieces.

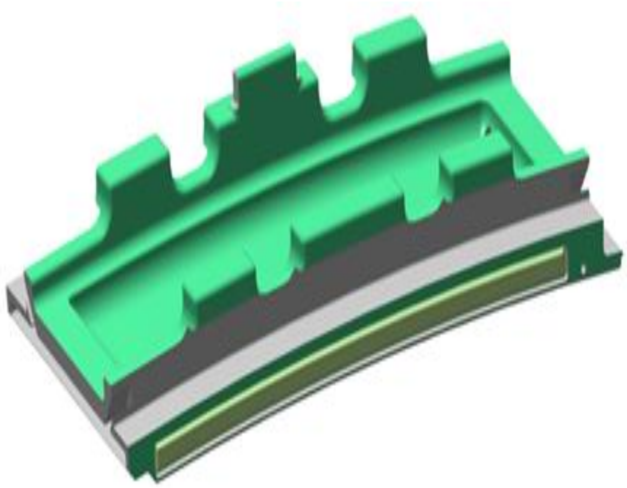

Figure 4: Target Component (160mm×100mm×20mm)

Figure 5 shows the flow of the work process throughout the EDM operation. These unit work processes are preparation and set of the workpiece by the worker, EDM with EDM machine, inspection and putting away by the worker. The total working time per piece is approximately 2000 seconds.

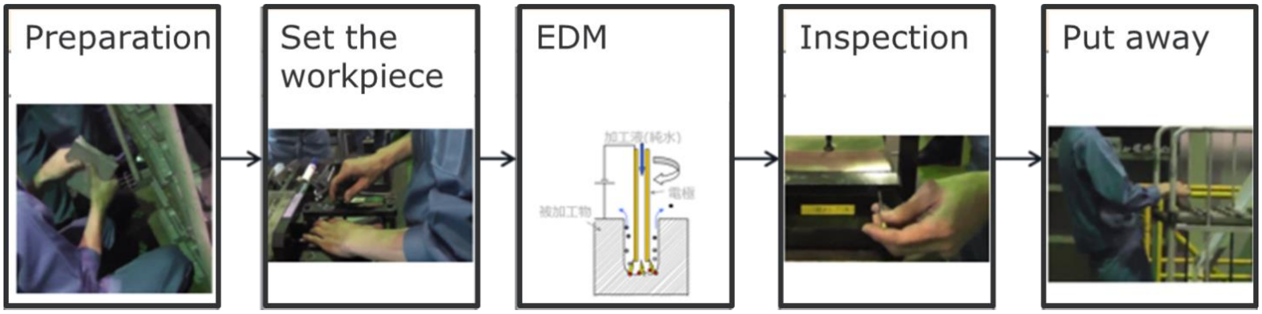

Figure 5: Target Work Process

4.2 Creation of Work Process Information

Work process information was created based on the machining process shown in **Figure 5**. The total number of element work processes after subdivision is 52. As a reference, the first 6 processes are shown in **Table 1**.

Element Work number	Name of unit work $j=1$	Name of element work $j=2$	The degree of dependence on individual ability				LEAN information	
			Judgement level $j=3$	Skill level $j=4$	Quality level $j=5$	Safety level $j=6$	Work time $j=7$	Value of process $j=8$
$i=1$	Set the workpiece	Take out Work	1	1	1	2	0:00:07	BVA
$i=2$	Set the workpiece	Move Work	1	1	1	2	0:00:05	BVA
$i=3$	Set the workpiece	Form Spray area on work	2	1	2	2	0:00:29	BVA
$i=4$	Set the workpiece	Check Work surface	2	1	3	2	0:00:04	BVA
$i=5$	Set the workpiece	Check Contact surface of jig	2	1	3	2	0:00:03	BVA
$i=6$	Set the workpiece	Set Work in jig	2	1	3	2	0:00:14	BVA

Six Sigma Information								VE information
Man $j=9$	Machine $j=10$				Material $j=11$	Method $j=12$		Function of process $j=13$
Authorized personnel	Facility	Jig	Tool	Program		Procedures	Indications	
Forman or higher	Product storage	none	none	none	Superalloy	C-W-0333R0	C-Ep-TR-OK121	Decide Workpiece
Forman or higher	none	none	none	none	Superalloy	C-W-0333R0	C-Ep-TR-OK121	Transfer Workpiece
Forman or higher	Workbench	none	Blue marker	none	Superalloy	C-W-0333R0	C-Ep-TR-OK121	Attach Paint
Forman or higher	Workbench	none	none	none	Superalloy	C-W-0333R0	C-Ep-TR-OK121	Confirm Deposit
Forman or higher	Workbench	HOG-I-HT27	none	none	Superalloy	C-W-0333R0	C-Ep-TR-OK121	Confirm Deposit
Forman or higher	Workbench	HOG-I-HT27	none	none	Superalloy	C-W-0333R0	C-Ep-TR-OK121	Set Workpiece

Table 1: Example of Work Process Information of Target Work Process

4.3 Creation and Utilization of FAST Diagram

As shown in **Figure 6**, FAST diagram was created based on "Function of Work", "Value of Work" and "Degree of dependence on individual ability (Skills)" of the work process information shown in **Table 1**.

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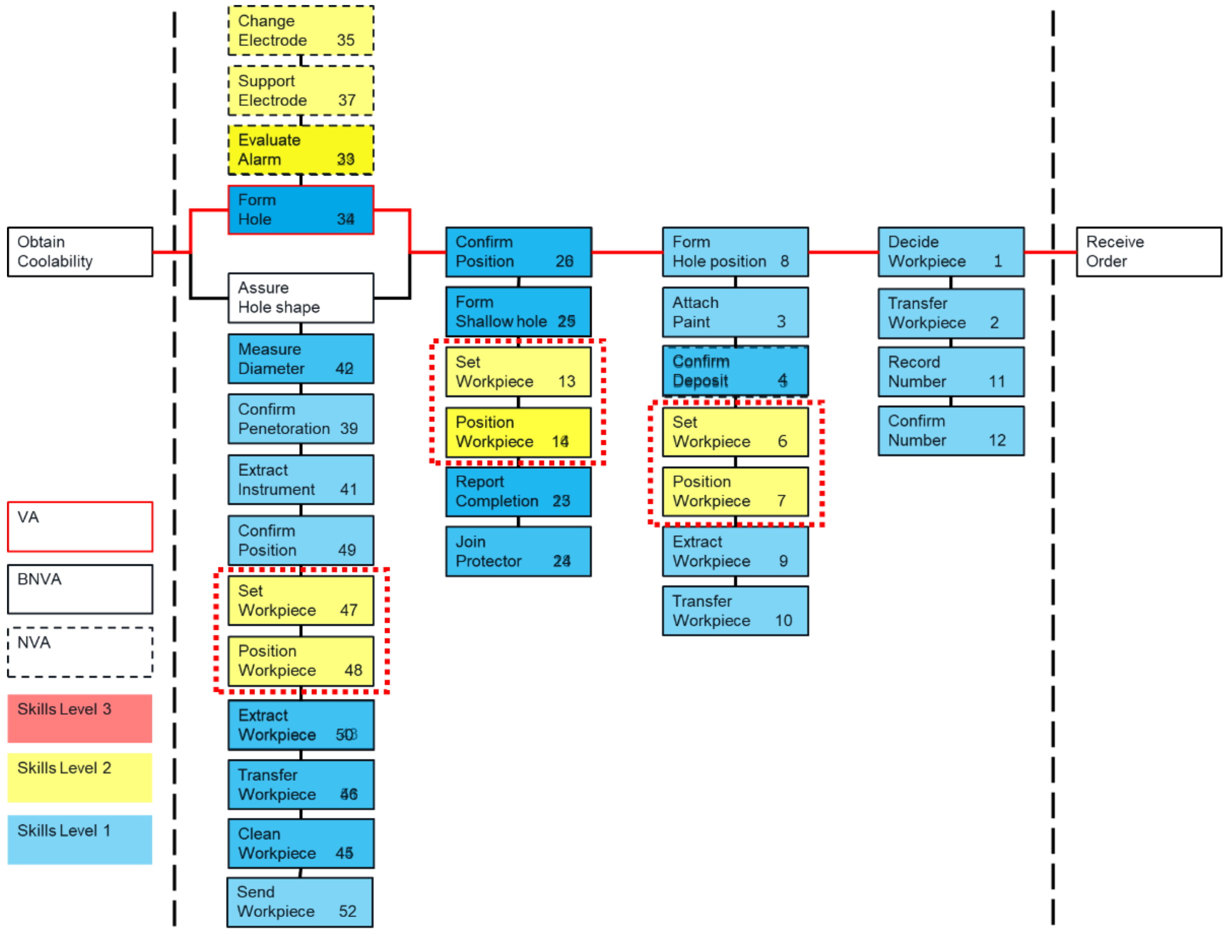


Figure 6: FAST Diagram of Target Work Process

In FAST diagram in **Figure 6**, there were several functions of "Set workpiece" and "Position Workpiece" which have high level of dependence on individual abilities. Therefore, as a result of observing the work video of these element work process in detail, the worker, was doing the difficult work of "tightening a bolt for fixing the workpiece with one hand while holding a heavy workpiece in upright position with the other hand at a prescribed position" as shown in **Figure 7**. Incidentally, the worker did not recognize that this is a difficult work, nor did he feel the need for improvement.

Figure 7: High-leveled Work; Setting Workpiece

4.4 Generation of Improvement Ideas with the TRIZ Contradiction Matrix and Invention Principles

In order to reduce the level of dependence on individual ability (Skills) of this element work process, elimination of "holding a heavy workpiece in upright position with one hand at a prescribed position" is set as a problem to be solved.

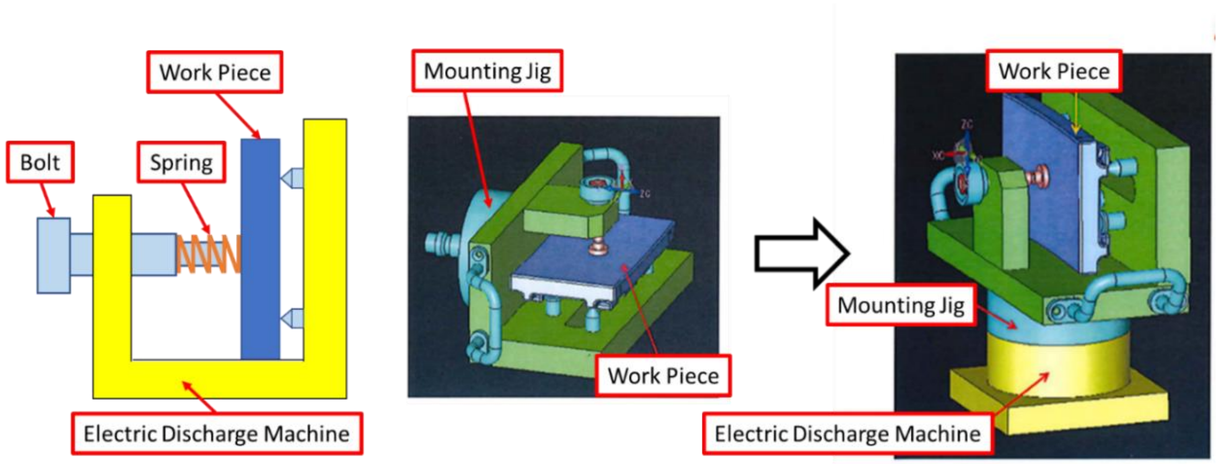
The characteristics that we wish to improve and that will be deteriorated are abstracted into 48 parameters. “34. Trainability/Operability/Controllability” was selected as a parameter we wish to improve. On the other hand, "41: Manufacturability" and "44: Productivity" were selected as the parameters which will become worse due to the increased labor required for the operation. By utilizing the TRIZ Contradiction Matrix [7], the following inventory principles that help to resolve contradictions have been obtained; 29: Pneumatics and Hydraulics, 36: Phase Transitions, 24: Intermediary, 5: Merging, 1: Segmentation, 28: Mechanics Substitution, 15: Dynamization, 25: Self-Service. Based on these parameters, the following two ideas (weakness-overcoming ideas) were generated.

Idea 1 (Principle of Merger)

It is an idea to merge the functions “Set Workpiece” and " Position Workpiece". Without changing the posture of workpiece, retain the workpiece by pressing with a spring attached to the tip of the fixing bolt and adjust and check the position by moving the workpiece to the prescribed position with both hands. After checking, fix the workpiece by tightening the bolt.

Idea 2 (Principle of Separation)

It is an idea to separate the functions of " Set Workpiece" and " Position Workpiece". First, fix the workpiece to an adjustable mounting jig, which is a separate part from the EDM machine. Then, fix the workpiece-mounted jig to the EDM machine. Ultimately, we decided to adopt the **Idea 2**.



Idea 1 (Principle of Merger) **Idea 2 (Principle of Separation)**

Figure 8: Ideas based on Inventory Principles (Weakness-Overcoming Ideas)

4.5 Generation of Disruptive Improvement Ideas by Leveraging Trend of technological Evolution

The functions of "Set Workpiece" and "Position Workpiece", which are clarified as a problem, are control works to set the workpiece to the right position. Therefore, they can be explained with "Controllability" of the trend of technological evolution shown in **Figure 9**.

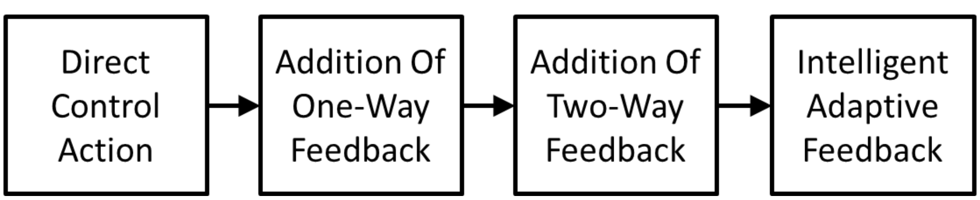


Figure 9: Controllability Trend cited from [8]

The improvement **Idea 2** described above corresponds to the idea generation from the viewpoint of "Indirect Control Action" of the controllability trend shown in **Figure 9**, since the improvement is only the mounting jig.

At this stage, ideas are generated based on the trend of technological evolution from the perspective of "Introduction of Feedback," which is the next stage of evolution. For the function of "Position Workpiece", which is currently checked by a worker, the idea of "EDM machine senses that the workpiece is mounted at the prescribed position and feeds the result back to the operator" (positional check result feedback idea) can be easily generated.

Furthermore, the idea is generated from the perspective of further evolved "Intelligent Adaptive Feedback". Instead of having the worker adjust the position of the workpiece, the idea of " EDM machine senses the mounting condition of the workpiece and automatically adjusts the position according to this sensed positional information" (automatic positioning idea) can be easily generated. This idea is to simultaneously achieve more than one function indicated with solid line frames on FAST diagram as shown in **Figure 10**. With this idea, it is anticipated that the quality will be improved by eliminating the inconsistency of installation by worker, and the work time per piece will be shortened by 579 seconds by utilizing the "work time" information of the work process information in **Table 1**.

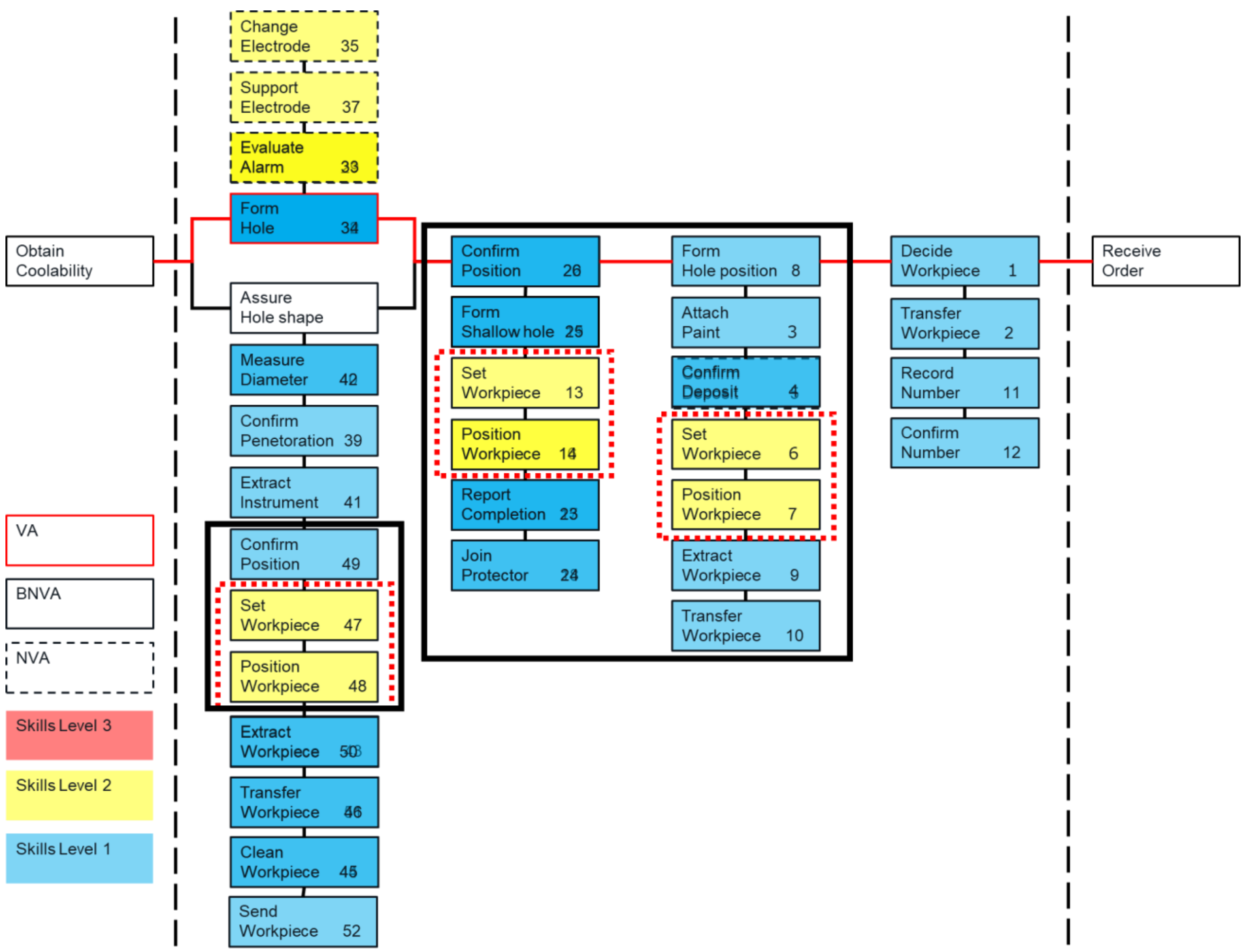


Figure 10: Simultaneously Achievable Functions (in Solid Line Frames) with Automatic Positioning Idea

5. Discussion

First, the creation of FAST diagram is discussed. In this case, FAST diagram, which can grasp the problem by changing the viewpoint as is the case of Fowler's viewpoint, was created on the knowledge of individuals depending on their ability. It is also confirmed that both of "Value of Work", which is a LEAN technique, and the proposed dependence level can be expressed on FAST diagram without trouble. When analyzing the functions of work process with time-sequential order, using FAST diagram seems to be easier than using functional diagram. The reason for this is thought to be that functions can be expressed from the viewpoint of "WHEN".

Next, the use of TRIZ technique is discussed. In this case, it was confirmed that improvement ideas can be generated by utilizing TRIZ " the TRIZ Contradiction Matrix and invention principles " and that disruptive improvement ideas can be generated by utilizing TRIZ "trend of technological evolution" for solving problems related to the knowledge of individuals depending on their ability. The proposed improvement ideas generated by utilizing the TRIZ Contradiction Matrix and invention principles corresponded to the least advanced idea of the "controllability" of the trend of technological evolution. In other words, in terms of idea generation, the trend of technological evolution can be described as "Ladder of Evolution," and the authors believe that it has an effect similar to "Ladder of Abstraction" of the functional definition of VE.

Finally, TRIZ technique was applied as an idea generation method in this case. However, the authors believe that the techniques of LEAN, Six Sigma, and VE can also be applied as idea generation methods.

6. Conclusion

In this study, we have demonstrated that problems to be improved can be clarified by converting the knowledge of individuals depending on their abilities related to the field work, which is tacit knowledge, into work process information that can be used for organizational improvement, which is explicit knowledge and analyzing the functions based on this information with FAST diagram. It is also shown that the problem on knowledge of individuals depending on their abilities can be solved by TRIZ technique. For the purpose of further promotion, authors are planned to demonstrate that it can be applied to other components and machining processes. In addition, other idea generation methods are also planned to be examined.

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THE POSSIBILITY OF VE AND MOT TECHNIQUES IN VARIOUS INNOVATION ACTIVITIES

MANABU SAWAGUCHI ,KOICHI AKAGI ,TAKESHI MORISHITA ,RYOSUKE KIMURA

Abstract

At the 47th VE Kansai Conference (in 2016), the authors conducted a questionnaire survey on innovation to the conference participants. In this paper, the authors show that there is a high potential for MOT (Management of Technology) techniques such as VE to be fulfilled in various innovation activities from the analysis of this survey result. And, in the last part of it, an actual case at a manufacturing company (Mitsubishi Hitachi Power Systems) regarding "process innovation" is introduced.

Biographies

Manabu Sawaguchi, Ph.D., CVS

Professor, RITSUMEIKAN University and Director, Value Innovation Institute Co. Ltd.

Graduated from KEIO University, Faculty of Technology, Department of Mathematical Engineering and got a position as a researcher at the SANNO Institute of Management in 1985. As a visiting researcher, he visited University of Michigan IOE (Industrial and Operations Engineering) in 1997. After that, he earned a doctoral degree in Engineering at WASEDA University in 2005. He had worked over 30 years of experience in practical technology management And, now, he is an advisor of SJVE, a vice Chairman of JTS (Japan TRIZ Society), a director of Value Innovation Institute Co., Ltd., a professor at RITSUMEIKAN University and a part-time lecturer at WASEDA University.

Koichi Akagi, PE, CVS

Chief Manager, Takasago Production Design Department, Mitsubishi Hitachi Power Systems, Ltd. and Consultant of SJVE

After 5 years of experience in the development and design of jet engines, he engaged in development and design of large gas turbines for power generation at Mitsubishi Heavy Industries. After six years in the manufacturing department managerial position, the company promoted company-wide deployment of VE at the Technical Headquarters. In 2016, Takasago Production Design Department was established to realize value creation design.

Takeshi Morishita, VEL

Engineering Manager, Takasago Turbine Production Design Department, Mitsubishi Hitachi Power Systems, Ltd.

Graduated from NIHON University in Mechanical Engineering. After graduated, joined power division of Mitsubishi Heavy Industries, Ltd. (later MHPS, Ltd.) as a welding engineer and production management engineer of large gas turbine welding section, and has experienced in the planning, production management, mounting of the production system, service work of the gas turbine. Currently, he applies the latest management technologies to promote the use of manufacturing ICT. He is certified VEL (Value Engineering Leader) by Society of Japanese Value Engineering.

Ryohsuke Kimura

Takasago Turbine Production Design Department, Mitsubishi Hitachi Power Systems, Ltd.

Ryohsuke Kimura has been working for the current company for 3 years. He worked as a service engineer of gas turbines for thermal power generation, responsible for providing technical and consulting services to customers on plant maintenance and inspection, repairing high-temperature parts, and proposing solutions to technical problems. At the same time, he was engaged in developing overseas repair bases for high-temperature parts with the aim of reducing costs. After transferring to Turbine Production Design Department, he engaged in improving production methods of high-temperature parts for gas turbines and preparing work manuals for the worksite. He is currently working on improving field operations by applying ICT.

1.Introduction

The authors had an opportunity to give a keynote speech at the 47th VE Kansai Conference (on February 19th 2016) entitled "Innovation Creation VE- Innovation Activities and Strategies that Japanese Companies Should Apply". In relation to the topic, they were able to conduct a series of questionnaire surveys on innovation to the audience before the lecture. This paper will discuss the role and potential of management techniques such as VE in innovation activities.

2.Transition of Japanese “*Monozukuri*” and VE's Role

2.1 Changes in The Manufacturing Industry in Japan

According to the outcomes of the survey on manufacturing conducted about 10years ago (April 2005-March 2007), it was found out that many Japanese manufacturing companies were confident in their quality technology and product & technology development capabilities, but they recognized some challenges in their innovation capabilities[1].

However, looking back in the past (mainly during the period of high growth), a number of innovative products were developed and gave big impacts in the world such as Nissin Foods' “Cup Noodles”, Sony's “Walkman”, and Nintendo's family computer. However, such innovative new products at that time were developed during the glory days of the founding presidents, and it is likely that those products were born through the strong leadership of company management.

On the other hand, in Japan's main manufacturing industry today, the era of the founding president is generally over, so it is essential to establish a system to plan and develop innovative products with organizational capabilities within the company. Because of this background, it can be interpreted that the “*Japanese Muanufacturing (Monodukuri) industry*” [A)] recognizes that there are challenges in the mechanism of product planning and the ability to innovate at the organizational level.

Term A): It mainly refers to manufacturing production activities but as a broad concept, includes the service industry which respects the manufacturing type business structure

By the way, the authors wrote a paper in “VALUE ENGINEERING No.288[2]” on the transition of the Japanese manufacturing industry and provided a long-range analysis in a systematic way, using Japanese "*karakuri doll*" as a unique example of manufacturing technology. Here, they explained the thoroughness of the quality-oriented field-focused thinking which is a traditional Japanese philosophy and the scientific manufacturing thinking such as QC (quality control) which was born in the US are combined in a fine balance in a period during which led Japan from high growth to stable growth resulting in the increase of brand value for what is called “Made-in-Japan” in the global market. It can be presumed that this is the background which leads to the high evaluation of "technology in terms of quality".

On the other hand, after the collapse of the bubble economy, they also mentioned the harsh reality of Japan's manufacturing industry, which is unable to compete in the emerging world market, where high-quality strategies alone are no longer competitive as they used to be. Figure.1 shows those periods of transition from the high growth period to the present and later which are systematically divided into five generations.

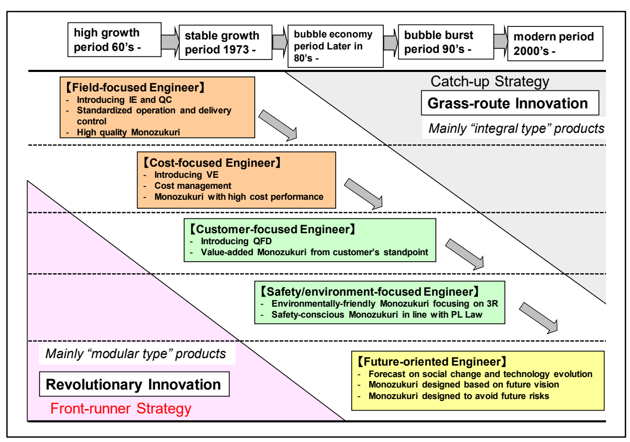

Figure.1 Changes in Japanese Monozukuri

In this figure, as the period goes on like "high growth period>>> stable growth period>>> bubble economic period>>> bubble burst period>>> present day and beyond", the required image of engineers will also change, and the policy of Japan's manufacturing industry will also has to shift from "catch-up strategy" to “front-runner strategy” which

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requires creating new businesses. In this strategy, "radical innovation" is the primary premise. The root cause of such a strategic turnaround is that the product architecture (basic design philosophy) has been dramatically changed from “integral type” to “modular type” (See Table 1) with increased markets which are easier to join for new entrants from emerging countries such as China and India.

In particular, the area where IT is becoming more advanced (weak electric appliances such as IT appliances) is a typical modular product with a high configuration rate of packaged electronic components. “*Grassroots Innovation*” [B)] aiming to achieve high quality through on-site capabilities, has no longer become competitive enough against emerging countries.

Table1 Types of Product Architecture [3]

Integral type (harmonized)	When a system is composed by several subsystems due to intensified interface, and if the subsystems are highly inter-dependent with no regulation on the interface, the product structure of the subject system is “integral type”).
Modular type (combined)	When a system is composed by several subsystems due to intensified interface, and if the subsystems are highly independent with established regulation on the interface, the product structure of the subject system is “modular type”).

Term B): Incremental innovation aiming at cumulative improvement effect by field power

2.2 Changes in VE activities in Japan

With reference to Figure 1, on the transition of Japan's manufacturing industry, the authors organized which role was required for VE at each of the conversion points ("high growth period>>> stable growth period>>> bubble economic period>>> bubble burst period>>> present day and beyond") (See Figure 2).

In order to organize Figure.2, the research outcome [4] from “Use of VE and its management” which was presented in March 1993 and VE research papers presented at past VE national conferences were also helpful.

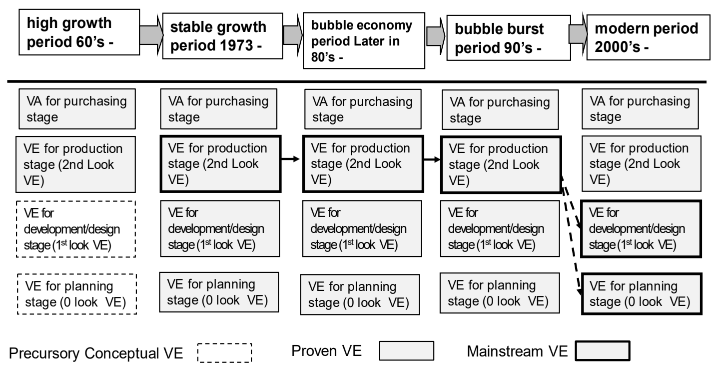


Figure.2 Changes in VE Activities in Japan

Especially, from the past VE research papers in 1970, according to “Application of VE in product development (Mr. T. Nishikawa)” and “Applying VE method to new product development (Mr. Y. Futami)”, it can be confirmed that VE application was highly oriented from the upstream stage (R&D and product development stages) of manufacturing even during the period of high growth. Also, the authors identified that there is a number of research papers presented in relation to the keywords “*genka* (cost price)/cost/expense” on SJVE website “VE paper search NAVI”; *genka*=75, cost=197, and expense=14 with a total of 286 papers are related to these topics. As the total number of VE research papers presented during 1970 and 2015 is 501, the majority of them are somewhat cost-related. If divided into more detailed keywords, "cost reduction=12","cost saving=38","cost control=11" cost management=8","target costing=16","life cycle cost (LCC)=15”. From this search result, VE can be recognized that it is highly compatible with cost.

In this context, VE was originally developed as a technique to improves product functionality and reduces costs under the name Value Analysis (VA) [5]. Although the name VE is commonly used in these days, many people still recognize it as a management technique effective for *genka*/cost management. While VE focuses on *genka* or cost, there is no doubt that the application of VE to design phase (1st Look VE) and development phase (0 Look VE) are becoming more and more important rather than conventional approach to production phase (2nd Look VE) during the course of the transition of Japanese manufacturing.

3."Innovation" addressed in this paper

There was a time when the term “innovation” was translated as technology revolution, but this is a narrow-minded definition of innovation (See Figure.3).

The innovation addressed in this paper, as the authors mentioned in “VALUE ENGINEERING” Journal No.261[6], is based on the results of a preliminary survey on the innovation image conducted in 2006 for multi-disciplinary participants [7]. The image can be described according to the "Purpose-Means (or Why-How)" logic as shown in Figure.3.

Based on this image of innovation, the innovation activities at a broad level can be defined as follows [8].

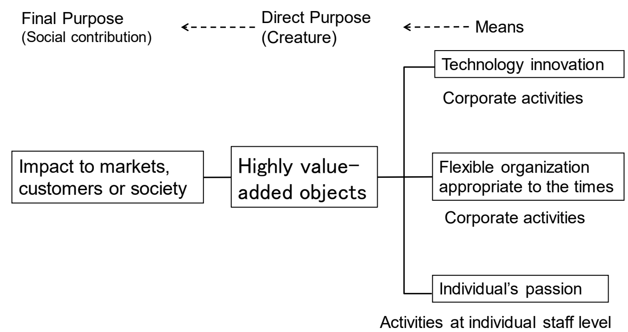


Figure.3 Diagram of Innovation Image

> Definition of “Innovation” in companies:
> It is a process and its outcome (profit) to build unique business model and generate new value (customer value and business value) by using element technology as leverage.

Therefore, the questionnaire survey covered in the next chapter also follows the same level of broad sense, focusing on the process and its results of creating added value and new value of objects and things, addressing a wide variety of innovation activities which are not necessarily limited to technology revolution. Recently, key innovation patterns featured in International conferences on innovation management (such as ISPIM and PICMET), technical publications and papers [9],[10],[11] can be summarized in Table 2.

Table.2 Main Innovation Patterns

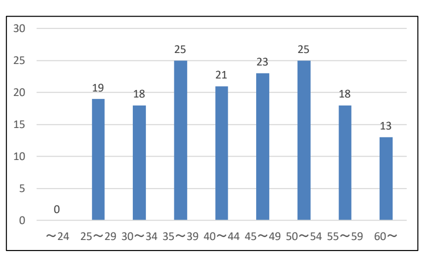
Disruptive innovation (破壊的イノベーション)	Disrupt the value of conventional product and create a completely new value for product or service in the next generation
Incremental innovation (持続的イノベーション)	Improve the conventional product and continue to improve value of the existing product
Radical innovation (革新的イノベーション)	Innovative product or service which is non-continuous and different from the past creating a new S-curve
Grass-roots innovation (草の根イノベーション)	Through steady improvement efforts in the workplace making small effects instituted and resulting in accumulated improvements
Frugal innovation (“質素”なイノベーション)	Innovation using the lowest resource and cost and creating the greatest value agilely and it creates value suitable for recycling society
Bootleg innovation (あんぐらイノベーション)	Create value in an informal and free atmosphere
Reverse innovation (リバースイノベーション)	Develop product with simple functions and low cost from a standpoint of developing country and later expand business to developed country as well.
Product innovation (製品イノベーション)	Crete innovative value on products in the next generation which replace existing products
Process innovation (プロセスイノベーション)	Manufacturing process is accomplished through a completely different and in a revolutionary way
Business innovation (ビジネスイノベーション)	Improve customer value and corporate value in a revolutionary way through new business model which is completely different from conventional management methods

4.Conducting surveys on innovation

As mentioned at the beginning, the authors took advantage of conducting a series of surveys on innovation (Number of respondents:162) when he delivered a keynote speech at the 47th VE Kansai Conference. The survey itself, of course, was conducted before the start of the keynote speech, so that the fairness of the questionnaire is secured.

4.1 Preliminary questions about the basic attributes of respondents

The following Figure.4 – 7 cover basic attributes of respondents such as age, job, employee size, and product production category.



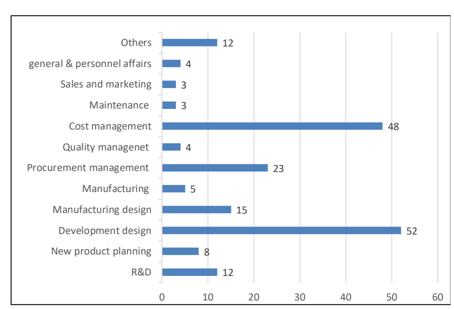


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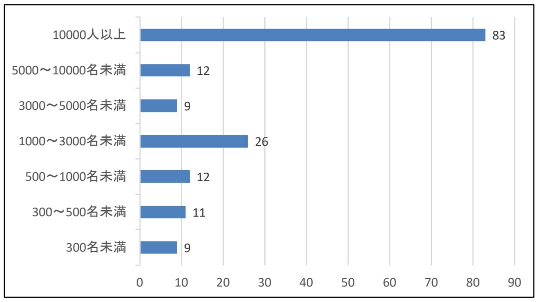
Figure.4 Age Group Distribution of Respondents

Figure.5 Job Distribution of Respondents (Multiple Responses)



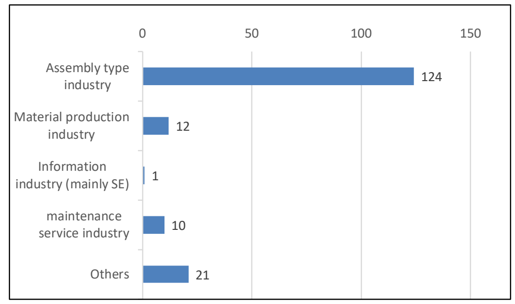


Figure.6 Employee Size

Figure.7 Product Production Category (Multiple Responses)

Age distribution (See Figure.4) covers almost every generation, from the late 20's to the 60's. without disproportionally emphasized on a particular generation. From the job distribution (See Figure.5), engineers in the field of development design and due to the nature of VE conference, It can be seen that there are many people regarding the cost management; approximately 63% of jobs in the technical section (including materials and outsourcing management) and approximately 25% in cost management. The employee size (See Figure.6) shows that companies with more than 1,000 employees account for a large percentage, so it can be understood that most respondents to this questionnaire belongs to large enterprises. As for the product production category (See Figure.7), the assembly type product manufacturing industry is about 74%, and it can be noted that so-called general manufacturing companies are the mainstream.

4.2 Questions on innovation

Q1: What is innovation? (Select the most suitable item)

This question asks the respondent to select one from the 10 choices which is the closest to his/her image. Respondents who think that there is not in the 10 choices in the questionnaire choose "other" and write their own comments. The 10 choices are the results of a descriptive survey of innovation images conducted in 2006 [7] and along with a reference to Christensen's publication [9], who is one of the pioneers of innovation research. The results are shown in Figure.8. Q1 had 129 valid responses.

a	**Creation of new market with new technologies**	**23**	**17.8%**
b	Creation of new market with existing technologies	11	8.5%
c	Cumulative benefit by continuous improvement	10	7.8%
d	Creation of added value	9	7.0%
e	**Technological innovation**	**29**	**22.5%**
f	**Creation of new business models**	**22**	**17.1%**
g	Big impact for society	7	5.4%
h	Discovery of new principles or low	4	3.1%
i	Improvement of the standard in the industory	12	9.3%
j	Dorastic cost reduction	2	1.6%
k	Others	0	0.0%
	Items which "alternative hypothesis H1" was adopted by a one-sided testing with a significance level of 1%	**129**	**100.0%**

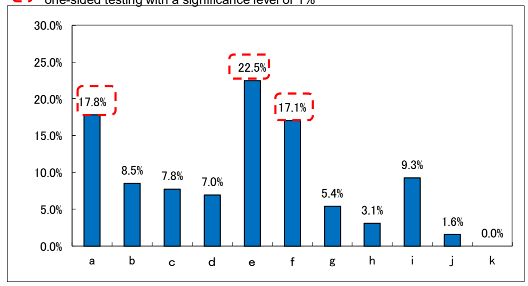


Figure.8 Distribution of Innovation Images

Incidentally,10 items are uniform distribution, assuming that there is no statistically significant difference between each item: "null hypothesis H_0"and there is more than 10% greater ratio from the expected value: "alternative hypothesis H_1" and conducting a one-sided testing with a significance level of 1%. As a result, the alternative hypothesis H_1 was adopted in 3 options; "a. Creating new market with new technology (17.8%)","e. Technological Innovation (22.5%)" and "f. Creating new business model (17.1%)". Through the choices a. or e., there are still many respondents who want to superimpose innovation on new technologies (more than 40% of total respondents). While it is not bad to stick to new technologies, but as the authors mentioned earlier, technology revolution is only one type of innovation (See Figure.3). It should be noted that it is not the true innovation if we do not contribute to society by improving value from the customer's point of view and lead to corporate profits. In that sense, those respondents who chose "f. Creating a new business model" may be strongly aware of the balance between customer satisfaction and corporate profits.

Q2: What is the most important factor in improving innovation capabilities? (Select the most suitable item)

This question asks the respondent to select one from 7 choices about which factors are most important to increase innovation. Respondents who determine that the choice is not in the 7 choices (a-g) must select "Other (i)" and write down the answer.

The 7 options are based on the prior research on innovation [7]. The results are shown in Figure.9. Q2 had 124 valid responses.

Similar to Q1, the statistical ratio test was performed by a one-sided testing with a difference in significance level of 1%. As a result, the choice "b. Organization flexibility (25%)" and "c. Research and development capabilities of new technologies (25%)", followed by "d. Vision of top management (21.8%)" and "a. Improving personal creativity (20.2%)" are those which marked high in significance level. Many responses to "specific items" related to design thinking, such as research and technical capabilities and strengthening individual creativity, there were also many choices related to top management, such as organizational flexibility and top management's vision, at an almost equal ratio. Ultimately, the leadership of the top management and organizational change that is appropriate for the times are essential to innovation.

a	**Enhancement of individual creativity**	**25**	**20.2%**
b	**Flexibility of an organization**	**31**	**25.0%**
c	**R&D power based on new technologies**	**31**	**25.0%**
d	**The vision of top management**	**27**	**21.8%**
e	IT(Information technologies) innovation and application	1	0.8%
f	Power of cost reduction	3	2.4%
g	Skilled worker's ability at field site	5	4.0%
h	Others	1	0.8%
		124	**100.0%**

Items which "alternative hypothesis H1" was adopted by a one-sided testing with a significance level of 1%

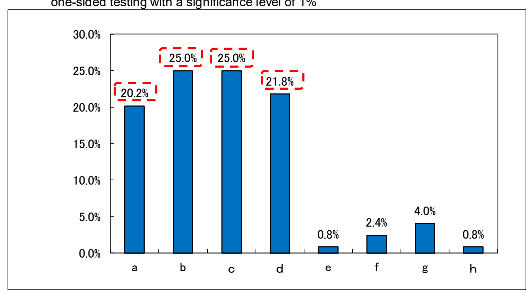


Figure.9 Distribution of the Most Important Factors for Improving Innovation Capabilities

Q3: What is the most important thing to survive in the world market? (Select the most suitable item)

This question asks the respondent to select one from 8 choices which is most important in order to increase the innovation capabilities of Japanese companies and survive in the global market. Respondents who determine that the choice is not in the 8 choices (a-h) must select "Other (i) " and write down the answer. The 8 choices were determined based on the prior research on innovation [7] and presentations at the international conferences (ISPIM, PICMET, etc.). The results are shown in Figure.10. Q3 had 108 valid responses.

Similar to Q1 and Q2, the statistical ratio test was performed by a one-sided testing with a difference in significance level of 1%. As a result, the choice "a. Strengthening of appropriate elemental technology (30.6%)", "d. Strengthening innovation-related education (in-house) (23.1%)" and "b. Strengthening of R&D department (16.7%)" these 3 items were marked significantly high ratio. The results are generally similar to Q2, which show that the company's technical capabilities and employee innovation training are important.

a	**Enhancement of relevant element technologies**	**33**	**30.6%**
b	**Enhancement of R&D division**	**18**	**16.7%**
c	Practice the daily cycle of PDCA(Plan-Do-Check-Act)	13	12.0%
d	**Implementation of employee training courses focusing on innovation**	**25**	**23.1%**
e	Implementation of recruitment for doctoral engineers	0	0.0%
f	Improvement of skilled worker's ability at field site	11	10.2%
g	Active recruitment for foreign employees	2	1.9%
h	English as an official language in the company	2	1.9%
I	Others	4	3.7%
		108	**100.0%**

Items which "alternative hypothesis H1" was adopted by a one-sided testing with a significance level of 1%

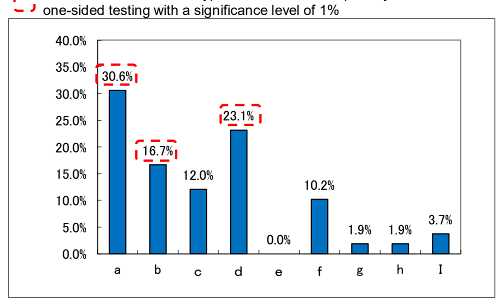


Figure.10 The Most Important Things to Survive in the World Market

On the other hand, the authors noted in Q3, there was no respondent who chose the option "e. Strengthening of hiring doctoral engineers”. In the global market, innovation is based on advanced technologies (ex. information and communication, video technology, biotechnology, etc.) This result is a little different from the international trend [12] to recognize the importance of actively recruiting the doctoral personnel who come in contact with advanced technical information in the industry sector as well. In this background, Japanese companies have traditionally recruited technical employees as new graduates (graduated and master's degrees) followed by in-house training (OJT), it is assumed that there is a long history of having those employees trained to be leading engineers under a long-term outlook. However, the manufacturing industry today is rapidly globalized and mobilized, traditional Japanese-style in-house education based on lifetime employment is unlikely to be carried out. Considering the current circumstance, it is necessary to think about the employment of the doctoral talent in the future.

Q4: What innovation patterns do you remember? (Multiple answer allowed)

For 10 innovation patterns covered in Table2, respondents are asked to select those which they have heard of through their workplaces, books, Internet, etc. (multiple answers are possible).

As with other questions, the statistical ratio test is performed with a one-sided testing with a difference in significance level of 1%. As a result, the options "c. radical innovation (20.7%)” and “h. Product Innovation (13.9%)” had significantly high ratio. What can be seen from this result is that the innovation pattern linked to "technological innovation" which had a high ratio in the innovation image has been chosen. In addition, if one-sided test with significant difference of 5% is included, “i. process innovation” is also selected as a high ratio.

a	Disruptive innovation	39	12.1%
b	Incremental innovation	41	12.7%
c	**Radical innovation**	**67**	**20.7%**
d	Grass-roots innovation	15	4.6%
e	Frugal innovation	3	0.9%
f	Bootleg innovation	2	0.6%
g	Reverse innovation	26	8.0%
h	**Product innovation**	**45**	**13.9%**
I	Process innovation	43	13.3%
j	Business innovation	42	13.0%
		323	**100.0%**

Items which "alternative hypothesis H1" was adopted by a one-sided testing with a significance level of 1%

one-side testing with a significance level of 5%

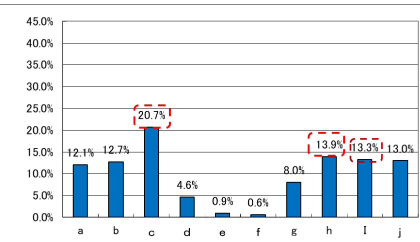


Figure.10 Distribution of Awareness in Innovation Patterns

5.What is the role of VE in innovation activities?

A series of survey results highlighted that "the innovation that is currently needed is the radical innovation to create new market; by emerging innovation of technology and through the power of advanced technology" and many respondents recognize the innovation as it is. This result is exactly close to the model answer from the standpoint of Japan which is called as technology-oriented nation. As also described in Figure.1, the manufacturing industry in Japan today is demanding radical innovation through the “front-runner strategy”. However, although this understanding of innovation is quite central, it is not enough. Because innovation activities ultimately provide high added value to customers, and for companies it is essential to increase business value and make money.

Conversely, if this point can be resolved, existing technologies could create new markets by innovation in business models and dramatically increase customer value, and even on-site grassroots improvement activity also could be a good innovation activity, if it increases customer satisfaction in a cumulative manner and leads to increased revenue. At the beginning, the authors mentioned the fact that Japan's improvement capabilities have become less effective as they used to be because the product architecture has increased the number of modular applications due to the progress of ICT.

However, in the heavy-length large industry for social infrastructure, there are still many integral product domains, where the social impact of Japan's on-site capabilities and improving capabilities is still strong in the global market [2]. Therefore, the practice of "Japanese-style grassroots innovation" that is world-class like “Kaizen activities” also plays a vital role and should be strengthened in combination with radical innovation by complementing each other. It is also a form of innovation which should be transmitted to the world.

6.Case of process innovation involving VE and TRIZ at MHPS

MHPS (Mitsubishi Hitachi Power Systems, Ltd.), one of Japan's leading social infrastructure companies, has succeeded in promoting organizational knowledge of on-site capabilities that depend on individual skills by utilizing VE, TRIZ, etc. to innovate production processes. At the same time, organizational change is underway, and Toyota's CFT (Cross Functional Team), a symbol of Kaizen activities, has been introduced on site, as a driving force of innovation [13] which is also worth noting. "i. Process innovation (13.3%)" like this case marked the third highest ratio in this study, and the ratio is significantly higher by one-sided testing with a difference in significance level of 5% in the statistical ratio test (See Figure.10). It is no doubt that it is one of the most important innovations.

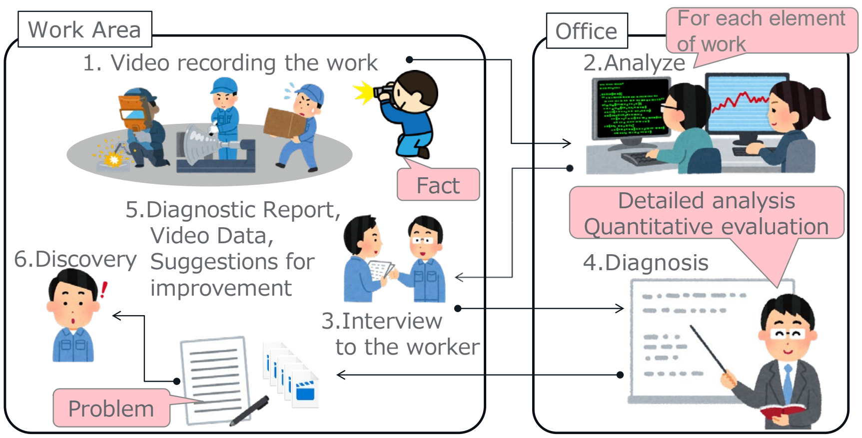


Figure.11 Overview of Process Innovation at MHPS

7.Conclusion

In Q4, the innovation patterns (See Figure.10) which respondents found they knew little about are, for example "Frugal Innovation " and "Business Innovation". Design-thinking problem-solving skills are important to deal with these innovation patterns, and for grassroots innovation, sustainable QC/IE based on PDCA improvement activities are also essential. In the future, we should also pay attention to these innovation patterns, and in a variety of innovation activities, not only the most advanced technology is important, but also MOT techniques including VE has an important role to play depending on the patterns of innovation.

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Apply Systematic Value Engineering Methodology to Assess the Value of Building Construction Project

Qi Liang[1]*, Hong Liang[2]

Abstract: Cost has long been one of the project management objectives. Every building project is unique, and building cost vary significantly along with differences in materials, structure types, clients' requirements, project characteristics, and so on. This makes direct comparison of the building cost for projects impossible and unreliable. Current study aimed to apply a value engineering methodological approach to allow for comparison of building cost for projects with different characteristics. Mixed research method was designed to achieve the research purpose, including interview with experienced construction professionals and case studies for real building projects. Algorithms were proposed to process and analyze the data regarding the building cost and the function performance of the building elements. The research results demonstrated that the difference in the building element cost was significant between two projects, which made it possible for comparison of function cost in later stage. By applying the proposed algorithms, the element cost was transferred to function cost in according to construction professionals' evaluation. The function cost of the two projects were compared, and based on the concept of value index, the project 2 has better value than the project 1 does. This paper contributed to propose a value engineering methodological approach for the comparison of building cost for projects with varying characteristics.

Keywords: Building cost; Building element; Function; Function cost; Value engineering

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Introduction

It is the common knowledge that the cost of building construction project is usually very high, because of the massive use of materials (e.g., concrete and steel), employment of a lot of manpower, and so on. As a result, how to manage cost of building construction project has long been one of the project management objectives (Clough and Sears, 1991). However, project management in term of cost control is not an easy task, and cost overrun has been not uncommon for the building construction projects in the industry (Tulacz and Rubin, 2004).

It is also not easy to assess the performance of building construction projects in term of cost, as every building construction project is one-off and unique, involving a lot of variations in terms materials, structure types, equipment, construction methods, use of technique and amount of manpower, and so on. All the variations contribute to different building cost, and make a benchmark unavailable to compare the cost of varying type of buildings. To fill the research gap, current study attempts to apply a value engineering (VE) methodological approach to assess value (i.e., function cost) of building construction project in order to allow for easy comparison among building projects with different characteristics.

VE, which originates in manufacture industry, has been introduced into the construction industry in 1960s (Dell'Isola, 1982). Since its application, it has been bringing about various benefits to the construction industry, including cost saving, time control, innovative problem solving, upgrading industrial standard, etc. (Cleton, 2018; HKSAR, 2002). VE claims that cost is spent to achieve functions, not product or project itself (Ellegant and Bushman, 2000). Based on this concept and the potential benefits of VE for innovation, current study proposed a framework to apply the VE methodological approach to allow for the comparison of the value of different building projects. Algorithms were provided for the assessment of building value under VE framework, and real case studies were carried out to test the applicability of the proposed framework for real building construction projects.

Literature

Building Cost

For any building projects, cost is always a significant factor, and cost management has long been implemented in the construction industry (Tulacz and Rubin, 2004). The cost management should include estimation of cost budget and cost control during the construction process (Best and Valence, 1999). Either inappropriate budget estimation or cost overrun in construction process could lead to high building cost. In fact, it is not easy to assess the building cost to determine whether it is high or low, as there are many factors contributing to the uniqueness of every building project. For instance, the construction methods could lead to different building cost (e.g., for tunneling, drill and blast method requests lower level of mechanization but higher level of manpower than tunnel boring machine method does, leading to varying cost). The client's requirement is also one of the factors causing varying building cost, as it determines the scope of work, quality level, and so on (Woodward, 1997). There are also other factors that could lead to variety in building cost, such as soil condition, height of flats, level of decoration and so on (Smith and Jaggar, 2007).

The cost of a building could be broadly divided into various building elements that are the portions of a project fulfilling a particular purpose despite the type of building (Morton and Jaggar, 1995). There is a widely accepted list of building elements, including *substructure*, *superstructure*, *finishes*, *fitment*, *services*, *external works*, and *preliminary* (Architectural Services Department, HKSAR 2001; Royal Institution of Chartered Surveyors, 1969). The content of *services* varies from project to project, and thus, there is lack of items to compare; *external works* is heavily subject to the influence of the external environment of the site, probably distorting the research results; and *preliminary* is mainly determined by the main contractor's preference, which exceeds the scope of this study. In this regard, current study considers the cost of four groups of building elements, including *substructure*; *superstructure*, such as frame, upper floor, roof, staircase, external walls, windows, internal walls, internal doors; *finishes*, including wall finishes, floor finishes, ceiling finishes; and *fitment*.

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Systematic VE Approach

VE is a systematic and innovative problem-solving approach for multiple-disciplinary team (Ellegant and Bushman, 2000). Since its introduction to the construction industry in 1960s, VE has been bring about various benefits to the construction projects and the industry, such as cost saving, time control, upgrading industrial standards, promoting innovations, etc. (HKSAR, 2002; Kelly et al. 2004).

VE has three elements, including value, function, and cost, relationship of which could be expressed as blow:

$$value = \frac{fuction}{Cost}$$

In order to achieve better value (e.g., same value with lower cost, higher value with same cost and higher value with lower cost), a systematic VE Job-plan was devised and has been widely applied. The VE job-plan consists of six-phases job plans, including information phase, function analysis phase, creativity phase, evaluation phase, and development phase (Norton and McElligott, 1995).

Among the six phases, the function analysis phase differs the VE from other problem-solving approach. In function analysis phase, several steps should be carried out, including identification of functions, diagramming the function by Function Analysis System Techniques (FAST), allocate building cost to function cost, and determination of function mismatch. As emphasized by the VE methodology, the cost is spent to achieve function, not the product or project itself (Ellegant and Bushman, 2000). Despite the different characteristics of varying building projects, the functions that a building performs should be more or less the same, such as create space, accommodate people, ensure esthetic, etc. In addition, FAST diagram, which presents the functions of building in a how-why logic, should also have wide applicability for building projects. By allocating the building cost to various functions cost, it is applicable to compere and assess the value of building projects with varying characteristics.

Research Methodology

Overview of Research Method

Current study aims to propose a frame for assessing the value of building project through comparison of the building function cost. The detailed methodology of current study is shown in Figure 1, including data collection, data processing and propositional VE assessment framework. Mixed research methods were designed to collect empirical data in order to achieve the research goal, including group interview with construction professionals and real case studies. The group interview was to collect the professionals' evaluation of function performance of building elements, which was further used to allocate building element cost to function cost through proposed algorithms. The case studies were to test the applicability of the proposed VE approach for the assessment of building value.

Step 1: Data collection → Step 2: Data processing → Step 3: Propositional VE assessment framework

Figure 1 Detailed Methodology

Data Collection

The identification of functions and establishment of FAST diagram was often made based on a group of participants' team judgment in the VE process (Ellegant and Bushman, 2000). In current study, several steps were adopted to identify the functions and develop FAST diagram for building projects: 1) past VM workshops for building were reviewed to select appropriate functions; 2) a group of construction professionals were invited to group discussion to identify the functions of buildings; and 3) these construction professionals were invited to development FAST diagram by presenting the identified functions in a logic manner (i.e., how-why logic) (Norton and McElligott, 1995).

In current study, a pilot study was carried out at first involving two experienced construction professionals. Both of them are qualified professionals in the construction industry and have different

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professions. A total of twenty functions were identified by the group of participants, including *divide space, enclose space, enclose space, support load, transfer load, resist corrosion, resist fire, promote accessibility, circulate people, improve privacy, protect space, manipulate light, resist weather, control ventilation, express appearance, decorate inner-space, utilize daylight, insulate ventilation, beautify community, express luxury,* and *upgrade facility*.

Based on the how-why logic, the relationships between twenty functions were diagrammed. After identification of the functions, the participants were also requested to give their judgment on the function performance of building elements by using scale ranging from 1 (very low) to 5 (very high).

Data Processing & Data Analysis

To identify the participants' opinion about the function performance of building elements, equation (1) was provided to calculate the average evaluation of the total participants:

$E_{aij} = (E_{1ij} + E_{2ij} + E_{3ij} \ldots + E_{aij}) / a$ (1)

Where E_{aij} represents the average evaluation of the participants about the function performance *i* of building elements *j*, *i* = 1, 2, 3, …, 20, *j* = 1, 2, 3, … 13, and a = 1, 2, … n. E_{1ij}, E_{2ij}, …, E_{aij}, represent the evaluation of the participant, which could be expressed in one (*i* x *j*) matrix (see Table 1 below):

Table 1 Evaluation Matrix for Participant a

E_a	1	2	…	i
1	E_{a11}	E_{a21}	…	E_{ai1}
2	E_{a12}	E_{a22}	…	E_{ai2}
…	…		…	…
j	E_{a1j}	E_{a2j}	…	E_{aij}

Note: i = 1, 2, 3, …, 20;
j = 1, 2, 3, …, 13.

Let k_{ij}, where i = 1, 2, 3, …, 20, j = 1, 2, 3, … 13, be the percentage of the building element j performed on function i. Then, k_{ij} can be calculated by dividing the performance of building element j on function i (i.e., E_{aij}) with the sum of the performance of the building element on all functions (i.e., $\sum_i E_{aij}$) (see Equation 2).

$k_{ij} = (E_{aij} / \sum_i E_{aij}) \times 100\%$ (2)

Lastly, the function cost, FC_i, can be calculated by allocating the cost of building elements based on the k_{ij} (see Equation 3).

$FC_i = k_{i1} \times BC_1 + k_{i2} \times BC_2 + k_{i3} \times BC_3 + \ldots k_{ij} \times BC_j$ (3)

Where BC_j represents the cost of building element j, i = 1, 2, 3, …, 20, j = 1, 2, 3, …, 13.

Propositional VE Assessment Framework

In VE methodology, the value of product /project could be assessed by calculation of value index, which is equal to the function worth divided by function cost (i.e., Equation 4) (Norton and McElligott, 1995).

Value index = Function worth /Function cost (4)

The function worth is often defined as the lowest cost to achieve the wanted functions (Ellegant and Bushman, 2000). If the value index is higher than 1, it is good value; and if the value index is lower than 1, it is poor value. In current study, the function worth could be set as a same constant for building projects (i.e., 1). Then, higher value index, which indicating better value, is associated with lower function cost.

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Case study

To test the applicability of the proposed VE approach for assessing the value of building, case studies were carried out for two real building projects in Hong Kong. Case study method is a powerful research method, as it allows for yielding extensive data to deeply understand specific phenomenon (Berg, 2001). It has been widely used in the construction, engineering and management research, and is often applied to test, cross-check and validate conceptual model and framework (e.g., Lu et al. 2014).

The first project is a villa house development project with a total gross floor area (GFA) of around 8,300 square meters, which was completed in 2014. The second project is a high-rise building development project, consisting of varying size of flats. Its total GFA is over 100,000 square meters, and the whole project was completed in 2011. As the two projects were completed in different years (i.e., 2014 for first project and 2011 for second project), the inflation rate should be considered. In current study, the benchmark year is set in 2017, and according to the statistics for the inflation rate (i.e., the consumer prices index) between 2012 – 2017 (Census and Statistics, 2018), the building cost of the two projects in 2017 are calculated and presented in Below Table 2.

Table 2 Building Cost in Elements in 2017

Building elements	Project 1		Project 2		Difference	
	Element cost HK$/m^2	%	Element cost HK$/m^2	%	(P1 -P2) HK$/m^2	(P1 -P2)/P1 %
1A-Substructure	**3,622**	**19.80**	**2,286**	**13.47**	1,336	36.90
2A-Frame	107	0.58	742	4.37	**-635**	**-593.85**
2B-Upper Floor	946	5.17	1,051	6.20	-106	-11.18
2C-Roof	1,057	5.78	561	3.30	496	46.94
2D-Staircase	139	0.76	173	1.02	-35	-24.91
2E-External walls	**3,106**	**16.98**	**2,729**	**16.08**	377	12.14
2F-Windows	**2,619**	**14.32**	1,706	10.05	913	34.85
2G-Internal walls	1,111	6.07	434	2.56	677	60.94
2H-Internal doors	487	2.66	603	3.55	-116	-23.87
3A-Wall Finishes	2,150	11.75	1,770	10.43	380	17.66
3B-Floor Finishes	2,101	11.48	**2,103**	**12.40**	-3	-0.13
3C-Ceiling Finishes	612	3.35	1,257	7.40	-644	-105.28
4A-Fitment	238	1.30	1,554	9.16	**-1,317**	**-554.21**
Total cost	18,295	100.00	16,970	100.00	-	-

Note: P1 =Project 1; P2 = Project 2

As shown in Table 1, the total building cost of project 1 (HK$ 18,295/m^2) is higher than cost of project 2 (HK$ 16,970/m^2). The costliest building element for project 1 is *substructure* (HK$ 3,622/m^2; 19.80%), followed by *external walls* (HK$ 3,106/m^2; 16.98%) and *windows* (HK$ 2,619/m^2; 14.32%). For project 2, the costliest building element is *external walls* (HK$ 2,729/m^2; 16.08%), followed by *substructure* (HK$ 2,286/m^2; 13.47%), and *floor finishes* (HK$ 2,103/m^2; 12.40%). As for the difference in building elements between the two projects, *substructure*, *windows* and *Internal walls* are much costlier for project 1 than for project 2, with a difference at HK$ 1,336/m^2, HK$ 913/m^2 and HK$ 677/m^2, respectively. For project 2, it also has higher cost than project 1 does in building elements *fitment* (difference = HK$ 1,317/m^2), *ceiling finishes* (difference = HK$ 644/m^2), and *frame* (difference = HK$ 635/m^2). The result in difference in term of percentage discovered big variations in various building elements cost between the two projects.

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Based on the diagram of functions developed in previous section, two construction professionals were invited to evaluate the function performance of the building elements for the two projects, respectively. By applying Equation 1 (i.e., $E_{aij} = (E_{1ij} + E_{2ij} + E_{3ij} \ldots + E_{aij}) / a$), the average evaluation of the participants for function performance of building elements could be calculated. The results were further manipulated by applying to Equation 2 (i.e., $k_{ij} = (E_{aij} / \sum_i E_{aij}) \times 100\%$) to understand the percentage of the building elements performed on specific functions (i.e., k_{ij}). After obtained the index k_{ij} for every of the functions, the function cost could be calculated by applying Equation 3 (i.e., $FC_i = k_{i1} \times BC_1 + k_{i2} \times BC_2 + k_{i3} \times BC_3 + \ldots k_{ij} \times BC_j$). The calculation of the cost of the function *divide space* for project one is shown as example below, while the comprehensive function cost for project 1 and project 2 are presented in Table 3:

$FC_i = k_{i1} \times \text{Substructure} + k_{i2} \times \text{Frame} + k_{i3} \times \text{Upper floor} + \ldots k_{ij} \times \text{Fitment}$

$= 3.57\% \times HK\$3{,}622/m^2 + 6.45\% \times HK\$107/m^2 + 5.49\% \times HK\$946/m^2 + 3.41\% \times HK\$1{,}057/m^2 + 3.85\% \times HK\$139/m^2 + 4.41\% \times HK\$3{,}106/m^2 + 2.34\% \times HK\$2{,}619/m^2 + 7.44\% \times HK\$1{,}111/m^2 + 5.79\% \times HK\$487/m^2 + 2.68\% \times HK\$2{,}150/m^2 + 2.42\% \times HK\$2{,}101/m^2 + 2.48\% \times HK\$612/m^2 + 3.00\% \times HK\$238/m^2$

$= HK\$670/m^2$

Table 3 Function Cost for Project 1 and Project 2

Functions	**Project 1**		**Project 2**		**Difference**	
	Function cost HK$/m²	**%**	**Function cost HK$/m²**	**%**	**(P1-P2) HK$/m²**	**(P1-P2)/P1 %**
Divide space	670	3.66	597	3.52	73	10.90
Enclose space	868	4.74	748	4.42	**119**	**13.74**
Support load	1,018	5.57	887	5.23	**132**	**12.93**
Transfer load	1,015	5.55	906	5.34	110	10.79
Resist corrosion	**1,164**	**6.36**	**1,069**	**6.31**	95	8.18
Resist fire	1,029	5.62	972	5.74	56	5.46
Promote accessibility	581	3.18	558	3.29	*22*	*3.87*
Circulate people	710	3.88	654	3.86	56	7.91
Improve privacy	906	4.95	850	5.01	56	6.20
Protect space	**1,092**	**5.97**	974	5.75	118	10.80
Manipulate light	626	3.42	665	3.92	-38	-6.13
Resist weather	953	5.21	859	5.07	93	9.79
Control ventilation	971	5.31	885	5.22	86	8.88
Express appearance	**1,047**	**5.72**	**984**	**5.81**	63	5.97
Decorate inner-space	873	4.77	888	5.24	*-15*	*-1.71*
Utilize Daylight	837	4.57	758	4.47	78	9.38
Insulate Ventilation	924	5.05	808	4.77	**116**	**12.56**
Beautify Community	976	5.33	881	5.20	94	9.68
Express Luxury	1,065	5.82	**1,022**	**6.03**	43	4.04
Upgrade Facility	971	5.31	**984**	**5.81**	*-13*	*-1.32*

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Function Cost	18,295	100.00	16,970	100.00	-	-

Note: P1 =Project 1; P2 = Project 2

As shown in the Table 3, the highest function cost for project 1 is *resist corrosion* (HK\$ 1,164/m^2; 6.36%), *protect space* (HK\$ 1,092/m^2; 5.97%), and *express appearance* (HK\$ 1,047/m^2; 5.72%), respectively. For project 2, the costliest functions are *resist corrosion* (HK\$ 1,069/m^2; 6.31%), express luxury (HK\$ 1,022/m^2; 6.03%), *upgrade facility* (HK\$ 984/m^2; 5.81%), and *express appearance* (HK\$ 984/m^2; 5.81%). The differences in function cost between the two projects were also calculated. The results revealed that on one hand, the biggest difference lies in enclose space (difference = HK\$ 119/m^2; 13.74%), support load (difference = HK\$ 132/m^2; 12.93%) and insulate ventilation (difference = HK\$ 116/m^2; 12.56%). On the other hand, there were also similarity in function cost between the two projects, including *upgrade facility* (difference = HK\$ -13/m^2; 1.32%), *decorate inner-space* (difference = HK\$ -15/m^2; 1.71%), and *promote accessibility* (difference = HK\$ 22/m^2; 3.87%).

Discussion

Current study reports the attempt to apply VE approach to improve current practices in assessment of build value. Because of the different building types (i.e., low-rise building and high-rises buildings) and the diverse development types (i.e., villa houses and apartment flats), the building element cost was varying significantly between the two projects (see Table 2). For instance, the biggest difference in building element cost between the two projects lie in frame (i.e., difference = HK\$ 635/m^2; 593.85%), and then in fitment (i.e., difference = HK\$ 1,317/m^2; 554.21%). The huge difference could not be used as indicator to compare building value and in thus assess the project performance in term of building cost management.

By applying the VE methodological approach, the comparison of the building cost was able to be transferred to the comparison of function cost which was based on the evaluation of experienced construction professionals and an established FAST diagram. The results of the function cost allocation reflected less discrepancy between the two projects, ranging from 1.32% at least (i.e., difference = HK\$ 13/m^2 for function *upgrade facility*) to 13.74% at most (i.e., difference = HK\$ 119/m^2 for function *upgrade facility*). The function cost was able to set a simple benchmark (i.e., the functions) to facilitate the comparison of building value for projects with different building types. It is also reasonable to claim that this VE-based comparison should be able to lead to reliable and realistic comparison. According to the VE methodological approach, value index is equal to the worth divided by function cost (i.e., Equation 4 Value index = Function worth /Function cost). Given that the function worth should be same for buildings, the lower function cost could achieve higher value index, indicating better performance in building cost.

Conclusions

Every building project has unique characteristics, contributing to varying building cost. This nature has been making the assessment of the building cost cross different types of building difficult. Current study applied a VE methodological approach to make the value of different types of building project comparable. Through a case study for two projects and with experienced construction professionals, the element cost of building and the function performance of building elements were collected. By applying proposed algorithms, the original building element cost was transferred into function cost, and the results of the comparison between the two projects shown that: 1) the difference in building element was too big to compare, which was caused by the varying characteristics of the two different type of projects; 2) after transferring the element cost to function cost, the comparison of the building cost become viable; and 3) based on the value index, the client and the construction professionals are able to judge the building value and in turn the project performance in building cost management. Current study contributed to make it possible for comparing the building value of different types of projects.

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EXPLORING VALUE MANAGEMENT PRACTICES IN REGIONS ALONG THE BELT AND ROAD

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Abstract

Value management (VM) as a decision-making approach organized by multi-disciplinary members may be used to achieve the best value of the project and satisfy the requirement of the clients in the construction projects in the Belt and Road (B&R) regions. However, most of the developing countries along the B&R regions are still lack of VM knowledge during the complicated team decision-making process. This study proposes some insightful recommendations for promoting VM to the countries along the B&R regions. In order to investigate the current VM practices and the possible challenge factors influencing the VM application, face to face semi-interviews with VM and project management experts in different countries (including, Hong Kong, Malaysia, the US and Sri Lanka) were conducted. Through the qualitative analysis, some factors of VM application related to pre-workshop (objectives setting, process identification and stakeholder), workshop (information, analysis, creativity, evaluation, development and presentation) and recommendations (awareness improvement, VM education, senior support and standard application) were extracted. The comparison of the qualitative results between those four countries showed that the US practitioners had the most experience on VM implementation and innovative VM techniques application, whilst Hong Kong and Malaysia practitioners still had rooms to be improved. VM workshops were never arranged independently, while it was just used as a cost reduction tool in Sri Lanka. Practical recommendations were put forward, including organizing various VM seminars and training, offering VM courses in college education, gaining senior supports, using SAVE standards, and building close relationships among developed and developing regions along the B&R in order to gain advanced VM techniques and promote VM properly in the construction industry.

Keywords: Belt and Road, Hong Kong, Malaysia, Sri Lanka, Value Management

Introduction

The Belt and Road (B&R) initiative has been put forward in October 2013 when Chinese President Xi visited Kazakhstan and Indonesia. It has become a significant strategy with the intention to create a regional economic co-operation framework particularly among countries along the proposed B&R routes for benefits to all (HKTDC 2019). In fact, more and more government officials, academia and business communities have been attracted by this strategy (Yu, 2017). The B&R initiative is the combination of “The Silk Road Economic Belt” (mainly target central Asia and Europe) and “The 21st-Century Maritime Silk Road” (most target Southeast, South and North Asia). According to the official website of the B&R, 138 countries, up to January 2020, have been signed the cooperation agreement of the B&R initiative (Liu, 2020), including China (e.g., Mainland China, Hong Kong and Macau), Asia (e.g., Malaysia, Pakistan, Sri Lanka, Indonesia, Laos, etc.), Africa (e.g., Morocco, South Africa, Sudan, etc.), Europe (e.g., Russia, Poland, Hungary, Croatia, etc.), Oceania (e.g., New Zealand, Fiji, etc.), South America (e.g., Chile, Uruguay, etc.), North American (e.g., Panama, Costa Rica, etc.). The Belt & Road Initiative consists of policy coordination, facilities connectivity, unimpeded trade, financial integration and people-to-people bond, while infrastructure development plays a central role in it (NDRC et al., 2015; Huang, 2016).

Based on the B&R initiative, many mega international infrastructure projects have been designed and developed, such as ports (Gwadar port and Hambantota port), railways (China-Laos railway and Jakarta-Bandung high-speed railway) and bridges (Padma Bridge and Zemun-Borca Bridge) (Ministry of Commerce Public Services, 2020). Participants in the B&R projects involve various backgrounds, experiences and knowledge, which may i communication, information sharing and

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ideas creation and judgment and subsequently lead failure to achieve the expected value of the project (Ochieng and Price, 2010; Shahhosseini et al., 2017). To obtain the best value for the construction projects among multi-stakeholder along the B&R regions, VM may play a key role to facilitate complicated team decision-making. It supports participants to define the responsibilities clearly, specify ambiguities and misperceptions in the projects, and improve the relationships and communications among stakeholders (Harry, 2002). Meanwhile, experience has proven that VM can result in the cost-saving from 5% to 10% of the total cost in construction projects, while the performance can be greatly enhanced in terms of construction time, maintainability, aesthetics, and sustainability (Norton and Mcelligot 1995; Zhang et al. 2009). This paper aims to find out the current VM practices and challenges in the regions along the B&R.

International VM Application

VM was first proposed by Mr. Lawrence D. Miles in 1947 in the US as Value Analysis (VA) and was introduced to the construction industry 1963 (Dell' Isola, 1997). The Society of American Value Engineers (SAVE) has been established in 1959 in the US as a leading professional VM institution in the world. Through decades of development, VM has been spread widely in the world, especially in Japan, Australia, European countries, etc. (Leung, 2009). Among the regions along the B&R regions, VM has been adopted in Hong Kong, Singapore, Malaysia, and so on. In fact, the Hong Kong Institute of Value Management (HKIVM) and the Institute of Value Management Malaysia (IVMM) were established in 1995 and 2000 respectively by various professionals (e.g., architects, builders, engineers, surveyors, etc.). Nevertheless, VM is still a new concept in developing countries. There is no formal VM institutions and guidelines in most of the countries along the B&R regions like Sri Lanka, Pakistan, etc. at the moment (Kurnuasena and Rajagalgoda, 2017, Shaikh et al., 2015).

The formal application requirements of VM have been designed in some B&R regions (e.g., VM for all projects with a total sum of over HK$ 200 million and RM 50 million in Hong Kong and Malaysia respectively) (WTBC, 05/2002; EPU, 2009). Different regions have their particular culture and economic situations, which may cause differences in VM applications (e.g., workshop duration, number of team members, etc.) in real situations. Therefore, to improve the VM application along the B&R regions, it is necessary to understand the specific VM characteristics and difficulties in those areas.

VM Process

VM is an organized, systematic and logical decision-making process (Dell'Isola, 1997; Green, 1994) In general, pre-workshop activities need to be conducted before formal VM workshops in order to identify the objectives of the study, set the workshop arrangement, choose the participants of the workshop and so on (Kelly et al., 2004, Leung et al.,2013). Identifying specified objectives of VM before the workshop is essential for value study team members fully understanding the client's requirements and results in more specified project goals (Leung et al., 2003). The value study team needs to be assembled as a heterogeneous team and the team members should be carefully identified based on their expertise and experience to fully cover the project issues and objectives. (Leung and Wong, 2002; SAVE, 2020). To ensure the participation of team members and facilitate effective team discussion, a well-organized work schedule should be established (Leung et al., 2013).

The carefully crafted and thoroughly tested job-plan is a critical element of VM workshop which helps value study teams overcome human limitations to make reasonable decisions (Chen and Liao, 2010). Normally, the systematic job-plan involves six components, namely, information, function analysis, creativity, evaluation, development and presentation (SAVE, 2020). In the commencement of the VM workshop, participants share all project-related information (i.e., specification, drawings, documents, etc.) and express project-related opinions to understand the project scope, clarify objectives, and specify participants' needs (Liu and Liang, 2002). After that, value study team analysis functions based on the shared information to find out both basic and supporting functions for improving overall project values. In this phase, the mission and functions are identified, the logical relationships between the functions are revealed, and the cost associate with various functions are analysed by function analysis techniques such as verb-noun phrases, how-why logic, Function Analysis Systematic Techniques (FAST), value index, etc. (Leung et al., 2013; Spaulding et al., 2005). A number of function-based ideas were then generated by different creativity techniques (i.e., brainstorming, six hats, etc.) in the creativity phase. Every i or crazy ideas are valuable in this phase,

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because they could help team members to stimulate creative thinking (Green, 1994). After ideas generation, the number of ideas could be reduced and the best ideas are selected by evaluation tools such as voting, scoring, paired comparison and so on (SAVE, 2020). The detailed proposals which may include detailed drawings, cost estimates and action plans are developed for the best ideas in the development phase (Green, 1994). In the presentation phase, the value study team members need to present their innovative VM ideas and possible VM proposals to the project team in order to gain approval for implementation (SAVE, 2020).

Research Methodology

To investigate the current VM practices and the factors influencing the VM application in the regions along the B&R, face to face semi-interviews were conducted to construction professionals, including Hong Kong, Malaysia and Sri Lanka. As VM has been adopted in the US for over 70 years, an additional interview was also conducted to an American VM expert who has wide experience in VM facilitation, in order to understand the fundamental VM standard. The background information of the respondents is shown in Table 1. The US respondent has the most VM facilitation experience in comparison with the other three interviewees from the B&R regions, while the Sri Lankan interviewee has the least. In addition to Sri Lanka respondents, the remaining three respondents (Hong Kong, the US and Malaysia) are qualified VM facilitators in their local VM institution.

Table 1 The Background Information of the Respondents

Respondents	US	Regions along the B&R		
	United States	Hong Kong	Malaysia	Sri Lanka
Professional background	Architect	QS	QS	Architect
VM institution	SAVE	HKIVM	IVMM	None
The times that facilitate VM workshops	Over 600 times	5-10 times	Over 70 times	1-5 times
Whether a qualified VM facilitator	Yes	Yes	Yes	No

Note: QS- Quantity Surveyor.

All qualitative data were collected by immediate note-taking during the discussion process in order to ensure the reliability of the data (Leung and Chan, 2012). The data was double-checked via voice recording and analyzed by qualitative software *NVivo 12*. In the end, the keywords and phrases of the qualitative data were summarized, coded and outlined.

Results and Discussion

Comparison of VM practices

The purpose of the pre-workshop is to plan and organize the VM study (SAVE, 2020). Three factors were extracted in the pre-workshop phase, including objective setting, process identification and stakeholder (see Table 2).

VM is a method of helping the client to better achieve their goals (Connaughton et al., 1996; Male et al., 1998). Respondents from Hong Kong, Malaysia and the US indicated that the identification of VM objective was based on the requirements of the client, while the objective of VM in Sri Lanka was mainly for cost reduction (Sri Lanka interviewee). In Sri Lanka, they always mixed all phases together, because VM was just a minor part of the project management workshop and the stakeholders actually did not want to spend too much time on it. VM facilitators in Hong Kong and Malaysia normally discussed with their clients for the workshop arrangement in advance, while the VM process in the US straightly "followed the six-step job plan in the SAVE Standard" (the US interviewee). The US participants did not need to spend extra time on the discussion of the job plan in the pre-workshop meeting due to the mature VM system.

The VM team is a multi-disciplinary group involving experienced professionals (e.g., structural engineer, architect, etc.) and project stakeholders (e.g., project owner, user, etc.) (SAVE, 2020). The person invited in VM workshops should be decided by the client in Hong Kong and Malaysia. However, the project manager had to choose VM team members due to no qualified VM facilitators in Sri Lanka. The participants were mainly client and c Back to TOC hitect, structural engineer, and surveyor, etc.) from different disciplines for all four countries, while other interested parties such as community and government were also invited to the workshops in HK, the US, and Malaysia.

Table 2 Summary of Pre-workshop Items

Factors	Description
Objective setting	
Client's need	The objective was identified based on *the client's needs* in HK, MA, and the US.
Cost duction	The objective of VM was *cost reduction* in SL.
Process identification	
Standard	The VM process in the US followed the six-step job plan in the *SAVE Standard*.
Discussion	The VM process was *discussed before the workshop* in HK and MA.
Mix-together	In SL, all VM phases *were mixed* together.
Stakeholder	
Selection	The *client chose the team members* in HK and MA, but the *project manager was the one who selects the team members* in SL.
Sample	The stakeholders in the VM workshop were *client and consultants in all B&R regions and the US. Besides, other interested parties, such as community and government were also invited in all of the countries, except SL.*

Note: HK – Hong Kong; MA – Malaysia; SL – Sri Lanka and US – United States.

The typical VM process is a six-phase job plan (Bowen et al., 2010; SAVE, 2020), but VM techniques may be various in different regions (see Table 3). In the information phase, "each workshop participant contributed different information and the project managers need to record all the information in Sri Lanka" (Sri Lanka interviewee), while participants in Hong Kong shared the detailed latest information with other workshop teammates" (Hong Kong interviewee). The Function analysis phase is a key step during the VM process in Hong Kong, Malaysia and the US, while Sri Lanka normally ignores this phase. Function identification and/or FAST diagram for understanding the relationships among the functions logically were applied in HK, MA and US. (Spaulding, 2005).

All the respondents indicated that the quantity of ideas was emphasized in the creativity phase (say, 200-300 ideas in Malaysia). In Hong Kong Malaysia and the US, no idea was evaluated in this section. On the contrary, participants in Sri Lanka could judge and delete ideas at any time when someone disagreed with them. The selected ideas were always simply based on the agreement of the participants in Sri Lanka, while some techniques such as scoring, evaluation matrix, champion methods were used in other regions (Hong Kong, Malaysia and the US). Proposals for the selected ideas were developed in Hong Kong, Malaysia and the US in order to enable the project team to make decisions for implementation (Lee et al., 2009). Unlike the other three regions, "there was no specific development phase in Sri Lanka". They did the presentation after the evaluation phase (Sri Lanka interviewee).

In the end, a presentation is needed to introduce or summarize outstanding ideas to the client (Male et al., 1998; SAVE, 2020). Normally, VM facilitators are more skillful in presenting and familiar with the VM process among the VM team members. In Hong Kong, each team member presented their own ideas, but the VM study team would choose a team member to present the ideas when the time was limit. In Malaysia and the US, VM facilitators were presenters in the presentation whereas the project manager should take this responsibility in Sri Lanka.

Some advanced techniques were applied in the VM process in the US, such as function tree, function cost model and quality model. However, Hong Kong and Malaysia mainly used some common traditional techniques in the VM process, such as function analysis, brainstorming and scoring. In Sri Lanka, the VM techniques were not properly used. Participants usually analyzed information by handwriting and totally based on the agreement among team members to evaluate ideas.

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Table 3 Summary of VM process Items

Workshop Process	Statement
Information	
Information Type	The detailed *latest information* such as l*ayout plan, key issues, and relevant documents* was shared in HK. In SL, *each role* of the participants contributed different information.
Information techniques	Different information sharing techniques, including brainstorming (HK, US, and SL), presentation (MA), and value models (MA and US) were applied.
Analysis	
Function analysis	*The functions* of the projects were analyzed in the analysis phase in HK, MA and the US.
Analysis techniques	*Verb and noun phases* were used to identify functions, while the *FAST diagram* was applied for analyzing the logical relationship between functions in HK, MA and the US. In addition to that, other techniques such as *function cost* (US), *function tree* (US) and *value index* (MA) were also be used. However, in SL, they just analyzed information on *the blackboa*rd *by handwriting*.
Creativity	
Judgement	*Judgment for ideas was not allowed* when generated ideas in HK, MA and the US. But ideas were *simply deleted when someone disagrees* in SL.
Creativity techniques	Brainstorming was used for generating ideas in the HK, MA, the US and SL. Other creativity techniques such as *force field* (US), *Delphi method* (US), *and six hats* (MA and US) were also applied in MA and the US.
Evaluation	
Evaluation techniques	The evaluation techniques including *T-test* (US)*, weighted* (US)*, choosing by advantage (US), scoring* (HK, MA and US*),* champion (US), *voting by red dots* (HK) and *evaluation matrix* (HK and MA) were utilized in HK, MA and the US.
Persuasion	Participants were *convinced by other team members for the best* idea in SL.
Development	
Proposal	*Proposals for ideas* were developed in this phase (HK, MA and US).
Presentation	
Presenter	*VM facilitator* did the presentation in MA and the US. *The VM team elected a team member to present* in HK while the *project manager* carried out the presentation in SL.

Note: HK – Hong Kong; MA – Malaysia; SL – Sri Lanka and US – United States.

Recommendation

After exploring the factors for VM practices and challenges in the B&R regions, the respondents also offered some practical recommendations for promoting VM: Awareness improvement, education improvement, senior support and standard application (refer to Table 4).

For promoting the VM application, the *improvement of VM awareness* is the crucial step. The VM awareness can be improved via *workshops and seminars* (Hong Kong, the US, and Sri Lanka interviewees) by introducing VM basic knowledge and some successful examples of VM application. On the other hand, offering VM courses in universities may also be a chance for people to learn professional VM knowledge. Some universities have included VM courses in Hong Kong and Malaysia (Che Mat, 2010; Leung, 2006). However, VM is not a formal course in most countries along the B&R regions such as Sri Lanka. Their universities "just taught a little bit about VM basic knowledge in quantity survey courses" (Sri Lanka interviewee). Thus, it is suggested to *offer VM education in the university* to enhance the VM knowledge. The government, as a policymaker, should take the responsibility to promote VM practices with other construction-related authorities (Cheah and Ting, 2005). Respondents from Hong Kong, M ka suggested that *senior support such as*

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government (Hong Kong, Malaysia and Sri Lanka interviewee)*, big* companies (Malaysia interviewee), *and VM institutions* (Malaysia interviewee) can improve the VM application in the B&R countries. VM institutes in VM founding regions such as SAVE and those in the B&R regions like the HKIVM should take the responsibility for promoting VM to the B&R countries by offer professional VM training and VM services. For example, the HKIVM has being conducted a series of influencing international conferences, seminars and workshops in 2018-2019 for promoting and extending VM professional services to the B&R regions (HKIVM, 2019). Producing a VM guideline is seen as a starting platform to guide and promote VM methodology to the local construction industry (Zainul and Jappar, 2010). A standard can define the VM steps, terminology, and guide practitioners in applying VM effectively (SAVE, 2020). Perhaps, using the international standard such as *use SAVE standard* (The US interviewee) in the B&R regions is a good way to promote VM.

Table 4 Summary of VM Promotion Items

VM promotion factors	Recommendations
Awareness improvement	
Workshops/ seminars	VM awareness could be enhanced *through seminars* (HK, US and SL) and workshops (SL).
VM education	
University course	VM could be promoted by *offering VM courses in the universities* (US and SL).
Senior support	
Governmental support	VM promotion needs to be *supported by the government* (HK, MA and SL), *the big company* (MA) and *other VM institutions* (MA).
Standard application	
SAVE standard	We should encourage the B&R regions to use *SAVE standards* (US).

Note: HK – Hong Kong; MA – Malaysia; SL – Sri Lanka and US – United States.

Conclusion

Over the past decades, VM has been successfully applied in construction projects in many countries. VM could significantly reduce life cycle costs, improve performance, and facilitate the decision-making process of the project. However, there is still a lack of VM application in most of the B&R regions. To promote the VM in the B&R regions, this paper explored the current VM practices and challenges influencing the VM application via semi-interview with VM and project management experts from the B&R regions (Hong Kong, Malaysia and Sri Lanka) and the VM founded countries (the US). Through the qualitative analysis, some factors were identified in terms of pre-workshop (i.e., objectives setting, process identification and stakeholder) and workshop (i.e., information, analysis, creativity, evaluation, development and presentation). The results revealed that the US practitioners had the most experiences for VM application and used the most advanced VM techniques among the practitioners of those 4 countries. Hong Kong and Malaysia practitioners were supposed to have more mature VM experiences among practitioners in other B&R countries, but VM participants in these two countries still had room for improvement. Sri Lanka professionals applied VM as a tool for just cost reduction in project management, while VM workshops were never arranged independently. Furthermore, several recommendations were proposed for the application of VM in the B&R regions by respondents, including awareness improvement, VM education, senior support, and standard application. In addition to the recommendations of the qualitative results, VM practitioners in developing countries along the B&R regions such as Sri Lanka should learn a systematic VM process and the advanced VM techniques from VM experts in developed countries (e.g., Hong Kong) as much as possible. On the other hand, VM experts in the developed regions long the B&R can also build close relationships with construction professional institutes in the developing countries in order to promote VM properly in the construction industry.

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Value Management in Africa: A Literature review

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Abstract

Previous researches revealed that construction projects in African countries fundamentally suffer from poor project outcomes. This implies that value management (VM) technique could be of immense benefits to the continent. However, knowledge of VM technique and its associated benefits are grossly insufficient among construction professionals in the continent. There is also a pretext that there is a considerable number of indigenous VM experts in African countries, in which the assertion cannot be verified. This study, therefore, conducted a critical review of VM application on construction projects in Africa with articles obtained from Web of Science (WoS) and Scopus databases. The articles were composed of researches conducted in Egypt, South Africa, Nigeria, and Ghana. The study revealed that VM had been introduced to South Africa for over 5-decade; however, the level of knowledge of VM and its application in the country is still very low. VM applications on construction projects in Egypt were most technical in African countries. The study also showed that Egypt is the only African country with a functional VM institute. Therefore, this study recommended that all African countries should collaborate with VM institute in Egypt for training, seminar, and workshops via the free and paid webinar programmes of the institute. Conclusively, African countries should embrace the benefits of VM in different sectors to ameliorate the problem of poor project performance, stakeholders' dissatisfaction, etc.

Introduction

Value Management (VM) is a team decision-making process propounded in the manufacturing sector of the US in the 1940s (Oke and Aigbavboa, 2017; SAVE, 2015). The process entails clearly stating the functions required to achieving the best value and objectives declared by clients and project stakeholders, such as minimization of capital cost, maximization of the operation period, achievement of possible safety standard, etc. (Leung and Yu, 2014). The process when undertaken by Lawrence D. Miles, the initiator of VM, led to the discovery of an alternative that was used to replace a scarce material during World War II (Jay and Bowen, 2015). Following the advantages such as suitability of the alternative material, and the cost saved in the process; the methodology became popular in other sectors (Fong, 2004; Khan, 2015). VM was first applied on a public construction project in the 1960s by Dell'Isola after two decades of its application in the manufacturing industry (SAVE, 2015). The advantages of its application of the first construction projects led to its wide acceptance in the construction industry, and other sectors in the US. Gradually, the methodology became popular in different countries across the globe for public engagement, public consultation, and other team decision-making processes on construction projects (Yu et al., 2020; Leung et al., 2013). It thus confirms the submission of Lawrence D. Miles on the importance of VM in achieving value for money. However, the application on construction projects in Africa is relatively little. There is also a pretext by some construction professionals that VM is being applied on construction projects (Ojo, 2018). Meanwhile, there is no report to substantiate this assertion. Therefore, there is a need to investigate the application of VM on construction projects in African countries, and to compare the extent of VM knowledge and usage.

Research Methodology

Critical review studies are often conducted to investigate the extent of application of a particular concept, phenomenon, or methodology in a field of study. Such reviews are undertaking with the aim of recommending future directions to researchers and practitioners (Yang et al., 2010; Flanagan et al., 2007).

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There are various methodologies employed in previous critical review studies. In some studies, published articles within a year range were retrieved and reviewed to draw conclusions; while others applied unique approaches to delimit the number of research publications to be reviewed in order to achieve the aims of their researches (Zhong et al., 2019; Wang et al., 2018). In sum, any critical review must indicate the aim of the study, scientific methodology with which published articles were sourced, approaches in delimiting the volume of the sourced articles, careful synthesis of the extant literature, and the possible recommendations for future studies.

To employ a suitable research methodology to achieve the aim of this study, VM researches conducted in African countries were sourced from scientific databases. There are two major influential scientific databases, i.e., Web of Science (WoS) and Scopus for identifying scholarly articles in any field of study (Olawumi et al., 2017; Mongeon and Paul-Hus, 2016). Therefore, literature search was first carried out on WoS using the search string "value management* and value engineering*". The search result was refined to include only articles written in English language. The result was further delimited to articles within the context of African countries. Scopus database was further searched following the processes employed on the WoS to source relevant VM research articles.

Results

A total of 34 articles were found including 29 of the articles were "certified knowledge", i.e., peer-reviewed journal articles (Ramos-Rodríguez and Ruíz-Navarro, 2004; Zheng et al., 2016); while 5 were conference papers. The journal articles Egypt (13), South Africa (8), Nigeria (6), and Ghana (2) were carefully checked to be sure that they were based on construction projects. Besides, the journals where the articles were published are internationally recognized as relevant to construction-related researches. Therefore, the VM-related articles from these journals were regarded as such that could help to achieve the aim of this study. To have a quality discussion on the VM application in the construction industry of the 4 selected countries, references were also made to other published materials for appropriate juxtaposition.

Discussions

This section explored the history, summary of VM application (i.e., hard VM), and VM promotion in the 4 selected countries. Extant literature was garnered and extensively reviewed, and juxtaposition in respect to VM articles in other developed countries were carried out as well.

History

VM was introduced into South Africa in 1968 by an engineer who worked with the Union Carbide (Siglé et al., 1999). The engineer realized the benefits of VM after his study in the US and decided to share the knowledge with his colleagues in South Africa. The Nigerian professionals were first introduced to the techniques of VM in the 1990s via a seminar organised by stakeholders in the manufacturing, and construction industry (Oke and Aigbavboa, 2017). No documented article indicates when VM was introduced to Egypt and Ghana (see Table 1). It is worthy to note that VM was introduced to South Africa at almost the same time with Australia in 1960s and the UK in 1965 respectively (Male et al., 1998). In fact, VM was first introduced to Hong Kong 2-decade, i.e., in 1988 after South Africa (Shen and Yu, 2012). It is worthy to note that the level of application of VM in South Africa is still very low compared to Hong Kong (Ma and Tam, 2013; Aigbavboa et al., 2016).

Table 1 History

Element	Egypt	South Africa	Nigeria	Ghana
Year of introduction		1968	1990s	
Means of introduction		Union Carbide	Seminars and workshop	

Value Management Workshops Conducted

To establish the level of knowledge and application of VM in African countries, the VM workshops conducted in the four selected countries were investigated in the review process (see Table 2). The traditional VM workshops often described in light of the techniques and process which is referred to as *hard VM* were basically considered (Kelly et al., 2004). Meanwhile, considering the team behaviour of participants in VM workshops were considered to be important to have a holistic view of VM (Leung, 2001).

VM workshop had been applied in the construction industry in Egypt. Recently, VM was applied on the construction of Egyptian museum (Morsi et al., 2018; Neha, 2019). The reason for conducting the VM workshop was to save cost on the multi-billion mega project, and to achieve value for money. It was also documented that there was cost overrun of US$400million, time overrun, the need to curb international loans, and avoid floating Egyptian pounds before the thought of conducting VM came to the mind of VM workshop initiator, i.e., Egypt military. However, the cost saved on the project estimated at US$1.1billion was not disclosed. The creative ideas suggested by VM workshop participants that helped in achieving the objectives of the study was *"sourcing stone cladding and local materials in place of imported materials".* Other VM workshops conducted in the Egyptian construction industry were on bridge construction (Basha and Gab-Allah, 1991); and residential project of 1700 housing units (Rachwan et al., 2016; Khodeir and El Ghandour, 2018). The cost saved on these construction projects ranges from 15 to 40 percent, while 7 percent saving on energy consumption was realized on the 1700 housing units in particular via VM study.

Scholarly articles reported that VM was applied on hospitals, schools, government office projects, and rail projects in South Africa (Aigbavboa et al., 2016; Oke et al., 2017). The reasons for the application of VM in the South African construction industry were cost-saving, value enhancement, risk mitigation, and time-saving (Bowen et al., 2007, 2010a, 2011). The tools employed for the evaluation of creative ideas suggested by VM workshop participants in the South African construction industry were Simple Multi-attribute Rating Technique (SMART); time, cost, and quality triangle; and lifecycle Costing (Bowen et al., 2011). Meanwhile, the South African quantity surveyors indicated in specific the use of quality function deployment technique in previous workshops (Bowen et al., 2010b; SAVE, 2007). This implies that VM workshops on construction projects in South Africa utilized the necessary tools to achieve values for money.

In the Nigerian construction, VM workshop was conducted on a football viewing centre, a 2-bedroom bungalow, single bedroom en-suite security gatehouse, and church building (Oke et al., 2015). The reason for undertaking VM study was for profitability enhancement during the lifecycle of the project, and cost-saving at the construction stage. The cost saved via VM workshop on these projects ranges from 15 to 38 percent. The suggested ideas that helped in achieving the objectives of the workshop were using locally available materials for the project, and replacing POP ceiling with PVC ceiling. It is important to note that none of the VM workshops conducted in Nigeria specified the use of FAST diagram at the analysis phase (see Table 2). Meanwhile, any workshop without the development of FAST diagram, calculation of function cost, value mismatch, the use of verb-noun phrase, asking "why?", and "how?" questions cannot be considered as VM workshop (Kelly and Male, 2001). Therefore, the function analysis phase is the *logic* to determine the real application of VM study and the knowledge of the workshop participants. Thus, it cannot only be inferred that the level of knowledge of VM by Nigerian construction professionals is very low; the workshops cannot be ascertained as VM workshop, it may be a brainstorming session among construction professionals on how to reduce the cost of some items or change the type of products.

From the extensive literature conducted, there is no application of VM on any construction project in Ghana. This corroborates the conclusions of Kissi et al (2017) that, VM is at the infant stage in Ghana. Besides, the possible benefits of VM application on the Ghanian road projects were researched (Antwi, 2015). Recommendations were proffered to road professionals, road infrastructure, and support agencies under the ministry of roads and highways of the government of Ghana to give urgent attention to training on VM. Among the four selected countries in this study, Ghana is considered the most backward in the knowledge and application of VM.

In the selection of VM facilitators in the countries, listening ability and innovativeness were considered to be important in South Africa and Nigeria. Mental alertness, leadership skills, and other behaviours that would help the team to work collaboratively together towards a common goal were also considered to be vital (Oke and Ogunsemi, 2013; Oke and Aigbavboa, 2017). The soft dimensions of VM were also considered to be important for holistic investigation in the review conducted (Leung, 2001), which could

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support conflict management, enhance participants' commitment, and ultimately, improve the final satisfaction (Leung et al., 2005; Leung et al., 2014). The values expected of VM facilitators in Egypt are similar to that of the American standard (SAVE, 2007; Abdallah, 2020). The team composition in VM workshops were multidisciplinary stakeholders of the internal and external team in Egypt, South Africa, and Nigeria.

Table 2 Summary of Value Management Workshops

Element	Egypt	South Africa	Nigeria	Ghana
Industry	Construction	Construction	Construction	-
Type of project where VM was applied	• Bridge project • 1700 residential units • Grand Egyptian museum	• Hospitals • Schools • Government office projects • Rail projects	• A viewing centre • 2-bedroom bungalow • Single bedroom en-suit security gate house • A church building	-
Initial cost of project before VM study	US$1.1billion (Grand Egyptian Museum)	-	US$10,000.00 to US$190,000.00	-
Reasons for VM study	• Cost saving • To achieve best value for money	• Cost saving • Value achievement • Risk management	• Cost saving • Profitability enhancement	-
Initiator of VM study	Egypt military	-	-	-
Pre-workshop activities	• Team selection • Data presentation	• Team selection • Gathering project data	• Team selection • Obtaining relevant data	-
Number of VM team	-	-	5 to 6 members	-
The use of FAST	Specified	Specified	-	-
Creative ideas in the VM study	Sourcing stone cladding and local materials in place of imported materials.	Critical thinking of alternative materials that can give the same function	Replacement of POP ceiling with PVC ceiling, and using local materials	-
Tool(s) adopted for evaluation	• Brainstorming • Lifecycle costing • Net present value • GO and NO-GO approach • Champion	• Lifecycle costing • Sime Multi-attribute Rating Technique (SMART)	• Brainstorming	-
Evaluation criteria adopted	• Maintenance cost • Construction cost • Ease of construction • Availability of resources • Construction progress rate		• Maintenance cost • Construction cost • Ease of construction • Sustainability	-
Cost saved	15-40%	5-25%	15-38%	-
Post-workshop activities	• Implementation plan • Follow up	• Review of implementation approach	• Action plan meeting	-

	• Monitoring proposal effectiveness	

Value Management Promotion

This study also checked various methods through which VM knowledge and practices are being promoted in the countries. Egypt is the only African country with formal basic and advanced VM training. Free webinars on the institute website of Egypt is another means through which professionals in the countries were being educated; while coursework at the postgraduate level of tertiary institutions, seminars, and workshops are methods employed in the other 3 countries. The South African Qualification Authority (SAQA) proposed a national certificate on value engineering to construction professionals who successfully completed the required course (SAQA, 2019).

Egypt established a VM institute named the Egyptian Institute of Value Studies (EGCVS) in 2019 (Abdallah, 2019). Awareness programmes of VM are being channeled through various wikis, i.e., online post, and training by the institute. The institute has collaboration with SAVE international and the Miles Value Foundation. The institution flags all upcoming activities of SAVE international (e.g. value summit, registration link, etc.) on their website page (EGCVS news, 2021). Other courses that could increase the knowledge and training of construction professionals on VM methodology are constantly displayed on the institution's website.

A VM institute known as the *Value Engineering Management Society of South Africa (VEMSSA)* was established in 1997 (Siglé et al., 1999). Meanwhile, the information on the website reveals that VEMSSA was established in 1977 as against 1997 mentioned by Siglé et al (1999). Secondly, the institute website is hosted on another professional institute's website *(i.e., South African Institute of Mechanical Engineering - SAIMechE)* (SAIMechE, 2021). This may be as a result of the influence of the professional institution which Van Heerdeen, the engineer that established VEMSSA belongs (Siglé et al., 1999). There is no other information on the website to indicate any recent VM-related activities, except for the vision statement, mission statement, and definitions of VM. Obviously, these information were written on the website at the inception of the institute and could be regarded as obsolete. This could be one of the reasons why the application of VM in the South African is relatively low (Aigbavboa et al., 2016). In fact, a study revealed that South African engineers (i.e., civil, mechanical, and electrical engineers) do not have a good understand the concept of VM (Bowen et al., 2010a). Therefore, it can be technically concluded that the EGCVS is the only VM institute in Africa as a result of its activeness since its establishment.

Recommendations

Based on the findings of this study, the Egyptian construction industry performed best in the application of VM on construction projects. The country has functional VM professionals, affiliations with SAVE international and other VM institutions, an active VM institute, and recognition on WoS with resourceful publications. *Therefore, it is recommended that Egypt could devise methods such as free webinars, short courses with certificate, and practicum on real-life construction projects purposely to educate construction professionals in the entire countries in Africa.* Some collaborations between Nigerian and Egyptian authors were noticed in recent studies (Kineber et al., 2021a, b, 2020). However, engaging in scholarly writing may not guarantee practical experience of VM application on construction projects. In fact, a reviewer opined that Nigeria has enough VM experts, in which there is no article to underscore the assertion was true. Besides, all studies in Nigeria have always highlights the lack of VM experts, and insufficient knowledge of VM techniques as critical hindrances to the application of VM in Nigeria (Dahiru, 2019; Ojo and Ogunsemi, 2019; Tanko et al., 2018). This indicates some level of inconsistency, or possibly lack of experience on the part of some academics in the construction industry. *Therefore, it is recommended that construction professionals (i.e., academics and construction practitioners) in other parts of African countries collaborate with the Egyptian construction professionals to acquire the necessary skills required via training. It is also recommended that all construction professionals such as architect, quantity surveyors, builders, project managers, and engineers in South African construction industry come together to build a formidable VM institution which can function properly without the intrusion of any professional body.* This would assist all

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South African construction stakeholders and professionals to have a platform to learn techniques for achieving value for money for construction clients.

Conclusions

Previous researches show that VM was introduced to some African countries for decades. For example, VM was introduced to South Africa in 1968, and Nigeria in the 1990s. Considering the years of introducing VM into these countries, one would expect massive application of VM on construction projects. It is appalling to note that, scholarly articles constantly reveal lack of VM knowledge, unawareness of VM benefits, etc. as impediments to wide acceptance and usage of VM in these countries and other African countries. There is also a pretext that certain African country possess a considerable number of VM experts. Therefore, this study conducted a critical review to investigate the application of VM in 4 African countries to determine the extent of VM usage.

The study shows that Egypt has the most logical VM application in which the use of function analysis with the use of FAST diagram, verb-noun phrase, etc. were carefully carried out. The country has recently applied VM to multibillion dollars construction projects, and other numerous projects. Meanwhile, South Africa and Nigeria had also applied VM to few construction projects. However, the logic of VM process, i.e., function analysis was not clearly stated in the VM workshops on construction projects in Nigeria. This could imply that VM workshops were possibly conducted as a cost-cutting exercise. Thus, it corroborates previous findings that show a low level of VM knowledge in these countries. There was no application of VM on any construction projects on any construction project in Ghana. It can therefore be concluded that the Egyptian construction industry is the only African country that has considerable knowledge of VM, and had applied the methodology to achieve values for construction projects.

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FUNCTION ANALYSIS – PERSPECTIVES AND ALTERNATIVE APPROACHES

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ABSTRACT

The key differentiator between Value Methodology and any other cost oriented studies/techniques/practices is the effective usage of "Study of Functions" and not only "Cost". The cost is brought into the study a derivative of "Functions".

One of the very important phases in VM is Function Analysis phase wherein Function Analysis System Technique (FAST) diagram is an integral element of Function analysis. FAST diagram is used to represent a logical relationship among functions, which answer to How-Why-When logic. The VM practitioners create FAST diagram and present their perspectives on the effectiveness of the same as part of function analysis.

Likewise, another important activity within Function Analysis Phase is "Function Cost Worth" (FCW) which is done to identify Value Gap/Index so as to focus more on high potential functions.

This paper attempts to bring out various perspectives about the effectiveness of Function Analysis Phase (especially FAST diagram and Function Cost Worth analysis) and recommended alternates.

INTRODUCTION

Value Methodology is a systematic process used by a multidisciplinary team to improve the value of projects through the analysis of functions. It can be applied to a wide range of applications, including industrial or consumer products, construction projects, manufacturing processes, business procedures, services and business plans.

The Value Methodology is commonly applied under the names Value Analysis, (VA), Value Engineering (VE) and Value Management. These term can be used interchangeably with value methodology. Other Value improvement processes also qualify as 'Value studies' as long as they adhere to the Value Methodology job plan and perform Function Analysis as part of their total process.

The value methodology focuses on improving value by identifying alternate ways to reliably accomplish a function that meets the performance expectations of the customer. Identification of functions and their analysis is the foundation of a value methodology and is the key activity that differentiates this methodology from other problem-solving or improvement practices.

HCL team typically execute VA/VE projects using the following stages of activities (also shown in the diagram):

1. Stage 1: Pre-Workshop Study – which includes activities in preparation to detailed project execution

2. Stage 2: Workshop – the core activities which are mapped to the SAVE International Recommended Value Methodology (VM), such as Information collection, Function Analysis Phase, Creative Phase, Evaluation Phase, Development Phase and Presentation Phase

3. Stage 3: Post Workshop – the activities involved with implementing the VM recommendations

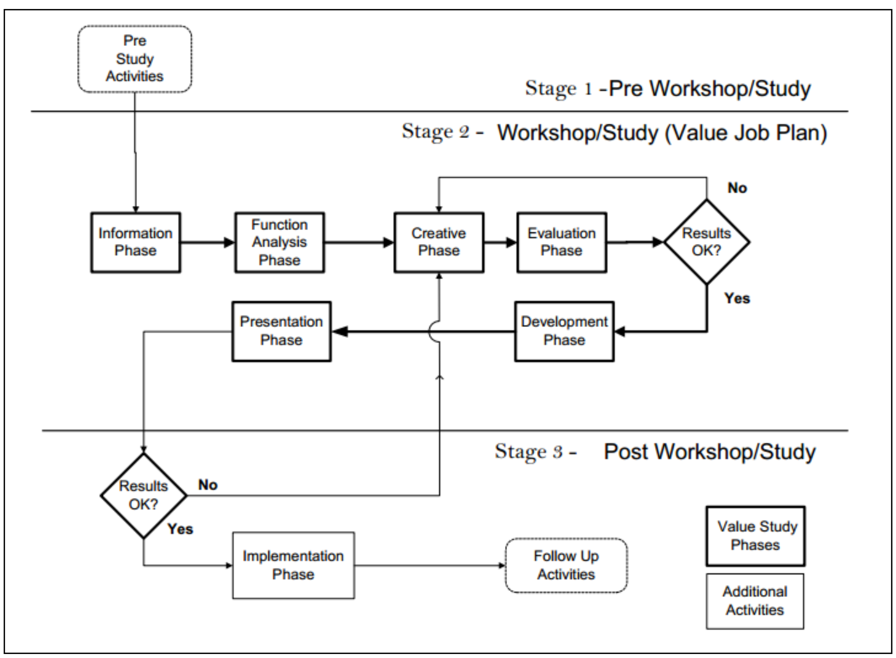

Figure-1: VA/VE projects - Stages and Activities

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TYPICAL FUNCTION ANALYSIS PHASE – PROCESS FLOW

The activities that are typically carried out during various stages of Function Analysis Phase are as shown in the figure below:

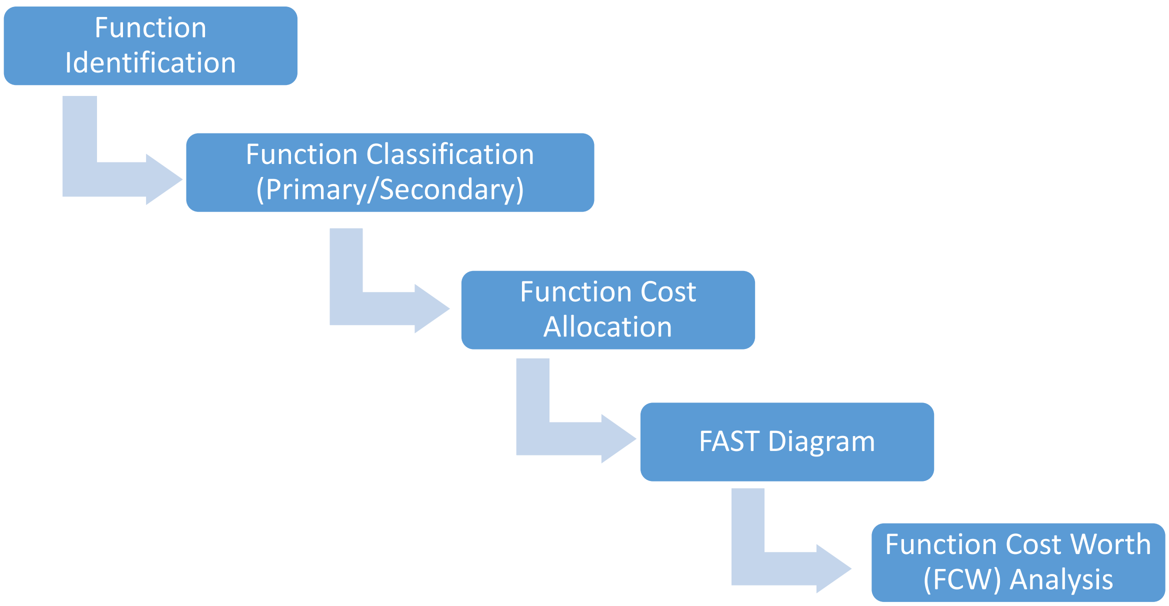

Figure-2: Activities during Function Analysis

We would now like to discuss the perspectives & apprehensions faced by the authors as also expressed by Value Methodology practitioners, and recommended alternative approaches to address these issues.

Perspectives & Apprehensions -

As seen in the process flow above, typically the Function Analysis Phase starts with identifying & listing down the functions of parts/components (based on features). However, most of the times functions at sub-assembly level and top level assembly level are not identified and listed.

Post/During function identification, the functions are classified as "Primary" and "Secondary" which by definition can be done. However, that does not provide any specific output which can flow as an input for the next step. The classification category as "Primary" also sometimes is confusing with other category i.e. "Basic" used in subsequent stages.

Next activity is to allocate cost to functions based on the cost incurred to achieve the function in the product/assembly being studied. The apprehension with this is that bringing in "Cost" perspective and that too in close context with current design/manufacturing cost does not offer a neutral or fresh & blank platform.

Another very important activity under Function analysis is to create a FAST diagram. The FAST diagram or FAST model is a diagrammatic representation of the functions of a product, process or system, and their inter-relationships that ensure it functions on expected lines. The FAST diagram works on the principle that the functions of a product, process or system work in a logical way. Usually the best technical FAST diagrams represent a portion of a total product, process or system which serves end customers or users.

Another activity performed during Function analysis phase is “Function Cost Worth Analysis” wherein finding worth of a function is attempted based on known or existing alternates. Nevertheless, there is subjectivity in this process and might mislead when we try to identify high potential (high value gap/index) functions. This may also limit the creative thinking of team during Creativity phase because they have already discussed about other known or existing alternates for the function.

Listed further herein are some of the voices against deployment of the subject Function analysis techniques:

- They are very difficult and challenging tools to master….
- There is too much subjectivity at every step in the approach, right from Function definitions through assessing Worth of a function to creating FAST diagrams.
- A designer has all that is needed for his/her analysis by way of system layout, specifications, and envelope/space constraints, so what good does a Function Analysis or even an elaborate VM study do?
- Why bother about Function analysis, when all that is needed is some Cost saving solutions, which can be obtained through Ideation workshops or brainstorming exercises?
- FAST diagram is very similar to a Flow-chart, so that technique can be used instead, rather than going through the trouble of understanding what is needed for FAST and developing one
- A full-sized VM study starting from project kick-off to recommended solutions could take a lot of time, in some cases several months to execute
- When a VM project is proposed to a decision-making or the funding authority, the timelines and project costs proposed could be reasons to reject the proposal. Such authority may contend that tangible savings may not be possible to justify the proposed investment on costs and time
- How the overall understanding from FAST diagram goes as “input” for the next step in process?
- Most of the time it is created just to follow the classical methodology and/or for documentation?
- Logical arrangement or understanding of functions and further classification does not really serve as key inputs to “Creative” phase, then what is the use of such arrangement or classification?

Having analyzed all the perspectives & apprehensions above and based on the experience while working diversified products/processes across industries, the authors would like to present the following alternative approaches which can be selected suitably as per project requirements & expectations.

Recommended Alternative approaches or Good Practices –

- Identify and list down function at sub-assembly and top level assembly level too and add them in Creative Phase
- To avoid confusion between "Basic" & "Primary", identified functions can be classified as "Basic" & "Secondary".
- Validate existence/importance of the Function with respect to "Requirements" first (especially for VE projects. i.e. for new design/process etc.) before getting into Function Classification, Cost allocation, FAST Diagram & FCW analysis.
- Especially for New Design/Process projects, where the focus is more on generating and developing innovative solutions to existing problems, it is recommended not to bring in the "Cost" perspective, since it is based on current design/manufacturing cost which will constrain "Innovative Thinking"
- Yet another way could be to take only "Basic Function" and go for "Creative Phase". This will provide an opportunity to have completely out of box and innovative ideas or alternatives because Creative phase then would not be influenced by current design/process characteristics.
- Focus should be more on High Cost Functions and Major Critical Path Functions during Creativity
- Explore deployment of automation in VM process (through the use of auto-templates, formats for Function analysis activities in particular and other VE activities in general). This would lead to improvement on efficiency of solutions, and project timelines could be brought down from months to a few weeks.

Level			Description	Feature	Function	Basic/Secondary
1			Vent	Assembly	Allow Flow	Basic
					Contain Fluid	Basic
	1.1		Cover Assembly			
		1.1.1	Cap			
				Shape	Support Part	Basic
					Allow Flow	Secondary
				Material	Strengthen part	Basic
					Weigh Less	Basic
				Cover face	Support Part	Basic
				Holes	Connect Component	Secondary
				Finish	Prevent Corrosion	Secondary
					Conduct Electricity	Secondary
				GD&T	Position Component	Secondary
		1.1.2	Ring			
				Shape	Support Part	Basic
					Allow Flow	Secondary
				Material	Strengthen Part	Basic
					Weigh Less	Basic
				Knurled Surface	Grip Component	Basic
				Finish	Conduct Electricity	Secondary

Figure-3: Sample Function Analysis using Template

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		A	B	C	D	E	F		
		Allow flow	Mount Part	Direct Flow	Transfer Load	Connect Part	House Part	Score	% Share
A	Allow flow		A3B1	A3C1	A3D2	A3E1	A3F1	15	31.9
B	Mount part			B1C2	B2D2	B3E1	B3F1	10	21.3
C	Direct flow				C2D1	C1E1	C1F1	7	14.9
D	Transfer Load					D2E1	D2F1	9	19.1
E	Connect Part						E1F1	5	10.6
F	House Part							1	2.1
							Total Score	47	100.0

Figure-4: Sample Function Cost Allocation using template

- Another way could be to take all the functions from Function Identification activity to Creative Phase. The focus for FAST Diagramming and FCW analysis should be mainly to validate the identified Functions
- By definition, Worth is the least cost of reliably achieving a function which is not often understood or paid attention to. Also it is to be understood that the purpose of Value gap or Value Index assessment, a key step under FCW analysis is chiefly to look at the magnitude of Cost-Worth gap. The basis or Worth itself shall not be used as an idea or solution to the VE problem.
- Every VE project team shall include at least one certified Value Engineer to drive the project. Depending on size and timeline of the project, more trained or certified Value Engineers may be included.
- During Creative phase, the invited cross-functional team is only to be responsible for generating the ideas. It is the responsibility of the VE practitioner among the team to perform all Function analysis activities and present the findings to the full team before-hand. Similarly, after the idea generation, it is again the responsibility of the VE practitioner to classify and validate the ideas against Function analysis findings.

EXECUTIVE SUMMARY

The table below presents a summary of the discussions from the previous sections:

Process Stage	Activities	Recommendations
Function Identification	Functions of all parts / components are identified and listed	Identity & List down Sub-Assembly Level and Top Level Functions too
Function Classification	After Function Identification, the functions are classified as "Primary" & "Secondary"	Classifying as "Primary" is most of the times confusing with classifying as "Basic"
Function Cost Allocation	Allocate cost to functions	Do not bring in "Cost" perspective based on current design/manufacturing cost which will constrain "Innovative Thinking" for New Design/Process projects
Function Cost Worth Analysis	Identify Function Worth (based on Known or Existing Alternate) and Find out Value Gap & Index	1. To eliminate subjectivity and to make "Creative" Phase more efficient & effective (focused towards Innovation), Use time & efforts of resources in taking "All" functions to "Creativity Phase" 2. The purpose of Value gap or Value Index assessment is chiefly to look at the magnitude of Cost-Worth gap. The basis or Worth itself shall not be used as an idea or solution to the VE problem
All Function Analysis Activities	All applicable activities	1. Deployment of automation in VM process would lead to improvement on efficiency of solutions, and considerable reduction of project timelines 2. Every VE project team shall include at least one certified Value Engineer to drive the project. 3. During Creative phase, the VE practitioner among the team shall be responsible to perform all Function analysis activities and present the findings to the full team before-hand. Similarly, after the idea generation, he/she shall be responsible to classify and validate the ideas against Function analysis findings.

CONCLUDING COMMENTS

Finally, authors wish to bring more focus on "Functions" and not on "Cost" (in any form) for "Innovative, Creative & Sustainable" outcome through VM study because Innovation doesn't necessarily mean Complex & Costly solution. Rather, innovation can provide solutions which are much simpler & cost effective and with many other tangible & intangible benefits.

The only obstacle in having something new or innovative as an alternate is the mindset about initial & development cost (time, efforts, money etc.) but then again if we encourage innovation & creative thinking, it may lead to benefits like more efficient & cost effective solutions (considering total life cycle cost & revenues through improved sales, Improved cost of ownership, Branding), first to market (competitive advantage) and change in overall culture of organization which is need of the hour.

During Creative Phase or Prioritization or Evaluation, authors also suggest to bring in parameters (and their weightages accordingly) like use of environmental friendly or recyclable material, Reduction in Carbon Footprint, Effective disposal techniques/plans, Reduction in harmful emissions, Reduction in Heat dissipation to environment directly etc. These parameters will be very important in meeting stringent compliances in future due to various environmental, community & health related issues.

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BUILDING BLOCKS FOR SUCCESS AS A CVS®, VERSION 2.0

GUIDANCE FOR FACILITATING A VE STUDY OUTSIDE THE FACILITATOR'S EXPERTISE

BY JOHN CORCORAN, PE, CVS®

The text that follows shares my experience as a new Certified Value Specialist (CVS®) and lends advice and guidance based on that experience to other value engineering (VE) study facilitators who have achieved the title of CVS®. The paper specifically demonstrates some of my lessons learned from my first two years as a CVS® facilitating studies for projects that were predominantly outside of my expertise. The paper discusses how proper preparation for a study and appropriate reaction within a study will contribute toward a positive outcome. I also share learning tools that I developed to help facilitate VE studies in a specific field outside of my own expertise and I encourage the new CVS® to develop their own tools to improve their facilitation. Finally, I convey to the reader the importance of trusting the six-phase process that provides the framework of a VE study.

The inspiration for the theme of this text is the paper that was presented by Laurel (Laurie) Dennis at the 2018 Value Summit in Austin, Texas. Laurie is an experienced CVS® and her paper titled *Building Blocks for Success as a CVS®* (Dennis, 2018) shares some of her experiences as a CVS®. I was a CVS® candidate and in the process of completing the CVS® application for submission at the time of the presentation, so I found the presentation content to be particularly relevant. This paper is offered as a continuation of Laurie's paper to further help others in the position of being a new CVS® to become better and more versatile facilitators.

In order to discuss the facilitation of a study beyond the expertise of the CVS®, it is important to first define expertise. Expertise is defined by the Cambridge English Dictionary as, "a high level of knowledge or skill." (Cambridge online). A typical VE study is comprised of appropriate subject matter experts that possess a high level of knowledge or skill within a certain discipline of the overall project scope. The success of the study is usually a direct result of the expertise of the study team. In the best-case scenario, the study facilitator will select the most capable subject matter experts to assemble a team or help the owner / client with the selection process. Candidates for study team participation may submit resumes that demonstrate their experience. The client or facilitator may request that minimum requirements are fulfilled, such as a minimum of 20 years of experience and or professional registrations. In addition to experience within one's discipline, experience in value engineering may also be deemed an asset. The capability of the VE team will almost always increase as more time is spent in the team selection process.

Unfortunately, the definition of expert can vary drastically in reality depending on the timing of the VE team staffing. The VE team leader may not always be involved in the team selection process and is instead assigned a roster of individuals that may be strangers. Some team members' experience may be more appropriately defined as proficiency versus expertise. Proficiency is defined by the Cambridge English Dictionary as, "the fact of having the skill and experience for doing something." Proficiency may be regarded as a level of knowledge that is somewhat less than expertise. A worse scenario is when a team member is merely the best candidate available from a limited talent pool. A lack of experience does not automatically preclude an individual from being a productive team member. It is necessary to continually introduce new talent to the value methodology. But a team member lacking experience is not as likely to contribute as much to the success of the study. I discuss these various levels of skill possessed by VE team members because management of team members is a key responsibility of a VE team leader.

Before discussing lessons learned for facilitating a study beyond one's expertise, it makes sense to recap my path to CVS®. Long before deciding to pursue training in value engineering, I was a part of a VE team as a drainage and construction expert for a state highway project. I had never heard of a value engineering study prior to that experience so I was taught the definition of value and led through the six-step process that comprises a VE study along with the other team members. At the conclusion of the study, I expressed to the team leader Randy Sprague how I had enjoyed the study and would be interested in participating in more studies in the future. I particularly enjoyed being focused on a single project for one week at an intense pace, then having my involvement completed at the end of the week.

After the third study on which I participated I was invited by Randy to consider pursuit of value methodology and eventually becoming a CVS®. He had complimented my verbal and writing skills in addition to my general demeanor within the team dynamic. He cautioned me that the path to CVS® can be long and tedious, but that Jacobs could support my pursuit. I accepted the challenge and continued to sit on VE teams as the drainage and stormwater expert. I also was placed on teams where I did not have specific expertise required for that project, but where I could perform the role of assistant team leader. As my VE team experience grew, I began looking at the various other requirements to become a CVS®. In 2015, I joined SAVE and completed the Module I Training. The Module I Training has since been replaced by VMF1 training. I began garnering all the requirements for the CVS® application including the completion of VMF2 training and finally submitted the application in 2018. My application was accepted in the spring of 2019 and in the summer of 2019, I passed the exam to become a CVS®.

Upon achievement of CVS®, my career changed almost immediately. As part of the presentation of her paper in 2018, Laurie asks the question, "You're a CVS®, now what?" I was about to learn the answer to that question. I learned that where I was previously the value methodology student as a VE team member, I was now the teacher of the value methodology as the VE team leader. I also learned that leading a team through the value methodology is not as easy as it looks when someone else as the leader.

In my pursuit of becoming a CVS®, I had the opportunity to work with various team leaders. I was fortunate to have two fulltime mentors instead of just one. Randy Sprague, who is mentioned earlier, is my coworker at Jacobs and is my mentor of record. I also participated on many VE teams led by Richard LaRuffa. Rich was a coworker at Jacobs and an additional mentor to me until his retirement in 2019. Over the years, I participated on dozens of studies with the studies led by Rich and Randy being approximately equal. I also had the opportunity to be a VE team member as a subconsultant for two studies for the New York City Office of Management and Budget (NYC OMB). The studies were led by Randy Barber who is an independent VE consultant. Working closely with Randy on the studies was Jill Woller, the value officer for the client. Randy and Jill collaborated continually throughout the study on their approach to achieve study results that were mutually agreeable. Jill was also my proctor for the CVS® exam. Finally, I completed both training modules under the instruction of John Sloggy. These individuals have all achieved the position of CVS® and I learned something from each of their unique styles.

As previously mentioned, however, leading a VE study is not as easy as it looks when watching another team leader. The team leader must develop a plan for instructing the basics of value methodology that is comfortable for them while also connecting with the team members. The leader should select the appropriate training materials to convey the value methodology and be prepared with answers to any questions that the team might have. The team leader must also expand their general knowledge base to the extent possible to understand the project disciplines and scope. Also, the team leader must engage more directly with the client and or design management. This often requires facilitation of the implementation process after the VE workshop has been completed. Perhaps most importantly, the team leader must manage all the unique personalities that comprise the team to maximize the productivity of the team as a unit. While the VE team is typically a collection of subject matter experts in the appropriate disciplines, there may be team members that lack the proper experience as previously discussed or are otherwise just weaker team members.

The foundation for any good VE study is proper preparation. While the need for proper preparation is obvious, there are specific areas where the facilitator can focus preparation efforts to make the best use of time. While it certainly benefits the facilitator to have a thorough understanding of all work disciplines that comprise the project, the facilitator must remember that he or she is surrounded by the team of experts who can speak on a technical level. Instead, the facilitator can maximize their preparation efforts by focusing on the operational aspects of the project. It is likely that the key project managers and stakeholders that attend the presentation at the conclusion of the study are more interested in the general operations of the project and less interested in the project's specific components. Therefore, the facilitator should be more prepared to engage in general project discussion while defaulting to subject matter experts on the team to answer technical questions.

The discussion of project site operations will often include ingress and egress, vehicular and pedestrian maneuverability, maintenance access, and emergency response. Therefore, the CVS® should be well familiarized with the local street names on the site and or immediately off the site. The CVS should know the names of the key buildings on site, particularly if they are memorials to important people in that site's history. The CVS® must always ensure they are correctly pronouncing street names when speaking and correctly spelling the names in written documents and visual presentations. Similarly, for architectural building projects, the discussion is likely to focus on circulation at key locations such as main entrances, lobbies, libraries, and other similar public access areas. The CVS® should spend more time becoming familiar with the building floor plans and less time on the internal systems that support the building functions.

As an example, I recently facilitated a VE study for the renovation of the Tomochichi Federal Building and U.S. Courthouse in Savannah, Georgia. The main project objectives were to address structural deficiencies, upgrade or replace failing systems, maintain historical fabric, achieve ADA code compliancy, and improve security, especially at the judges' parking area. The specific design disciplines included civil, mechanical, electrical, structural, and fire protection engineering and architecture. But prior to researching the project design plans, narrative, and cost estimate, I spent time researching who Tomochichi was. I learned with some quick research that Tomochichi was a head chief of the Yamacraw tribe, which resided in present-day Savannah. Tomochichi gave land to British colonist James Oglethorpe on which the City of Savannah was founded in the 1730's. (Wikipedia). This history was never discussed in the study, but I was prepared in case it was.

Another way that the CVS® can optimize their preparation is to become familiar with the owner terminology. A simple way to do this is to review the acronyms or list of abbreviations that are listed in construction plans and or design narratives. Most of the projects I have facilitated recently have been for military clients, mostly the United States Army Corps of Engineers (USACE). Military projects in particular include specific acronyms that are commonly used in project dialogue. Just a few examples of government acronyms I have memorized to support my facilitation efforts include AT/FP – anti-terrorism / force protection; FFE – Furniture, Fixtures, and Equipment; GOV – government owned vehicle; POV – privately owned vehicle; and UFC – Unified Facilities Criteria. As a civil engineer by trade, these acronyms were all foreign to me prior to facilitating VE studies.

In addition to preparation, a team leader may also need a proper reaction as the progress of the study may dictate. Some conditions that may require a reaction by the team leader include the discussion of important issues during the design presentation that were not captured with the same degree of importance in the design materials or new information being made available during the study. For example, design plans and reports do not usually include constructability considerations at the earlier design stages when VE studies generally occur. However, the client and or end user may use the design presentation meeting as a forum to vocalize concerns about site access, operations, and maintenance during construction. The team leader may have to revise the study focus to incorporate these concerns. These concerns should be captured in the Function Analysis and subsequent phases. The team leader may also have to change the direction of the Development Phase if new available information impacts ideas being developed. Material that may become available while the VE study is in progress could include geotechnical reports and cost estimate updates. The team leader must quickly determine whether ideas are still worthy of development as information becomes available.

As mentioned previously, my primary background is in stormwater management for highway projects. However, my recent VE study facility experience has been for predominantly building architecture projects for Department of Defense (DoD) clients. DoD projects are generally subject to the funding limitations stated in the DD Form 1391. The DD Form 1391 also states the building footprint limitations. This experience facilitating studies for architecture projects has led me to rethink how project resources are defined. SAVE International defines value (V) as a ratio of function (F) to resources (R), V = F / R, where value increases as functions are increased and or resources are reduced. Resources are generally defined by dollars or other units of currency and there is often a bias to define resources only by dollars. But because of these recent architecture projects, I give equal consideration to building space (square footage) as a resource. I have created some simple graphics to illustrate the opportunities for value improvement when changes to space usage are considered with respect to function and need.

The following graphics illustrate some simple floorplans for a fictitious building corridor. In all floorplans, the length is 120' and the width is 30'. The total floorplan square footage is 3,600 s.f. and is assumed to be constant. All floorplans include a central corridor flanked by rooms on both sides. The floorplans assume that the interior walls have a thickness of 0'.

Figure 1 below shows a proposed design with a 10'-wide corridor for the entire length of the floorplan and 24 rooms with dimensions of 10' x 10' for a square footage of 100 s.f. per room. There are 12 rooms on each side of the corridor. The base design and all alternatives assume that the customer's needs are the only criterion and that no building codes are applicable.

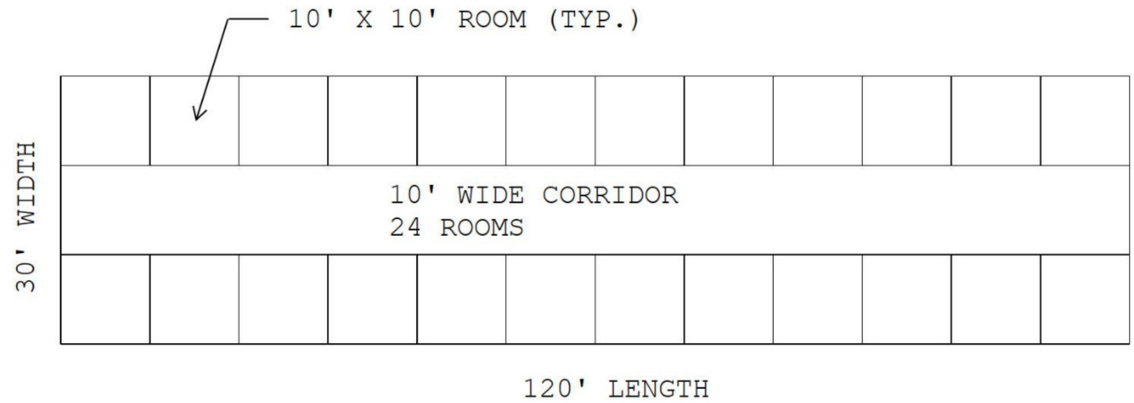

Figure 1 – Base Design, 10' Wide Center Corridor, 24 Rooms of 100 s.f.

The VE alternatives challenge the proposed design by asking some simple questions as follows:

- Is the ratio of corridor space to room space optimized or could one of them be increased to better support function and need?
- Is it advantageous to have more rooms with each room having a slightly reduced footprint?

Figure 2 below shows a VE alternative where the corridor space is maintained, but the room dimensions are changed to provide one additional room. The VE alternative maintains the 10'-wide corridor for the entire length of the floorplan but changes the room footprint from 10' x 10' to 12' x 8', so the footprint for each room is reduced from 100 s.f. to 96 s.f. The rooms are oriented so that there are 10 rooms on one side of the corridor and 15 rooms on the other side of the corridor. The total number of rooms is 25 which is one more than the 24 rooms proposed in the original design. It is recognized that the asymmetrical footprint may not be desired due to the impact on structural and architectural designs.

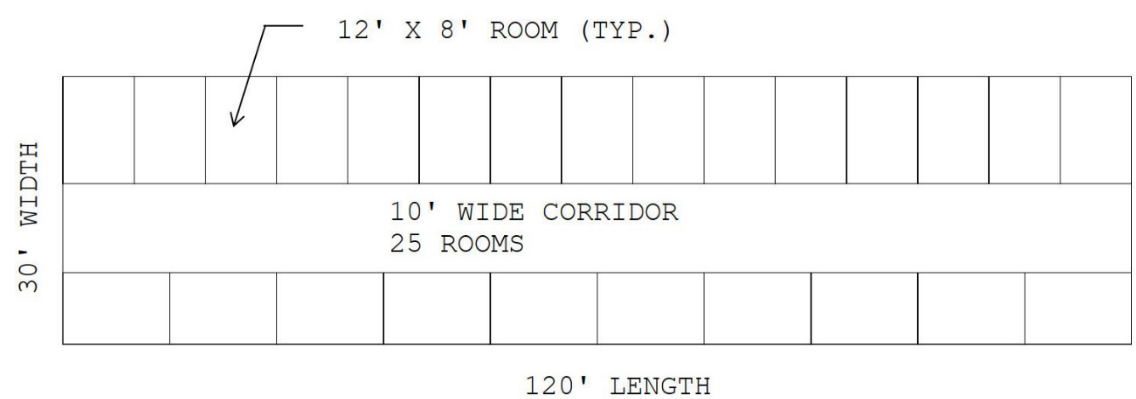

Figure 2 – VE Alternative 1, 10' Wide Off-Center Corridor, 25 Rooms of 96 s.f.

Figure 3 below shows a VE alternative where the corridor space is increased to meet the project function and need. The VE alternative increases the corridor width from 10' to 14' for the entire length of the floorplan and maintains the room footprint of 12' x 8' proposed in the previous VE alternative, so the footprint for each room is 96 s.f. The rooms are oriented so that there are 10 rooms on each of the corridor. The total number of rooms is 20 which is less than the 24 rooms proposed in the original design.

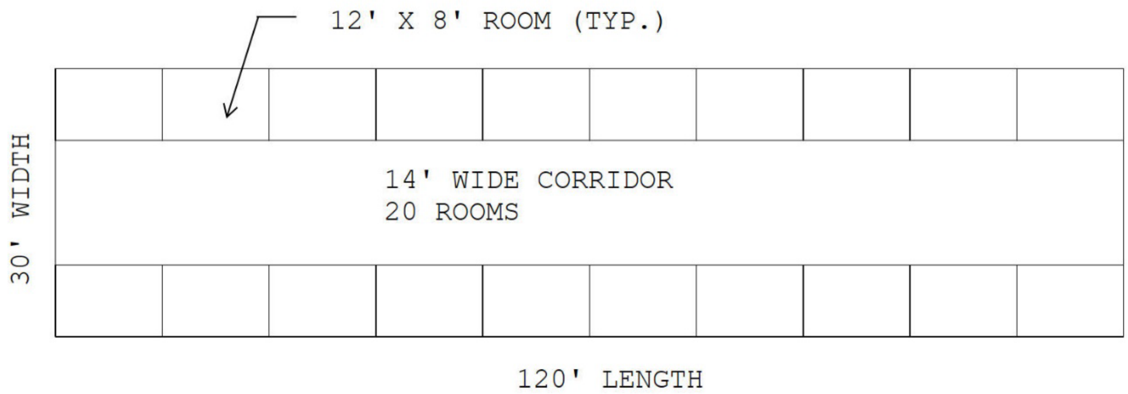

Figure 3 – VE Alternative 2, 14' Wide Center Corridor, 20 Rooms of 96 s.f.

Figure 4 below shows a VE alternative where the corridor space is decreased to meet the project function and need. The VE alternative decreases the corridor width from 10' to 6' for the entire length of the floorplan and maintains the room footprint of 12' x 8' proposed in the previous VE alternative, so the footprint for each room is 96 s.f. The rooms are oriented so that there are 15 rooms on each side of the corridor. The total number of rooms is 30 which is more than the 24 rooms proposed in the original design.

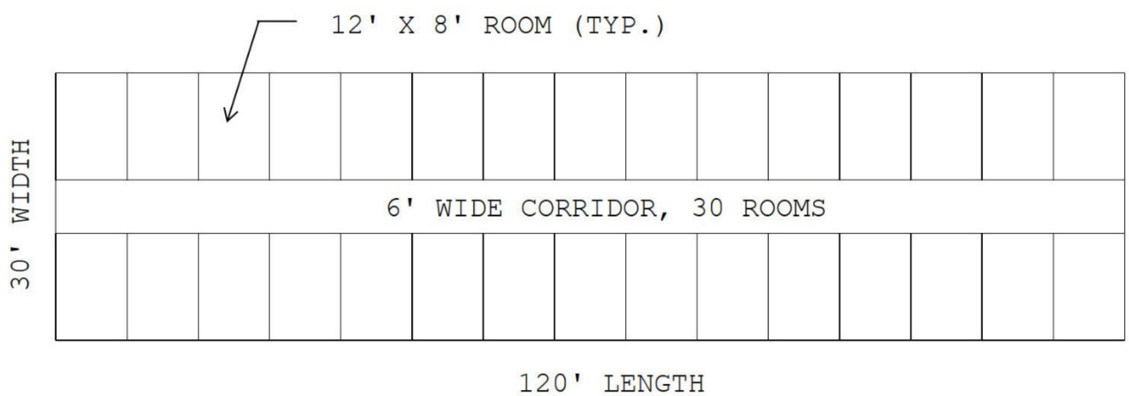

Figure 4 – VE Alternative 3, 6' Wide Center Corridor, 30 Rooms of 96 s.f.

The table on the following page summarizes the floorplan parameters and dimensions and will help the end user select the optimum floor plan to meet the operational function and need.

Floorplan Parameters	Base Design	Alt. 1	Alt. 2	Alt. 3
Length (ft)	120	120	120	120
Width (ft)	30	30	30	30
Floorplan Area (ft^2)	3600	3600	3600	3600
Corridor Width (ft)	10	10	14	6
Corridor Area (ft^2)	1200	1200	1680	720
No. Rooms	24	25	20	30
Room Dimensions	10 x 10	12 X 8	12 X 8	12 X 8
Each Room Area (ft^2)	100	96	96	96
Total Room Area (ft^2)	2400	2400	1920	2880

Table 1 – Summary of Floorplan Space Usage

The graphics are not intended to be complicated. Rather they are intended to simplify the relationship between function and space. The various options presented in the preceding figures illustrate the delicate balance that often exists between function and space and how optimization can frequently be realized with minor tweaks to the design. The options would help the owner or end users of the fictitious building select the floorplan that best meets the operational function and need. It is possible that the optimum floorplan is not one of the single floorplans shown, but a hybrid of more than one. In any case, the VE alternatives presented have helped the end user to consider function and need to select the optimum floorplan. I encourage all new facilitators possessing the title of CVS® to develop tools to help them convey the value methodology and become better team leaders.

In conclusion, my advice to any new CVS® is a lesson I learned from Laurie's presentation (Dennis, 2018) at the 2018 Value Summit. The advice is to, "Trust the Process." The referenced process is the six-phase approach to a VE study. The scope of each study will be different. The expertise of the optimum team will be different for each study. The process is always the same. The six-step process will work for any project in any field as long as each phase is employed properly. Proper employment of the six-step process will help ensure the success of any VE study whether the facilitator has expertise in the project disciplines or not.

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INTEGRATING SUPPLIERS IN VA/VE STUDIES

AUTHORS: MARC PAUWELS, Dr.-Ing., PVM, TVM, CVS, FSAVE
KREHL & PARTNER – The VALUE MANAGER

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Dr. Pauwels holds the European Certificates of Professional for Value Management and Trainer for Value Management as well as the CVS certificate. He is a certified trainer for VM1 – VM3 and the VMF1. In 2018, he became a member of the SAVE College of Fellows.

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Summary

In manufacturing environment, the use of suppliers is a normal situation for all companies. From suppliers of standard parts like screws via suppliers for sub-assemblies up to system suppliers – all is in the normal range for a company. How to deal with suppliers in VA/VE studies? Shall every supplier be part of the team? Or is it allowed to integrate a system supplier in a VA/VE study? This paper deals exactly with this kind of questions and wants to give the reader an overview over the opportunities, but also the risks of such an integration.

Initial Situation and Need for Action

The world became more and more complex in the last decades. Globalization, ecology and individualization are only three reasons for this development. Consequently, companies developing, producing and selling products of all kind are not able anymore to provide the extreme depth of production, so to produce everything on their own. At least some of the components are bought-in, but in most cases also sub-assemblies and more complex components are not produced internally. In some cases, e.g. in plant engineering, even all components, sub-assemblies and systems are bought in. Only the engineering and service are the core competencies.

Independent of a low or a high depth of production, all companies have the goal to have a reasonable margin with their products. In best case, they directly use a value-oriented method to develop their products, so of course VA/VE. Or they start some VA/VE studies when they identify a margin problem with their existing products. Having all processes and cost information inhouse, the study can directly start. But what to do, if the company does not have anymore the detailed information and cost transparency of the products? Is a VA/VE study impossible to start now?

Of course, the general methodology of the VA/VE study does not change. Only that one or more suppliers must be taken into consideration in the VA/VE study.

Supplier Management in General

The integration of suppliers is an important part of the supplier management. The latter one includes:

- Evaluation of supplier
  Identifying the performance of a supplier based on a set of criteria
- Development of suppliers
  Defining targets for suppliers and supporting suppliers by optimization programs
- Integration of suppliers
  Enlarging the scope for the supplier and getting him more and more involved
- Controlling of suppliers
  Continuous as-is/should-be evaluation, detecting and eliminating potential deviations

In the past, suppliers have been contacted relatively late in the whole supply process. The products have already been designed and the supplier was only asked to deliver the parts. Today, the companies are not willing and/or able anymore to manufacture everything on their own and thus they also lost the competencies to design a part in the right way. So, potential suppliers must be integrated into the process

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as early as possible. The supplier has the knowledge and the experience, and the company must purchase. This leads to another problem within the product development: companies are not able anymore to evaluate the performance of the sub-assemblies or systems. And even more, they do not have a clue about the cost in general and about the cost drivers in specific.

Supplier Integration in VA/VE studies

There are 3 general possibilities to integrate suppliers in VA/VE studies:

1. The supplier as a guest in a VA/VE meeting
2. The supplier becomes a full member of the VA/VE team
3. The VA/VE study takes place at the supplier

1. The supplier as a guest in a VA/VE meeting

This kind of collaboration is the simplest possibility to integrate a supplier in a VA/VE study. The time frame is strictly defined and is limited to the component or product of the supplier. Internal and confidential information can be separated from the discussion and the meeting can be guided accordingly.

The supplier could also be already integrated in the requirement analysis and in the function analysis. But the latest for the idea finding and first evaluation, the supplier must be integrated.

2. The supplier as a team member of a VA/VE study

Typically, a supplier can be integrated in a VA/VE study, if

- the most important part of the product was identified as the part of the supplier
- the technical principle of the part is set in stone (e.g. a hydraulic solution)
- the supplier for this part is defined
- the contractual framework is fixed

Very important in this context is the mutual trust between the supplier and the customer. It must be clear that the goal of the common activities is not a pure cost reduction at the expense of the supplier, but that the team is working together on the development of new ideas. In addition, the compliance according to knowledge transfer and confidentiality must be secured.

The choice of the VA/VE partner and the circumstances require the consideration of the following points:

- Cooperation with so far familiar partners on a cooperative basis
- Taking into consideration the (financial) interests of the partners
- Easy exchange of information between the partners
- Avoidance of conflicting interests, e.g. by a transfer of knowledge
- Agreement between the partners on the distribution of success and effort, on the disclosure of cost data and on the property of potential patents

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3. The VA/VE study at the supplier

In that case, the customer is asking the supplier to perform a VA/VE study on the dedicated component or product. It must be considered, if and how the supplier is willing to cooperate, who is paying for the effort and how the success will be distributed. Beside of these points, the VA/VE study is like a standard VA/VE study. It is highly recommended that the facilitator is an external one. This neutral facilitation avoids a one-sided work on the study or at least the suspicion of such a work. A member of the customer could also participate at some of the meetings to ensure the right information flow. But also here, the trust of the partners must be highly developed.

Practical example: Integrating 2 cascading suppliers in a VA/VE study

The customer company is a producer of electro-mechanical devices (general example see figure 1) and is the owner of the design of these products. The supplier 1 is producing the electronics and delivers it to supplier 2. This supplier is producing the mechanical parts and assembles the final product. It is openly communicated that the customer is aiming for an own assembly in the medium-term.

At the time where the product was developed, technical issues have been in the focus, not the cost for the product. As a clear consequence, the margin of the product is not satisfying at all. The goal of the project is a cost reduction of 35%, i.e. about 3 Mio. € per year.

The customer is fully aware that the cost reduction project cannot be realized without the cooperation of the 2 suppliers.

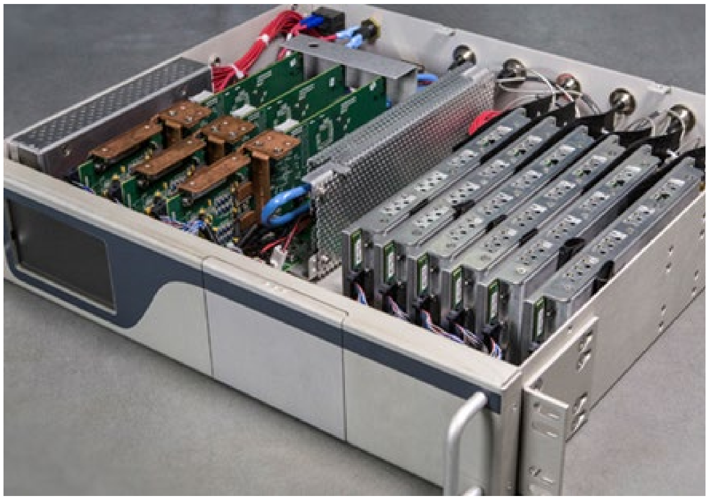

Figure 1: Example of an electro-mechanical device

(Only general example, not the real study & company! Source: https://www.arc-tronics.com/services/electro-mechanical)

The customer decided to perform a VA/VE project with the full integration of both suppliers in the team. To guarantee the neutrality of the whole project, an external consultant was asked to facilitate the team meetings: Krehl & Partner. The team composition is shown in figure 2.

Task setter:	NN	COO Customer company
Core team:	NN	Project leader
	NN	Purchasing
	NN	Production
	NN	Process engineering
	NN	Marketing
	NN	Key Account Supplier 1
	NN	CEO Supplier 1
	NN	Head of R&D Supplier 2
	NN	Site Manager Supplier 2
Krehl & Partner:	Consultant 1	
	Consultant 2	

Figure 2: Team composition

The 11 team meetings followed the typical procedure of a VA/VE study:

1. Analysis of markets, final customer groups and final customer requirements
2. Analysis of the product itself, including function analysis
3. Idea finding
4. Evaluation and definition of scenarios
5. Presentation and decision by the management

The first 2 phases have been very important to analyze the final customers' requirements and to understand the current product design with all pros and cons as well as the cost drivers. The function analysis is the core method of VA/VE to enhance the communication in the team and to really understand the product. Figure 3 shows an excerpt of the as-is function tree.

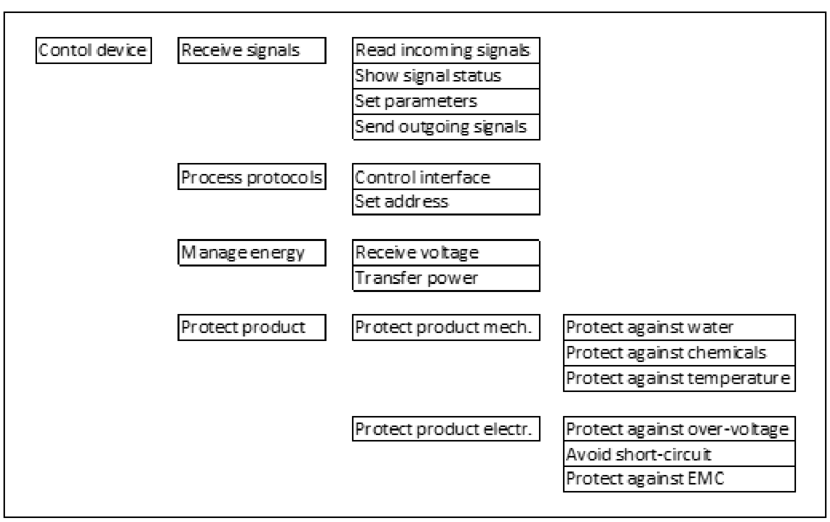

Figure 3: Excerpt of the function tree as-is

Within the idea finding phase, several creativity sessions have been organized. Partly with the whole team, partly with only each of the suppliers and also the customer alone. A large list of ideas could be generated, where a lot of different categories of ideas were covered. Some ideas touched mechanical issues, other electrical issues. But even more interesting, some of the ideas were focused on the whole supply chain between the suppliers and the customer. The overview over the ideas is as follows:

Mechanics: 50 ideas in total: Mechanical parts, pins, connectors, assembly, etc.

Electrics: 39 ideas in total: Voltage supply, temperature control, I/O, PCB, etc.

Supply chain: 11 ideas: Set stable volume forecasts, share third party suppliers and the good conditions, inhouse assembly of electronics.

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Of course, it is not possible to follow all 100 ideas. Some of them are also excluding each other or are not feasible with another idea. That's why a very important step is the definition of different scenarios. A scenario is a bundle of ideas which can be combined and that result in a reasonable concept.

The team worked on several scenarios. The most reasonable ones have been presented to the management in a final presentation of the whole team. The management took the decision for implementation and released the necessary capacity and budget for the upcoming work.

The overview on the most reasonable scenarios is shown in figure 4.

	Conzept 1: maximum saving	Conzept 3: Low hanging fruits	Conzept 4: maximum saving; own assembly electronics	Konzept 5: Medium risk
Total saving [€]	63,87	37,89	74,14	45,91
Relativ saving [%]	37,1	22,0	43,0	26,6
Investment for implementation [€]	421.270	177.120	442.950	207.560
ROI with 10000 pcs [years]	0,7	0,5	0,6	0,5

Figure 4: The most reasonable scenarios

Conclusions

The use of knowledge and experience of suppliers is inevitable nowadays. In most cases, the own depth of manufacturing was reduced in the last years and thus the own competency of the companies is limited to the core areas. This comes back to haunt the companies in projects for cost reductions or product optimizations, because only the suppliers have the necessary detailed knowledge. But the proven methodology of VA/VE can also be used very good in these cases. The integration of suppliers is possible in various ways and can be planned according to the project needs. The practical example of a project shows a very positive outcome for all companies involved.

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AN EXTENSIVE VA/VE-STUDY ON TEXTILE MACHINERY – CONSIDERATION OF THE VALUE CREATING CHAIN

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Summary

This paper shows, how a very challenging cost reduction goal for a machine for textile fabric production could be achieved. In order to be competitive on a specialized regional market, the manufacturing cost of this machine must be reduced by approximately 50%. To fulfill this request, the scope of the Value Study had to be increased drastically, as well as the degrees of freedom in creativity. Even in this study, Value Analysis is still the core element in order to achieve the goal. But the Value Study itself is embedded in a framework investigating deeply into customer´s and market´s requirements on the one hand and on the other hand investigating into the company´s value creating chain including overseas production facilities, logistics and intercompany transaction conditions. Sub-teams have been set up accordingly to the different scopes of work. As a result of the project, an outstanding cost reduction, transferable to market prices in order to achieve full competitiveness could be accomplished.

Chapter 1 – Initial Situation

Markets

In the South-Asian Market, a big sales opportunity for a certain machinery product is emerging. Our customer basically is able to deliver a machine capable to produce this kind of product. Unfortunately, the machine output (in terms of performance) is not good enough at the moment. Additionally, the current machine is pricewise not competitive by far. So, our customer modified the product by increasing the working width and keeping operation speed at the same level in order to increase the productivity. As a side effect, manufacturing cost increased at the same time, which worsens the competitional situation even more. In order to be successful on the market, manufacturing cost must be almost halved! It got obvious, that even a very successful value study can´t deliver this result. An even more wholistic analysis had to be applied in order to reach the goal. The total value creating chain, including sourcing, manufacturing, transportation, packaging, tariff situation and internal intercompany charges have to be considered.

Company´s infrastructure

Company´s infrastructure: Our customer with its headquarters in Germany is already active on Asian Markets since decades. Since more than 25 years, our customer also provides manufacturing capacity in different local markets. In this specific market, a well-equipped factory is available and could be considered for local manufacturing, if applicable. But the distribution of workload has to be considered as well. Being active in global markets makes it necessary to balance the workload in the factories.

Chapter 2 – Project Setup

In order to perform a drastic adaptation on the special market requirement, it was necessary to investigate not only in the product itself, but also in basic requirements on the one hand and on the value creating chain on the other hand. In an early stage of the project, the customer requirements had to be double checked. It goes without saying, that the central phase of the project has to be performed by the classical approach of a product-related value analysis project.

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The Scope of the project can be described as follows:

- Exact definition of the duty book as the basis for the cost wise optimal design of the parts, assemblies and functional modules of the machine.
- Value analytical investigation of the existing design concepts and elaboration of Ideas and measures in order to decrease manufacturing cost
- Elaboration of ideas, measures and wholistic approaches within the value creating chain in order to support achieving the demanding target costs.
- At the same time, assurance to deliver the acceptance of the product´s design and it´s features and full customer appreciation
- Achieving of salability at the time of an important trade fair in this machinery segment

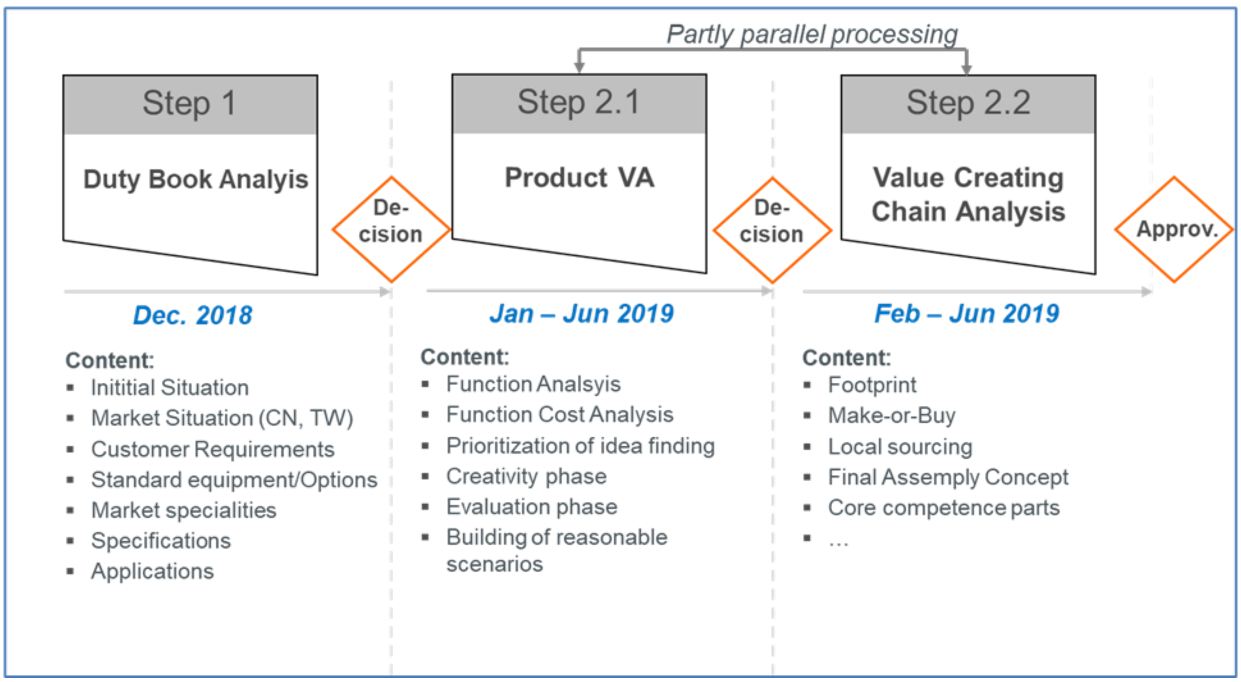

Figure 1: Value Study/Project Setup

Chapter 3 – Team Setup

In order to comply with the complexity of the value study and the variety of the tasks to be fulfilled, three sub-teams have been formed according to the three steps described in the chapters hereinafter.

Steering Commitee:
Head of mech. Design dept.
Head of el. Design dept
Mechanical design
Head of Product Management
Project Manager Design dept.
ext. Consultant (K&P)

Duty Book Analysis
Product Management
Head of mech. Design dept.
Application engineer
Mechanical design
Value Engineering Specialist
Project Manager Design dept.
Customer Service Engineer (CSE)
ext. Consultant (K&P)

Product Value Analysis
mech. Design
mech. Development
el. Design
VA/VE Specialist
Purchasing
Assembly
Manufacturing
Tech scout
Controlling
Tech specialist
ext. Consultant (K&P)

Value Creating Chain
mech. Design
Product Management
Tech Spec.
VA/VE Specialist
Manufacturing
Purchasing
Chief of Technology
China Manufacturing
Supply Chain Management
Controlling
ext. Consultant (K&P)

Figure 2: Setup of cross functional teams

Chapter 4 – Project/Study Work

Step 1: Duty Book Analysis

The determination of the specifications for the machine is the basis for value creation. Before starting, it must be clear which customer is to be served with the machine, which application is to be made possible with it, which services are to be achieved at which market prices. Further design areas are thus made possible, but the requirements for the machine type are also determined over the product life cycle. That is the content of the Duty Book Analysis Step 1: Requirements/Specifications.

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Duty Book Analysis

- What are the customer´s requirements – today and in the future?
- What are the buying decision criteria?
- Which markets are served today?
- Which are future markets and their special requirements?
- With what sales argumentation and approaches is the marked served today?
- Who are the competitors and how do their products perform?
- Which needs for actions and differentiation chances exist for our product?
- What is standard equipment, what is option, what is not available at the moment?
- How shall the future machine differentiate in the market and competitional situation?
- What is he correct specification for the future machine?

Step 2: Value Analysis

The actual value-design work on the product takes place in an interdisciplinary team and deals with the constructive design of the product functions as well as the added value in production, assembly and procurement. That is the content of the Value Analysis - Step 2.1:

Function Analysis

- What are the functions of the machine?
- Which functions are necessary, which are not?
- How are the costs distributed, what are the cost drivers?
- How are the costs distributed among the functions of the machine?
- In which priority must the functions/assemblies be examined?

Creativity Phase

- Brainstorming/brainwriting on the cost-driving components/processes (Main component of the project)

Evaluation Phase

- Rough assessment, potential assessment, risk assessment
- Compression of the measures into one or more conclusive concepts

Step 3: Analysis of the Value Creating Chain

Beyond the design of the machine, it is clear that the value creation concept holds further potential for achieving the manufacturing cost targets. These can also only be worked out and raised in an interdisciplinary team. This requires the input of different areas within the company - the areas that are actively involved in value creation. That is the Analysis of the Value Creating Chain - Step 2.2:

Analysis, Creativity and Evaluation on following topics

- Manufacturing facilities
- Assembly sites
- Internal suppliers
- External suppliers (in Europe)
- External suppliers (in China or similar)
- Assignment of core competence parts
- Other topics that occur and are processed in the project

Chapter 5 – Results

Results of Step 1 Analysis of Duty Book

In this step of the project, lots of measures could be elaborated in order to decrease manufacturing cost by changing the product specification. Examples for that were:

- Moving standard equipment to options, when clear that majority of customer does not need
- Limitation of boundary conditions, e.g. ambient temperatures, humidity, etc.
- Exact definition of performance parameters exactly coordinated to customer´s manufacturing processes
- The impact of these product strategic decisions is about 10% of the total manufacturing cost

Results of Step 2.1 Value Analysis

The core element of the study/project was the Value Analysis on the product itself. By analyzing functions, function cost for as-is-state and for should-be-state as well, the creative phase could be prioritized on the costliest functions and on functions customer is not willing to spend more money than really needed. Hundreds of ideas on almost all functions, represented by their function carriers in terms of main assemblies, sub-assemblies and single parts could be created. By evaluation of every single action item, the value impact in terms of cost, risk and implementation effort could be determined. A feasible and reasonable composition of ideas and measures could be given to implement in the specialist departments.

- With the sum of all reasonable, an additional 22% cost saving in comparison to the project reference could be accomplished.

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Results of Step 2.2 Analysis of the Value Creating Chain

By investigating into the value creating chain of this specific company, again significant cost reduction potentials could be discovered. In detail, following topics delivered an impact on the cost situation:

- Adjusting lot sizes for significant parts and assemblies
- Purchasing effects: negotiation of key components, bundling purchasing parts in order to get higher lot sizes and lower prices
- Optimization in manufacturing processes; lot sizes, introduction of fixtures e.g. for welded parts etc.
- Choosing the right manufacturing facility, utilization of manufacturing in overseas locations
- Introduction and establishment of new suppliers for costly core components
- The total cost reduction impact of this process step was about 15% of the manufacturing cost of the project reference.

Chapter 6 - Conclusions

The target of the project was to reduce the cost of machinery for processing textile fabrics by almost 50%. Although, function and performance of the machine must exactly match with customer´s expectations for a very delimited market. With utilization of a framework of analysis and investigation beyond the underlying product value analysis study in terms of duty book on the one hand and value creation chain on the other hand, a more than significant cost reduction of around 47% based on the pre-defined reference situation could be accomplished. The company is implementing or has already implemented the measures defined in this study and will launch the product in the specific markets in 2020.

Obstacles to the Implementation of Value Engineering in German Construction Projects

Dipl.-Ing. Natalia Bienkowski, LL.B.

This paper explains some obstacles to the implementation of value engineering in German construction projects. A value engineering study requires an interdisciplinary team that works together from an early stage of the design phase, which means combining design and construction. Nonetheless, the project management culture in the German construction industry is known to be confrontational, with a traditionally strict separation of planning and execution. However, there are many tendencies in the German construction industry that show strong openness to cooperative project management, interdisciplinary teamwork, cost reduction and innovative ideas. Furthermore, there are developments in procurement law that significantly facilitate combining planning and execution through involving the contractor from an early planning phase. Although value engineering is known in Germany for more than 50 years and is practiced in product design, it remains relatively unknown in the German construction industry. With the new developments, this can change in the future.

1. Introduction

The comparison of the United States and Germany concerning the use of value engineering in construction projects shows significant differences. In the US, the use of value engineering in construction projects seems well known, commonly practiced and is even prescribed by law in some cases. By contrast, in Germany it appears quite known in mechanical engineering and product design but hardly known in the construction industry. The question arises why nowadays – more than 70 years after the development of the method by L. D. Miles and after more than 50 years of value engineering in Germany – value engineering in the German construction industry is not as commonly known and applied as in the US or other countries.

Nonetheless, there are some indications and developments in the German construction industry that show the need and the gradually increased openness to the application of value engineering in construction projects. For example, some major public construction projects have attracted public attention due to major cost and time exceedance. A study conducted by the Hertie School of Governance showed that the costs of large construction projects in Germany were exceeded by 73% on average (Kostka/Anzinger 2015, 1). For example, the costs of the project Elbe Philharmonic Hall in Hamburg increased by 146% from the conclusion of the contract and the construction time rose by 200% (Fiedler/Schuster 2015, 1). In case of the Berlin Brandenburg Airport, costs rose by 125% and the construction time by 200% (Fiedler/Wendler, 2015, 1).

The implementation of lean construction in the German construction management is increasingly present in scientific and professional articles and initiatives. Therefore, cooperative contract models and integrated project management are also increasingly prominent. They include the contractor from an early point in the design stage, as a necessary condition not only for implementing lean construction management but also value engineering. However, the implementation of contract models that imply the inclusion of the contractor from the design phase is problematic in public sector building projects, as will be explained in chapter 4.

The following article discusses some obstacles to implementing value engineering in German construction projects. It starts with a characterization of the German industry with its culture and current trends, before exploring some obstacles.

2. Characterization and trends in the German construction industry

The contract culture in the German construction industry (as well as in other branches) is known to be confrontational. One reason is the separation of design and construction, as well as tender procedures that provoke conflicts and a confrontational project management. Because the most economic offer wins, contractors try to calculate low bid sums and speculate on amendments, which increase the costs and their profit.

Instead of a cooperative dealing with conflicts, cases are taken to court. Due to the many current lawsuits, it can take years to conclude the actual trial. In case the project is not yet finished, the building site stands still, which causes many costs and problems. For example, there are the contingency costs for the site equipment, price increases for building materials, and new standards that have to be implemented in the building, causing additional conversion costs. Furthermore, the contractor has to offer his industrial employees an alternative work.

To help ease these problems, the government has conducted some major changes in the law and court system. Since January 2018, there are new chambers at all country courts that deal solely with disputes arising from construction and architect agreements and engineering contracts in connection with construction works. In addition, based on the need for quick decisions during the construction process, the construction contract law now includes the possibility to obtain an injunction faster (§ 650d BGB – German Civil Code). Experts recommend alternative dispute resolutions (ADR) or/and using partnering contracts (BMVI 2015, 9). This avoids going to court and can ensure better relations between the parties than with a confrontational trial at court.

Partnering contracts and the lean construction management are the two major tendencies in the German construction industry at present. Many companies demonstrate lean as their “philosophy” on their website and brochures. There also many companies that use partnering contract models, either international standards or self-developed contract models.

Another trend is cost reduction, especially concerning the construction of housings. The government has initiated a construction cost reduction commission, which has developed some recommendations including the linking of planning execution at an early stage, research on cost-effective constructions, and anchoring interdisciplinary cooperation in the education of architects and engineers (BMUB 2015, 134).

In addition, a reform commission for major projects has been initiated by the government. In their final report, they recommend cooperative planning in a team with a detailed analysis of the user and project requirements, and interdisciplinary planning teams at an early stage with an exchange on a regular basis (BMVI 2015, 8). These are elementary factors for a value engineering study.

Furthermore, there is an initiative by the government to accelerate the planning process of infrastructure projects. A commission worked out recommendations and criticizes the insufficient communication, lack of work in interdisciplinary teams, and inadequate exchange between developers, authorities and other actors (BMVI 2017, 13). Applying value engineering would include these factors.

3. Obstacles in German construction projects

3.1. Unknown in the German construction industry

The main obstacle for applying value engineering in German construction projects is that the method of value engineering is widely unknown in this branch. Most of the asked (not formally interviewed) professors, academics and professional experts from the construction industry never heard of this before. In addition, the method is quite hard to explain in a short time. In a branch in which “time is money”, it seems hard to convince a professional to get to know the method.

It is difficult to prove the advantages of applying the method in the design phase. First, there is the monetary aspect. When applying the value engineering method to a new object to be designed, it is challenging to define the cost reduction. There has to be a fixed point defining at which planning state – including which cost groups and estimated with which method – the initial costs are to be set. With these initial costs, the beneficial cost reduction could be named. Second, the effects of the improvement of soft factors though conducting a value engineering study – for example, regarding better communication – is nearly impossible to express in figures. Therefore, convincing management staff to use these soft factors also seems impossible.

It is questionable why lean management is well known and present in the German construction industry, but value engineering is largely unknown despite being an older method. There is a German lean construction institute and a guideline for lean construction (VDI 2553 “Lean Construction”), worked out by the Association of German Engineers (VDI). Similar initiatives and guidelines especially worked out for the construction industry would help to create increased awareness of value engineering in the German construction industry.

3.2. Implementation in the planning and execution phase

Because there is no specific guideline for the application of value engineering in German construction projects, the implementation of the value engineering method during the planning and execution phase is unclear. Indeed, it is unclear at which planning stage, with which duration and with which topics the meetings should be conducted.

There are EU standards, national standards and guidelines for value engineering in general, although they are oriented towards the production sector. For example, there is a step of benchmarking: this is mostly not relevant for construction projects, so a special recommendation concerning this step would help in applying value engineering in construction projects. There are some experts in companies and engineering offices that offer value engineering as a service. However, in practice it seems that not everything offered under the name of “value engineering” matches the EU standards or guidelines of the Association of German Engineers. For example, it might be the case that one engineer checks the planning documents and develops some options using function analysis for cost reduction (Eschenbruch/Bodden 2015, 588 f.). Given the lack of an interdisciplinary team, the acceptance of such optimizations – especially concerning the design architect – is expected to be low.

There is one recommendation for the implementation in the planning and construction phase by Hans Dönges (2015, 22), who recommends value engineering studies at the following points:

- Setting up projects specifications;
- Completion of preliminary planning (cost estimate);
- During conceptual designs especially concerning fire safety;
- After the completion of the conceptual design (cost calculation);
- After the completion of specifications;
- After the submission of tender outcomes (quotation);
- In case of requests for modification by the owner and amendment proposals by the planning team or the contractor.

3.3. Cost planning and German Standard DIN 276

In Germany, there is a national standard for cost planning in civil engineering, DIN 276. The approach includes several steps from the beginning of the design phase until completion of the construction project and a definition of cost categories. For example, the first outline level of these cost groups is 100 property, 200 preparatory actions, 300 building – structural design, 400 building – technical facilities, 500 outdoor facilities and open spaces, 600 facilities and artwork, 700 additional building costs and 800 financing. In the design phase, no real costs for the project are available. The empirical data for the cost estimate that is used in civil engineering is structured according to DIN 276.

Now the challenge is to use the data for cost estimates in the function cost analysis. Because the cost categories of the DIN 276 are not structured according to the functions, it can be difficult to generate data for the function cost analysis. A good option for Germany is yet to be found. Of course, planning offices and companies can have their own data collected from previous projects, and especially for function cost analysis. The use of DIN 276 is not compulsory, unless it is part of the contracted service. However, even if cost planning has to be conducted after DIN 276, there can be a parallel cost estimate that allows an allocation of cost and function.

3.4. Remuneration and suggestions for extent of works

Another point that is unclear is the remuneration of the value engineer and the extent of works that a value engineering study in Germany should include. As the lawyers Eschenbruch and Bodden discuss, there are some possible options for the remuneration of the value engineer. For example, a fixed or time fee, a success fee or a combination of both can be agreed (Eschenbruch/Bodden 2015, 589 f.). As previously mentioned, it is challenging to clearly define the success of the value engineering study; therefore, the definition of the success fee can also be difficult.

Furthermore, they worked out a general "Value Engineering" performance description issued by the German AHO (Committee of the Associations and Chambers of Engineers and Architects for Fee Regulations). It serves as a suggestion and can be used in contracts on a voluntary basis for determining remuneration.

4. Obstacles specifically concerning public owners

Private owners can tender and contract however they want. They can use contracts from foreign countries. On the other hand, public owners are bound to public regulations, including the VOB, the award guidelines for building services. They include the three parts A, B and C, whereby part A applies for tendering, part B applies to contractual terms and part C applies to standard terms and conditions. These guidelines offer some options for tendering and contracting. However, there are challenges for applying value engineering, which will be explained in the following.

4.1. Tender procedure

The standard procedure (open procedure) is the public tender according to § 3 Nr. 1 VOB/A 2019, where the owner provides completed performance specifications and the potential contractors submit their offers only based on these specifications. According to § 2 VI VOB/A 2019, a call for tender of public owners should be launched not before the execution documents are completed. This means that the contractor cannot be involved in the planning phase, which means that a value engineering study cannot be conducted classically. Furthermore, according to § 2 II VOB/A 2019 no entrepreneur should be discriminated when it comes to awarding public works. Therefore, it is legally problematic to contract a contractor who has already worked in the planning phase and therefore is advantaged in comparison with the other contractors.

There are alternative tender procedures of limited tendering in § 3 Nr. 2 VOB/A 2019 that could offer the possibility of involving the contractor in the planning phase, namely the negotiation procedure and competitive dialog. Previously, in VOB/A 2016, they were only permitted if the works could only be executed by a limited class of contractors (§ 3a III Nr. 1 VOB/A 2016) or if the preparation of the offer required an exceptional effort due to the character of the works (§ 3a III Nr. 2 VOB/A 2016). Now with the new version of VOB/A 2019, there are no restrictions, whereas the owner can decide freely (§ 3a I VOB/A 2019). Accordingly, now with the reform of VOB/A it is easier for public contractors to combine planning and construction.

4.2. Forms of contract

As mentioned in the previous chapter, tender procedure and contract form correlate. For public owners, there are some possible contracts that can be used in construction projects. The "classical" call for tender is associated with a construction contract using VOB/B. There are two possible forms of compensation: the unit price contract and the flat-rate price contract (§ 4 I VOB/A 2019). Cooperative elements are not included.

Another possible contract form is the public private partnership (PPP). It involves the contractor in the planning, construction and use phase. This could be a possible frame for applying value engineering in public construction projects. However, this contracting form is only used for public infrastructure projects where the public owner wants a long-term but limited contractual relation with a private contractor, who undertakes construction, operation and – where appropriate – financing of a infrastructure, receiving in return fees from the public partner or the user (BMF 2016, 8). The use of value engineering in this contract form is possible, although the other way round PPP is not attractive or applicable for all construction projects due to the long-term contractual relation and facility management.

With this in mind, there should be a contract form that offers collaborating without a necessary long-term contract and which is applicable for all construction projects. In practice there is the discussion and claim to introduce design and build contracts into the possible contract models of public owners (Vergabeblog 2017). Until then, an alternative approach should be found so that a value engineering study can be conducted.

5. Summary and prospects

In contrast to the US, the application of value engineering in construction projects is largely unknown in Germany. There is a wide application in mechanical engineering and product design. In order to raise awareness of value engineering in the construction industry, value engineering should be included in the curriculum of civil engineering and architecture students. Furthermore, a specific guideline for value engineering in construction projects is to be elaborated for Germany, as it has been worked out for lean construction management.

A strict separation of design and construction and a confrontational project culture are widely spread, but obstacles to implementing value engineering. Nonetheless, there are many developments and tendencies in the construction sector that indicate a change towards cooperative project culture, interdisciplinary teamwork and a linkage of design and construction. In conjunction with the all-present aim of cost reduction in the construction industry, implementing value engineering in the German construction industry is obvious. Through a reform of the procurement law in 2019, even public owners can connect design and construction involving the contractor from an early planning phase.

There is still the challenge to use the cost estimate data, structured according the German standard DIN 276, because it is unclear how to allocate the costs during function cost analysis. The use of building information modeling (BIM) could contribute to the cost estimate and function cost analysis. Furthermore, the combination of BIM and virtual reality could help to find and show alternative solutions during the value engineering study. The use of BIM is aimed to be obligatory in public infrastructure projects from 2020.

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THE MANY USES OF FUNCTIONAL PERFORMANCE SPECIFICATION

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Abstract

Function analysis is the basic tool to improve the competitiveness of the products and services designed and built by an enterprise to fulfill needs that are not yet satisfied or not well satisfied. Teams of experts try to capture those needs and then design a product or service that will cover all those needs. Elicitation of the needs by the eventual users is not easy and understanding them well by those who will design the response is not easy either. Function analysis is a good method to facilitate this. The present paper will underline the various tools to use to do so in a Functional Performance Specification and it will explain the various uses of this document, including how to use them in FMEA (Failure Mode and Effect Analysis), in procurement of solutions and for the selection of a best option among many possible ones.

The topics covered in this paper will address the Core Competencies regarding the Value Methodology in general, as well as Transform Information, Function Analysis and Cost analysis.

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The Basics

Function analysis helps all enterprises better design its products, services, projects, processes…, considering the needs they must satisfy and the cost and delay objectives. Mostly, it is the basic approach to describe these needs and get a team of experts design the solution. But, capturing the needs of the users is no small feat. And if not well captured, how can the designers come up with a solution which will fulfill the needs in a satisfactory way, without going back and forth and correcting mistakes with “Band Aids” that will not be very robust?

The benefits of doing a proper function analysis are many:

- Effective Use of Resources
- Midcourse Spec Changes Minimized
- Use of Disciplined Methodologies
- Trade-offs Between Cost / Features / Performance
- “Voice of Customer” instead of “Voice of Engineer” or “Voice of Management”

But first, let’s have a look at a proper Design Strategy. This is one existing pattern and a few exist. For example, Design Thinking, and we will discuss that strategy later.

The needs begin with either an advised client (you are designing a smelter for a mining group) or from a market research (you are designing a new car, computer mouse, lighting fixture, software, service for a more general public). Both have a need that is not satisfied and they have identified a way to somewhat describe it. To the very least, they know they are not satisfied with the existing situation.

Once identified, the need must be well described by the owner of this need, either through interviews or through their documentation of it. This must be analyzed. When possible and as often as possible, the analysis must be conducted with representatives of the owner of the need, along with those who will design the solution. These meetings are facilitated by a value specialist using the Function Analysis methodology.

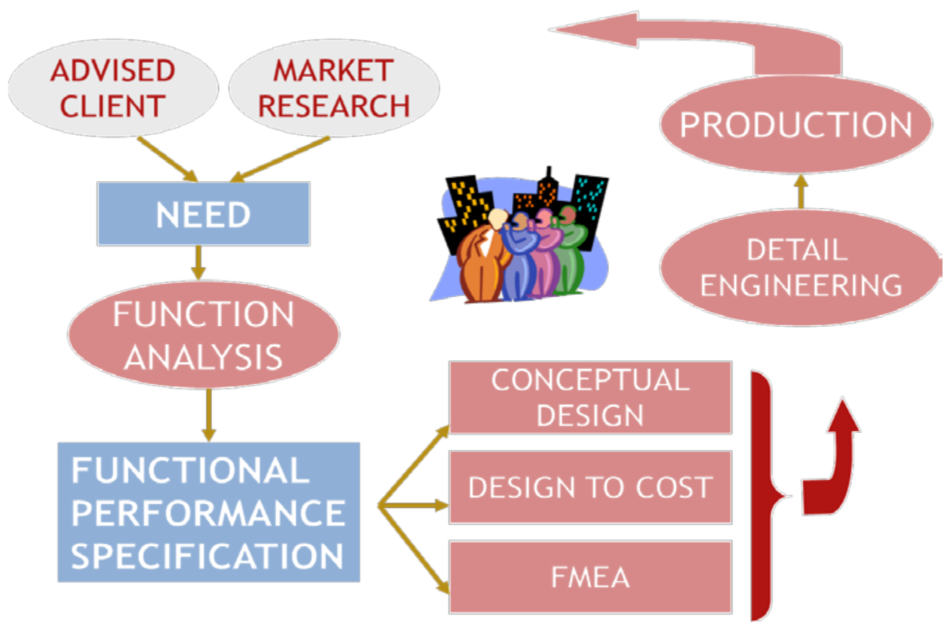

Figure 1 - Design Strategy

The Function analysis methodology is used to find, organize, characterize, set into a hierarchy and estimate the functions of a product. Functions will be defined using an active verb and a measurable noun. This forces us to be more specific and more precise, mostly it forces us to describe what needs to be done instead of jumping right away to the solution that could be used.

Examples of functions compared to possible solutions can be:

Function	Solution
Control temperature	Thermostat
Feed system	Conveyor
Carry passengers	Rail car
Greet clients	Queue

Table 1 - Difference between Function and Solution

So, in order not to jump to quickly to a solution, the facilitator must extract from the group of users and designers, a list of functions describing what has to be done, using this 2-word approach.

Describing a function:

- Requires precision
- Decompose the problem in smallest elements
- Reduce misunderstandings
- Clarify language
- Forces to think in terms of goals instead of solutions.

Also, when identified, functions can be of three types:

- Basic (or service) function, it is the expected action of the product, the service that the product must render. Obviously, it is essential to the accomplishment of the goal of the product
- Secondary or support function: internal action which supports the accomplishment of the basic function, that may be required by a technical need of the designer and be ignored by the user
- Constraint function: requirement that the product must conform to that could limit the latitude of the designer. It may be imposed by: environment, technology, market, company's situation, corporate choices...

Functions are independent of solutions; they express services to be rendered when using the product (through its life). And obviously, there may be many functions to an object and they are independent.

The Function Analysis approach

Thus, Function analysis will include the following five steps:

1. Identify
2. Organize
3. Characterize
4. Set into a hierarchy
5. Evaluate the functions of a product.

First, let's look at identifying the functions of a new product or service or building, etc. Many methods can be used, the most common ones would be:

1. Intuitive research where participants express intuitively the functions they would like to have in the product. This is more like common sense and is quite limited, finding maybe only 50% of the functions. It must thus be combined with other methods.
2. Environmental (or context) analysis, where participants will express the functions linking “interactors” to the product being analyzed. These “interactors” are elements around the product (not within the product) who have some kind of influence on the design of the product. They may interact with it during any phase of the life cycle of the product (design, construction, sales, uses, recycling, end of life). This approach is very efficient and provides a global vision, high level description of the needs which in turn may favour innovation.
3. Sequential analysis is where the product or service being used at present is analyzed using the sequence of activities happening during the use. This approach will challenge the need in relation with how the product is being used. It can only be done if an existing product or service exist since if you are working on a new product or service, there is no way yet to know how it will be used.
4. Movements and efforts analysis is used to question forces and clearances that would be required. It will help with a proper sizing of the new product or service, when applicable.
5. Reference product analysis may be used in many contexts where a similar existing product can be used as a reference to question influences and needs. It is also called benchmarking, and can be done with a competitor’s product or an existing product of the client including a first set of drawings or description of concept.
6. Rules and regulation analysis will most of the time identify constraints that are imposed by laws or certification bodies but must be included in the new design for reasons like safety, conformity, certification and so on.

All these methods allow the facilitator to capture real functions and not solutions. But now, it is impossible to give a random list of functions to the designers and simply tell them: “design something that will fulfil all these functions”! We must put some order in this list. This order will be based on level of abstraction, and will show the logic that link all these functions together. The basic method to do so is the Function Diagram.

So, now, let’s look at the second step of the function analysis which is the Organization of the functions, based on the logic behind the level of abstraction. The questions we use to determine the logic links between the functions are:

- WHY is the function necessary?
- HOW is the function accomplished?
- WHEN the function is accomplished, what else is achieved?

The function diagram (also called Value diagram) will illustrate the links between the functions and thus will be a Model of what the product/building/software/service must do to fulfil it’s mission statement, illustrated on the left hand side of the diagram.

Rules apply to the construction of the diagram:

- Going from left to right, we answer the question How?
- Going from right to left, we answer the question Why?
- Going up and down, we answer the question When? (not in the sense of At what moment? But in the sense When we do this, what is directly related to it.)

Also, the logical relations can be illustrated as follows:

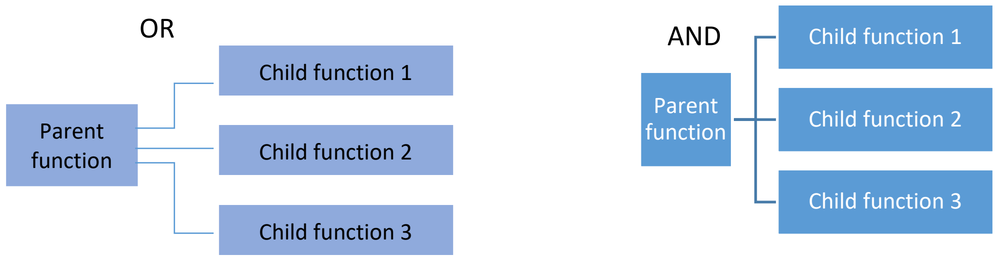

Figure 2 - OR and AND relationships

Using all these rules, the facilitator, along with its clients, will develop the Value graph which will represent a model of the new product being designed. It will look like this and each level represents a level of abstraction, the level at the left being very abstract and at the right being very little abstraction. Also, in product development strategy or reorganization strategy, each level represents a stage of the strategies such as: Mission – Strategies – Tactics – Deployment of processes – Activities. (most of the time, five levels are sufficient to well describe a product)

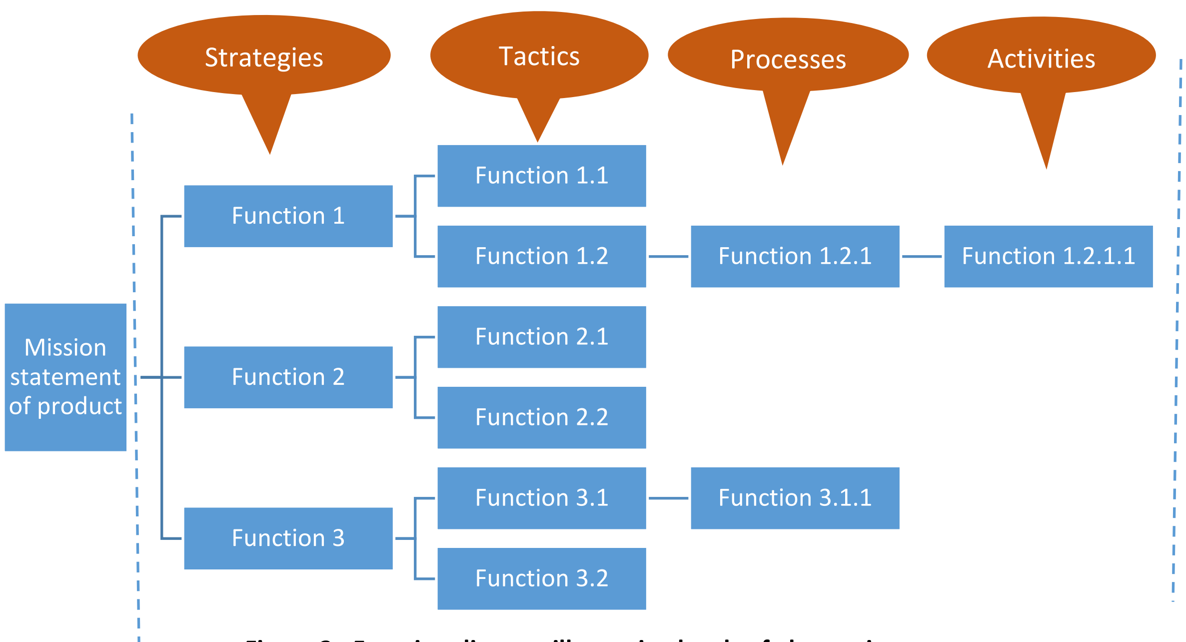

Figure 3 - Function diagram illustrating levels of abstraction

An example of a product being redesigned is shown below. It is the Function Value Tree of a new kiln.

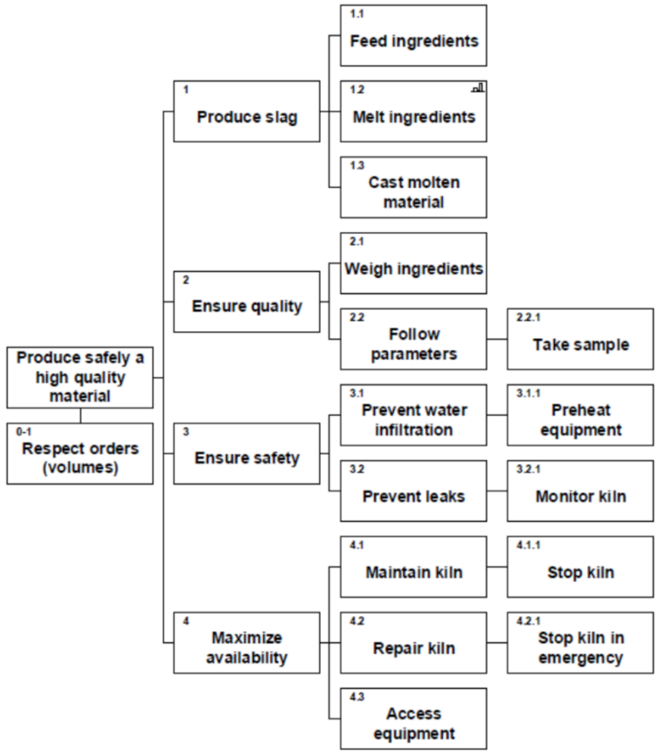

Figure 4 - Example of Function Value Tree

Building a Function tree allows the team to make sure all functions are captured. Indeed, if one is missing, there will be a "hole" in the diagram and it will not sound right when reading it. Once everybody around the table agrees on the functions and the links between them, the diagram can be put to many uses.

The first use of the function tree is to identify which functions need to be characterized. By this, we mean to state what in the function will be measured, in terms of performance. So, for the functions positioned at the right-hand side of the diagram, which have a low level of abstraction, it is possible to state performance criteria, with their associated level of performance (acceptable result of range of results) and flexibility of that level, which is an indication on how much that level can be negotiated or not.

For example, in our kiln described previously, some functions can be characterized as:

Number	Function	Criteria	Level	Flexibility	Comments
1.2.1	Insert electrodes	Number of electrodes	11 per day	F0 (no flexibility)	
		Speed of insertion	0,5 m per second	F2 (some flexibility)	
		Position	Just below level of molten material	F1(little flexibility)	No electrode must show above level

Table 2 - Example of characterization

Another use of the function tree is to identify the major functions that need to be done, the head of the "branches" of the tree. In this example, we have four (4):

1. Produce slag, which is the basic function of the kiln

2. Ensure quality, which is a support function
3. Ensure safety, which is a constraint function
4. Maximize availability, which is a support function.

It is then possible for the client to set those into a hierarchy, by saying where does he want to put the most efforts (or money!). A hierarchy pattern like the following can be used.

A. Vital, critical
B. Very important
C. Important
D. Desirable
E. Nice to have

A simpler 3-stage hierarchy can be used as well as a hierarchy based on percentage of importance. In this case, for the kiln, there was no “nice to have” functions. They were either critical, very important and important and the level of importance was based on a percentage base.

Functional group (branch of tree)	Hierarchy	Importance
1- Produce slag	A	30%
2- Ensure quality	C	10%
3- Ensure safety	A	40%
4- Maximize availability	B	20%

Table 3 - Levels of hierarchy

These levels of hierarchy will later be used in the cost analysis of the new system.

Once again, the function tree can be put to many uses, one of them being a creativity phase, where participants will find solutions to each “branch” of the tree and then combine them to deliver the most efficient solution.

One other use of the function tree is to find out where is spent the money. Once a first concept is in place and an estimate is done on the eventual solution, the cost of this solution can be distributed on the functional group (branches) in the diagram. This will allow the study group to compare the cost of each function, to validate the interest of the client in paying these costs for these functions, to identify the most expensive functions and to identify mismatches between cost and worth or importance of the functions.

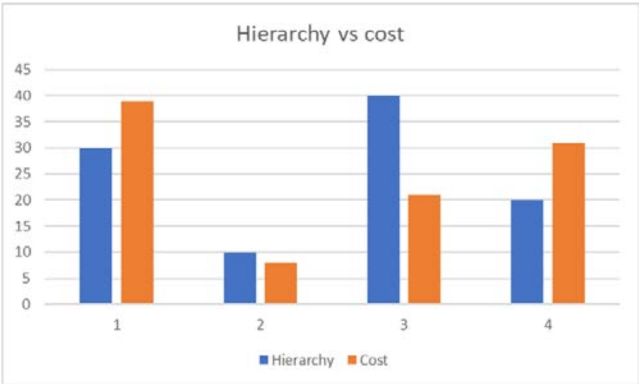

Figure 5 - Cost vs. importance of functions

One of the great advantages of using a Function Value Tree is to use these functions as comparison

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criteria for comparing possible options to fulfil the mission statement. For example, with the kiln,

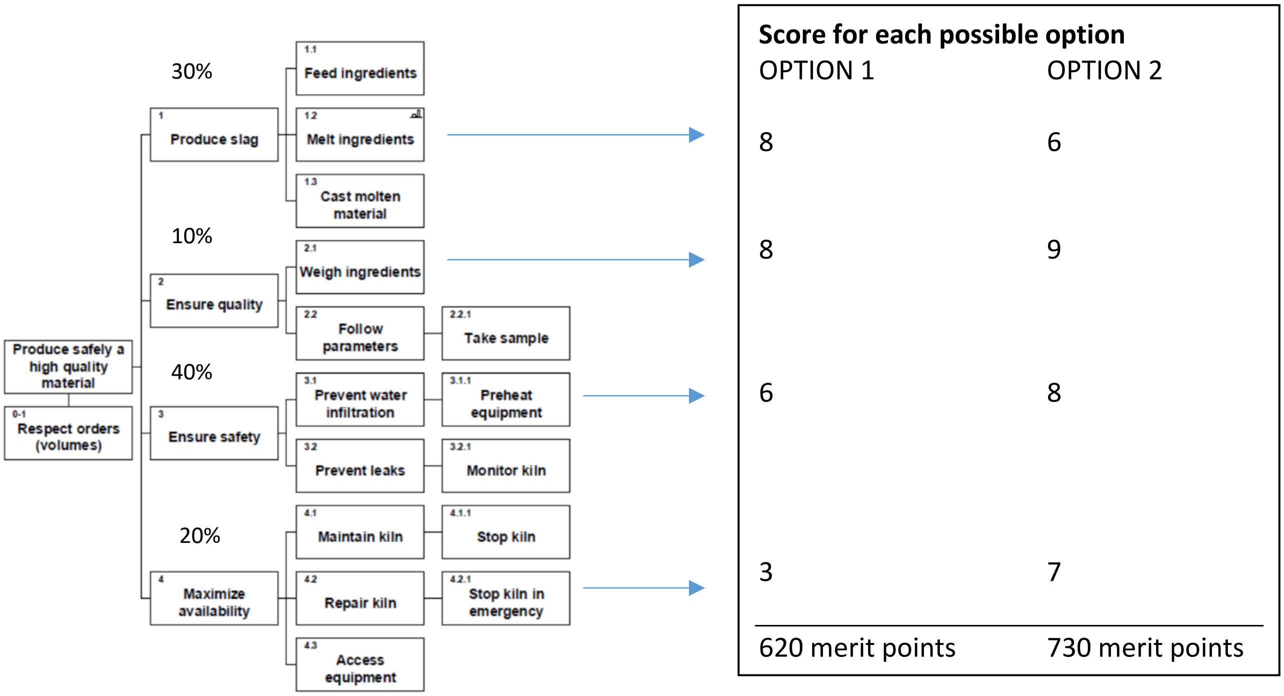

Figure 6 - Evaluation of options

It is possible to use the functions and their performance characteristics, to evaluate how well a possible solution will perform and realize the functions. Here, two options are shown, where scores were given on each option on a scale of 1 to 10 on how well they would fulfill the needs. A performance scale can be developed for some of the criteria, in order to give each solution a proper measurable score.

Finally, a Value Graph can be plotted to illustrate the value of all the options the design team had in mind. Now, these options may be internal design as well as off-the-shelf options that can be found in the sector under study. This example had 9 options to evaluate, as shown on the Value Graph.

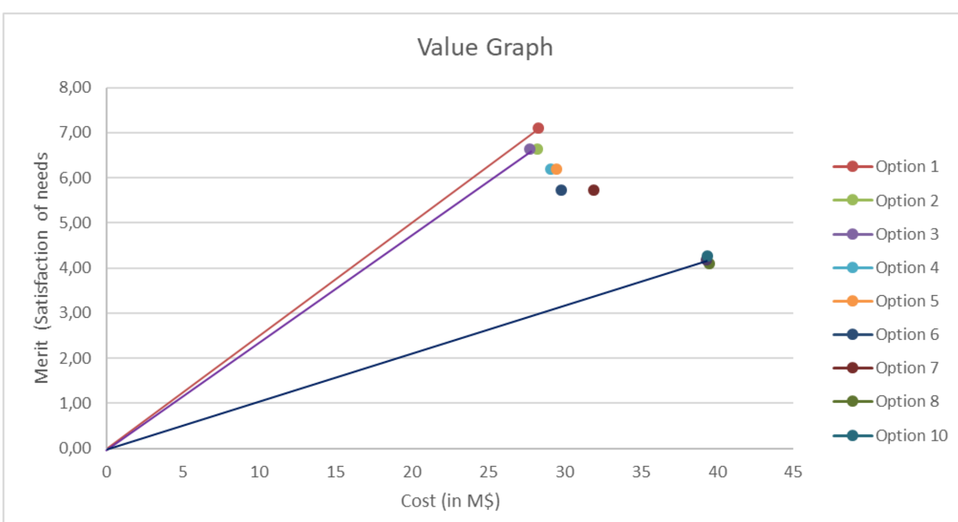

Figure 7 - Value Graph

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In the value Graph, it is possible to see that Option 1 has the best value compared to options 10 which has the smallest value, value being represented by the slope associated to each option.

Uses of the Functional Performance Specification

As seen in the Design Strategy, function analysis is done early in the process of designing a new product. One of the first output is the Functional Performance Specification which is the document where are captured and presented all the information discovered, discussed and analyzed through the Function Analysis methodology. This document favours the client-designer dialog, because it forces the client to define his needs in a formal, structured, efficient way and allows the design team to come up with a solution with the greatest value among a choice of alternatives that can all “do the job” but in different ways.

The Functional Performance Specification has allowed the Value Study team to:

1- identify the functions of the new kiln,

2- organize them in such a way to confirm that all functions have been included and that there is a logic to all these functions,

3- characterize them to make sure there is no overdesign or under design but to design with the required performance well in mind,

4- set into a hierarchy the main functions identified in the function tree

5- distribute the cost of the solution of those main functions to identify mismatches between cost and importance of functions.

Once the first 4 steps are done, it is possible to let the designer define the best solution(s), and make the designer responsible for these choices, identify many options that can “do the job”, and select the best alternative based on value, by doing the fifth step (distribution of cost).

Other uses of the FPS are to:

- Facilitate the negotiation between client and designers, since the client will, from the start, indicate what is “negotiable” and what is not, with the performance flexibility mentioned in the methodology.
- Serve as a Design guide for the project: goals to achieve and functions to realize are defined, demonstrated and linked with the use of the function tree methodology. It defines a “model” which describes all that needs to be done to fulfil the mission of the product.
- It can be used as a Design review document: indeed, it gives a great check list of what to include in the design of the new product and what not to forget. This is very useful when shopping for a solution, either an Off-the-shelf solution or an Engineered solution.
- It is the Reference point to procure the best solution, so all those involved in the buying process don’t compare solutions one to the other, but compare them all to a Reference point which are the needs to fulfill.

Conclusion

Functional Performance Specifications based on the use of the Function Analysis methodology, are very efficient tools to make sure design teams come up with the best possible solution to fulfill the needs. It will make sure the client gets the most value out of his new product.

Abstract: The Minimal Technical Solution

Value Management (VM) can accomplish many things depending on the focus gleamed from the Owner's Value Perspective, ranging from a focus on the efficient use of resources to one of maximizing creativity. One of the strengths of VM is the process of re-envisioning the current design into an abstract functional explanation, separating one's self from the constraints of the current concept to open the mind to envision substantially different solutions to the task. We will discuss the process to make this approach most effective, specifically, by identifying the Minimal Critical Path that leads to the Minimal Technical Solution.

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It is time to eliminate the Creative Phase from Value Methodology

Robert Prager, PE, CVS

Abstract

It is time to eliminate the Creative Phase from Value Management and replace it with the Imagination Phase. We start a value workshop with the original concept and recommend changes to improve its value. Original concepts are history. Creativity is the present and bridges between history and the future. Imagination is the future, the unseen potential. Imagination frees us from bias. A team imagining alternatives is less constrained than a team creating alternatives. Changing the mindset of a value team makes it more creative. The higher level of abstraction of a team imagining concepts results in better value alternatives. This paper proposes a way to take the creative power of imagination and channel it for better performance from value methodology.

Introduction

It is time to eliminate the Creative Phase from Value Methodology. It is time to replace it with the Imagine Phase. Why should we change such a fundamental part of our process? The goal of value methodology is to evolve the design, product, or process to improve functions in relationship to the resources expended. How will the third phase of a value workshop be different if instead of "It is time to list other ways of performing the basic functions.", the TEAM LEADER says, "It is time to re-imagine the project based on the functions."? The team's thought processes move to a higher level of abstraction.

It is especially vital to consider this change now. Performing virtual workshops limits team interaction, particularly on the interpersonal level. Discussions of the project or comparisons to similar projects while on break do not happen or do not happen without effort. Creativity is challenging in the virtual world. Creativity uses all our senses or should. Imagination frees us to engage all our senses.

Raising the level of abstraction may be necessary just to maintain the same level of performance that we achieve in in-person workshops. Early indications are that virtual workshops do not propose the same value improvements or have the level of acceptance of ideas as in-person workshops (Prager, 2020).

In Value Methodology (VM) the team leader guides how the team and stakeholders think. Each team leader develops their own style, but they all follow the same six-step process (SAVE website, 2020).

1. Information: Gather information to better understand the project.
2. Function Analysis: Analyze the project to understand and clarify the required functions.
3. Creative: Generate ideas on all the possible ways to accomplish the required functions.
4. Evaluation: Synthesize ideas and concepts and select those that are feasible for development into specific value improvements.
5. Development: Select and prepare the 'best' alternative(s) for improving value.
6. Presentation: Present the value recommendation to the project stakeholders.

The team leader's function is to extract talent from the team. The leader performs that function by guiding questions throughout the six phases. The basic questions for each phase are:

1. Information: What is the project, how is it being performed, why is it being done?
2. Function Analysis: Do we understand it?
3. Creative: How is it made better?
4. Evaluation: Which ideas do we develop?
5. Development: Does it work?

6. Presentation: Does the client understand it?

Questions shape the way the team and stakeholders think. "…good consultants quickly recognize what clients say they want and what they need are often two entirely different things. And the path to helping a client share that conclusion is littered with great questions which expose the root cause of a problem rather than merely addressing the symptoms." (Kayne, 2014, 118)

While function analysis exposes the root cause, the creative phase often falls prey to listing ideas that address the symptoms. Based on 25 years of VM experience, if the Value team sees themselves as the designer, they often concentrate on alternative methods addressing secondary functions. If they change their perspective through imagination, they are more likely to address the root cause. Create means to make. Imagine means to envision. Creativity is a physical exercise while imagination is a mental exercise. Imagination, like function analysis, should change the perspective of the team. The team leader can determine if the team is ready or can imagine by their actions during the information and function phases. Is the team observing or questioning? Curiosity and observation are intrinsically linked. Curiosity is expressed by detailed, incisive questioning. Observation answers what or how, curiosity answers why (Kayne, 2014, 116).

The Imagine Phase

The creative phase usually follows classic brainstorming techniques and rules. It is a textbook case of divergent thinking.

- Put everything on the table
- Offer one idea at a time
- Indulge in absolutely NO evaluation either internal or external
- Assume all ideas are good ideas
- Emphasize quantity of ideas over quality
- Ensure each idea is a change to the original concept
- State the change and what it substitutes
- Use other ideas as a springboard for a new idea. Variations of other ideas are encouraged
- Avoid vague language (e.g., fix the economy)

Some team leaders use unfettered brainstorming while others use extreme focus by function, technical discipline, items, systems, or process.

What might an Imagine Phase look like? The TEAM LEADER may still allow unfettered brainstorming or organize thoughts into categories depending on the team and client's psyche but brainstorming by listing one idea at a time without criticism is gone. Instead, the team's collaborative interactions improve alternative ideas and scenarios. Questioning and challenging creates more and better ideas. Imagination is encouraged although some team members will be creating and that is alright. In fact, the Creative Phase should be embedded in the Imagine Phase.

Team members are not sitting behind tables or in a small box on a screen in a virtual workshop. They may all be working on one idea or trying to understand it. They may be on their feet or in separate virtual rooms and interacting in small groups. If they need technical input, they call on that discipline. This is a livelier and more energetic process requiring a light but skillful hand on the part of the team leader. Some members use words, others use sketches to express their ideas. We may need new subject matter experts, graphic artists who can visually express the imagined and make it comprehensible for the rest of the team.

Each individual, sub-team or the team records their ideas or scenarios. The team leader compiles and categorizes as they see fit. The team leader reconvenes the team members periodically to assess progress and guide the teams thinking. Each re-convening should spark new ideas. The emphasis is on quality not quantity. An imagined idea often has more detail than a creative idea. Imagination is sparked by the right questions. A measure of imagining versus creating is are there more questions than answers.

Perspective matters. Great team members imagine themselves as the user, the designer, the bidder, the contractor, the owner, maintenance, local government, and other stakeholders, and through imagination they can be all at once. They envision the project holistically and easily cycle between convergent and divergent thinking.

Already always knows

Humans are wired for pattern recognition. Sensing a particular pattern elicits a specific response. This is basic programming in our brains that hardwires us for survival. It is also useful for sustainability. Not having to analyze each occurrence saves time and energy. The downside is that experienced designers already always know. They know what the component parts of a building are or what a flood reduction project looks like. We all bring bias with us into every situation. Bias is lessened when we imagine rather than create.

Dr. Kayne, in ImagineIt! Rediscovering Your Creative Inner-Child (Kayne, 2017), uses the lunar module of the Apollo program to emphasize the role of bias. Design goals included minimizing weight to optimize returning from the moon's surface. A second goal was to give the astronauts an extensive field of vision of the landing site so they could avoid rough terrain. This resulted in large heavy windows so they could observe the site from their seats. Every proposed solution centered on the size, shape, and composition of the windows until three members of the design team stepped up, literally. The bias was that astronauts need to be seated to fly the module. Pilots are always seated, at least in aircraft. The team recognized that if they stood directly in front of a window, it could be quite small and still provide the extensive field of vision. The flight from the orbiter to and from the moon's surface lasted less than 90 minutes and the G-force would never be greater than one-sixth that on earth. The pilots could stand to observe and fly, and they could sleep in lightweight hammocks like on old sailing ships. They do not need contoured, fitted seats and large windows. What changes if you imagine the trip to the moon as a trip of exploration to a new world standing behind the wheel of a sailing ship? This is lateral thinking.

Astronauts in a weightless condition and people who are bed-ridden or unable to walk, experience devastating side effects, such as muscle loss and cellular damage, in as little as a week. Artic ground squirrels hibernate for months barely moving without these side effects. Scientist and science fiction writers have long imagined using hibernation to mitigate these effects and are looking for ways to accomplish this. Medically induced comas are used to assist in healing neural damage or to slow blood flow during critical surgery. A group of scientists are studying the arctic ground squirrel to apply how the squirrel recycles nutrients within its body to produce proteins used to build lung, kidney and skeletal muscle tissue resulting in less muscular loss (Rasha, 2020). Imagination needs to include both what went wrong like cellular damage and what went right, like building tissue using recycled metabolites.

Society suffers from a lack of imagination. In the executive summary of the 9/11 Commission report, the opening paragraph began with the following statement. "The National Commission finds the attack on the United States on September 11, 2001 was, above all, a failure of imagination." No one imagined that anyone would launch that kind of attack against the US. Everyone knew that the twin towers were designed to withstand the impact of a small airplane. No one imagined that anyone would intentionally bank fully fueled airliners into towers causing damage to multiple floors. Our imagination and the ability to predict the attack was stifled by our assumptions and bias.

Afterward the nation's thoughts concentrated on what went wrong. How would society have reacted if what went right had been emphasized? The Federal Aviation Administration cleared the air space of over 4,300 aircraft in just 2 hours and 25 minutes. Under standing orders, the US Coast Guard armed its vessels and closed every port in the US. Private boats and ferries aided in the evacuation of Manhattan. Someone(s) imagined that a disaster requiring such speed and coordination might happen someday and planned for it. It was an extraordinary display of humans reacting at our very best in response to humans acting at their very worst. We might be living in a different culture if nearly 20 years ago, we had come to terms with both our failures and successes to imagine catastrophe. Failure to recognize our bias came with a heavy price. It always does. Team leaders need to understand bias and guide their teams to imaginative solutions. We should ask ourselves and our teams "what are the assumptions we don't realize we are making?"

What is so and so what

Subject matter experts are selected because they are problem solvers. As soon as they receive the original concept, they start solving the problem of how to make the project more valuable. They begin creating alternatives. Often the TEAM LEADER encourages the team to identify opportunities while they review the documents. During the information phase the team leader warns team members to ask about the project but not to express alternative ideas knowing that they have already formed some. Creativity occurs well before the third phase of the workplan. Creativity may be the emphasis of the third phase, but in reality, creativity starts as soon as project documents are reviewed.

How would the workshop change if the team were instructed to use their imagination rather than creativity from the very start? The team leader could guide the thought pattern to a higher level of abstraction by simply stating the project's name and location and requesting the team to imagine what the project looks like before they receive project documentation. Then during document review and the information phase the team members are asked to confirm or refute their imagined project. Each conflict represents an imagined idea of how to accomplish the design and which standards, assumptions, criteria, and constraints to challenge.

Imagination should underly all phases. Imagination is sparked by the right questions. Psychologist Bob Kreigel in Sacred Cows Make the Best Burgers (Kreigel, 1997), states, "Success doesn't come from how much you KNOW, but how much you LEARN. The expert says, "Based on my experience, that won't work!" The learner asks, "what do I have to do in order to learn whether this will work or not?" … The key to keeping ahead in a changing environment is to think not like an expert, but like a beginner." If you want to see imagination and creativity working together ask a child to explain something to you. The subject matter experts most valuable to team leaders combine their decades of experience with a beginner's mind, full of questions and opportunities.

Conclusion

This paper is full of questions. Did you ask why are there so many questions? Questions spur the imagination. Function analysis asks why and how. The question why is the gateway to imagination. We can be more creative and effective in our problem solving by imaging. By using lateral thinking, creative conceptualization, testing of assumptions and other techniques we can provide more high-performance solutions. How would our process be perceived if instead of being value methodology it was "Questioning to improve your project"? Imagine that!

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VALUE ENGINEERING: DEFINITION OF FUNCTIONS THROUGH REQUIREMENTS AND SPECIFICATIONS ON PRODUCT DESIGN.

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Abstract

The aim of this paper is to find a solution to determine functions without the need of a previous product. Frequently, engineering designers and designers must conceptualize, design and develop non-existing products, therefore using Value Engineering as a tool becomes a challenge since there is not a reference product to be analyzed. By providing a technique that allows them to understand what the product must do (through the use of functions) it should become easier to improve the product at an early stage, the conceptual design stage.

The information available at this early stage is the one given at the information phase, hence the proposal is to define functions through requirements and specifications. Requirements are identified and classified by areas, these areas are named in a checklist built by Pahl and Beitz.

Theory was applied to a Case Study for the development of a medical device designed to prevent lymphedema. Results showed that functions are possible to be determined through the requirements.

Key Words: Value Engineering, Function Analysis, Product Development, Concept Design, Engineering Design

Introduction

Understanding a problem is constantly a challenge in product design. To find a solution, the first step is to comprehend and properly define a problem. An excellent technique to achieve both the problem definition and the solution is Value Methodology, which through the use of functions, allows the multidisciplinary team to analyze and answer what must the product do instead of what is it or how does the product do it.

Since Lawrence Delos Miles created Value Engineering Methodology in 1947, the function analysis has been based on the study of the product by separating it into its components. But what would happen if we seek to develop a new product, one that does not yet exist? How can we determine functions? Where would our analysis come from?

Overview of Value Engineering

During World War II, Mr. Harry Erlicher asked Lawrence D. Miles, who worked at General Electric, to resolve one of the consequences the War brought along with other problems to the manufacturing industry: the scarcity of materials. Through observation Mr. Miles realized that a product is chosen for what it can do. He then concluded that it was necessary to understand the function of each of the product's parts and that this function should be formed by the compound of an active verb plus a measurable noun.

Value Engineering, which is also referred to as value analysis, value management, value planning, or value control, is a methodology for analyzing functions of an item or process to determine "best value," or the best relationship between worth and cost. (whitehouse, 2013)

Even though the terms: VE and VA are frequently used equally, there is a difference between the definitions:

Value Analysis is the review of an existing established product, system or service to remove unnecessary costs. Essentially, cost reductions. (King, 2007)

Value Engineering is the building of low cost and value into a product while in the design or conceptual stage. Essentially, cost avoidance. (King, 2007)

Nonetheless, as shown by Thomas R. King in the Value Engineering Application Cycle (Fig.1.0). Value Engineering is applied after the conceptual stage.

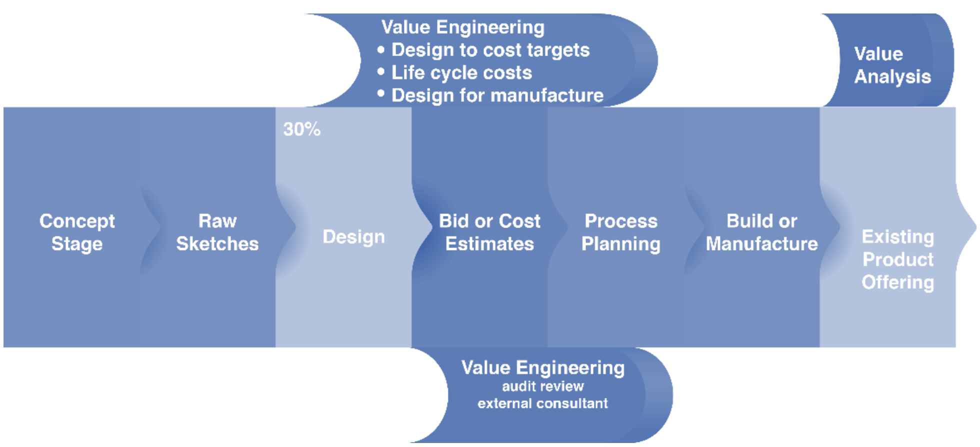

Figure 1. Value Engineering Application Cycle. (King, 2007)

Comparing and contrasting the VEAC with VE definition, there is a visible opportunity to start the application of VE even before the conceptual design. The earlier the Value Methodology is performed the better results will be obtained for the product, service or process. Now, what if the problem leads us to a new solution, an invention, the creation of something completely new? How can VE be applicable?

Scope

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With the aim to visualize the compatibility between VE phases and design process phases, a comparative diagram is shown below. For VM, the Job Plan phases in the illustration are those established by SAVE International. With respect to design process, several methods have been developed among the years though it is not the purpose of this paper to define the right method for design. The phases you will see are the general agreement extracted from the comparison of engineering design process models purposed by T. J. Howard, S. J. Culley and E. Dekoninck.

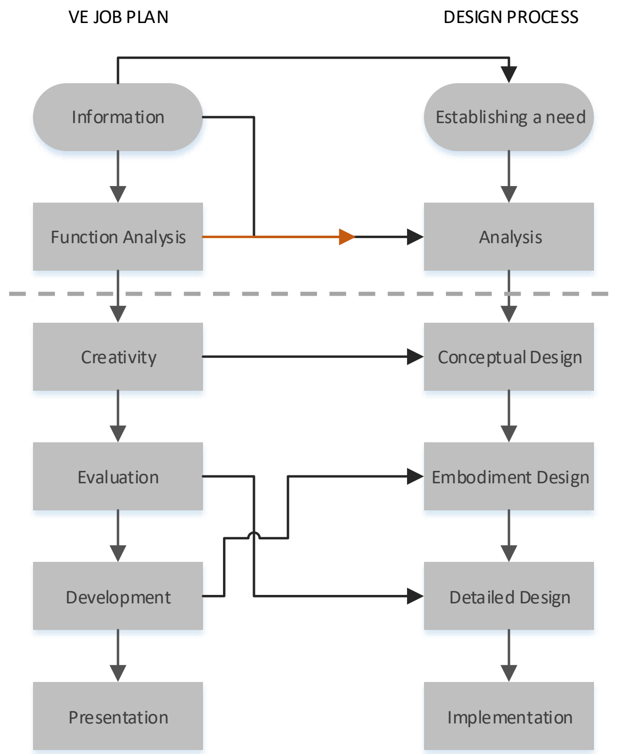

Figure 2. Comparative Diagram: Value Engineering Job Plan & Design Process

The main interest is to use VE as soon as possible, therefore a cutting line was placed above Conceptual Design to show in parallel which Job Plan phases were related with the design process. Phases from creativity to presentation are therefore not the focus of this paper.

If, as Mr. Miles concluded, creative thinking is constrained by the physical shape or concept of existing products or services (Park, 1999) how can VE be used with a nonexistent product if there is a lack of physical shape or a lack of a concept?

Functions must then be established before the conceptual design.

Regarding to Function Analysis, its procedure includes: determining functions, allocating cost to function, determining worth and calculating value index. This paper's scope is focused in identifying and classifying functions.

So the question for this research is: How can functions be identified and understood before the concept and development of a product or even a non-existing product?

Method

For the invention and design of a new product, the only thing available to start the Function Analysis is the data given in the Information Phase. This data is the key to drive the project into what must the product do. It is therefore essential data is gathered before the day the Information Phase is executed.

This paper is attentive in three main sections: need, requirements and specifications.

Concentrating on the need or the requirement, which Mr. Miles called the function, helps to break down the constraints to visualization and offers outstanding opportunities for creativity. (Park, 1999). Following the previous premise, the method of determining functions will be through the translation of the need,

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requirements and specifications into functions.

1.Information

The Value Standard and Body of Knowledge says the purpose of the Information Phase is to understand the current state of the project and constraints that influenced project decisions. This is where the project overview is described in order to bring all team members to a common, basic level of understanding of the project.

As discussed previously, the need, specifications and requirements must be provided in this phase. The use of the checklist (Table 1) is suggested to identify as many requirements as possible. The checklist elaborated by Pahl and Beitz point out the main product properties.

Main headings	Examples
Geometry	Size, height, breadth, length, diameter, space requirement, number, arrangement, connection, extension
Kinematics	Type of motion, direction of motion, velocity, acceleration
Forces	Direction of force, magnitude of force, frequency, weight, load, deformation, stiffness, elasticity, inertia forces, resonance
Energy	Output, efficiency, loss, friction, ventilation, state, pressure, temperature, heating, cooling, supply, storage, capacity, conversion.
Material	Flow and transport of materials. Physical and chemical properties of the initial and final product, auxiliary materials, prescribed materials (food regulations etc)
Signals	Inputs and outputs, form, display, control equipment.
Safety	Direct safety systems, operational and environmental safety.
Ergonomics	Man-machine relationship, type of operation, operating height, clarity of layout, sitting comfort, lighting, shape compatibility.
Production	Factory limitations, maximum possible dimensions, preferred production methods, means of production, achievable quality and tolerances, wastage.
Quality control	Possibilities of testing and measuring, application of special regulations and standards.
Assembly	Special regulations, installation, siting, foundations.
Transport	Limitations due to lifting gear, clearance, means of transport (height and weight), nature and conditions of despatch.
Operation	Quietness, wear, special uses, marketing area, destination (for example, sulphurous atmosphere, tropical conditions).
Maintenance	Servicing intervals (if any), inspection, exchange and repair, painting, cleaning.
Recycling	Reuse, reprocessing, waste disposal, storage
Costs	Maximum permissible manufacturing costs, cost of tooling, investment and depreciation.
Schedules	End date of development, project planning and control, delivery date

Table 1. Checklist for setting up a requirement list (G. Pahl, 2007)

2.Defining Functions through requirements

To define functions the team will collect and organize the requirements in a document (Table 2).

Function is the original intent or purpose that a product, service or process is expected to perform. It is expressed in a two-word active verb plus measurable noun structure.

Functions are useful to bring clarity to the project: by defining the basic function, the purpose of the product is established while secondary functions are useful to understand how the basic function and the subsequent functions will be achieved.

Project:		Scope:			
Information		Function			Comments:
Area	Requirement	Active Verb	Measurable Noun	Function Type	

Table 2. Function Translation Worksheet.

a) Area: Property of Beitz and Pahl's checklist, chosen to be analyzed in the requirements.
b) Requirement: Description of the property as something measurable or as an attribute.
c) Function: Active verb plus measurable noun.

Case Study

Improving the Conceptual Design of a Medical Device through the use of functions and the Function Analysis System Technique.

To illustrate in a pragmatic way the translation of requirements into functions, the VM Team worked in collaboration with the PhD student, Gabriela Durán, whose research focuses in solving the problem of lymphedema, a disease caused by removal or dysfunctional ganglions.

In order to understand the causes and the consequences of the illness. a general background of the disease was explained to the VM team. Given the presence of cancer cells, treatments such as radiation and nodal emptying combat and prevent the spread of malignant cells. Though these two processes are useful to fight cancer, the absence of nodes brings as a consequence the accumulation of lymph, since lymph vessels are cauterized after the node extraction.

The first thing the VM team observed is that the ganglion as part of the organism performs certain functions. This organ, when removed, leaves the organism without a substitute to keep with the work it does. This was an interesting opportunity, because even before the function translation based on requirement, some functions can be determined through the function analysis of the organ.

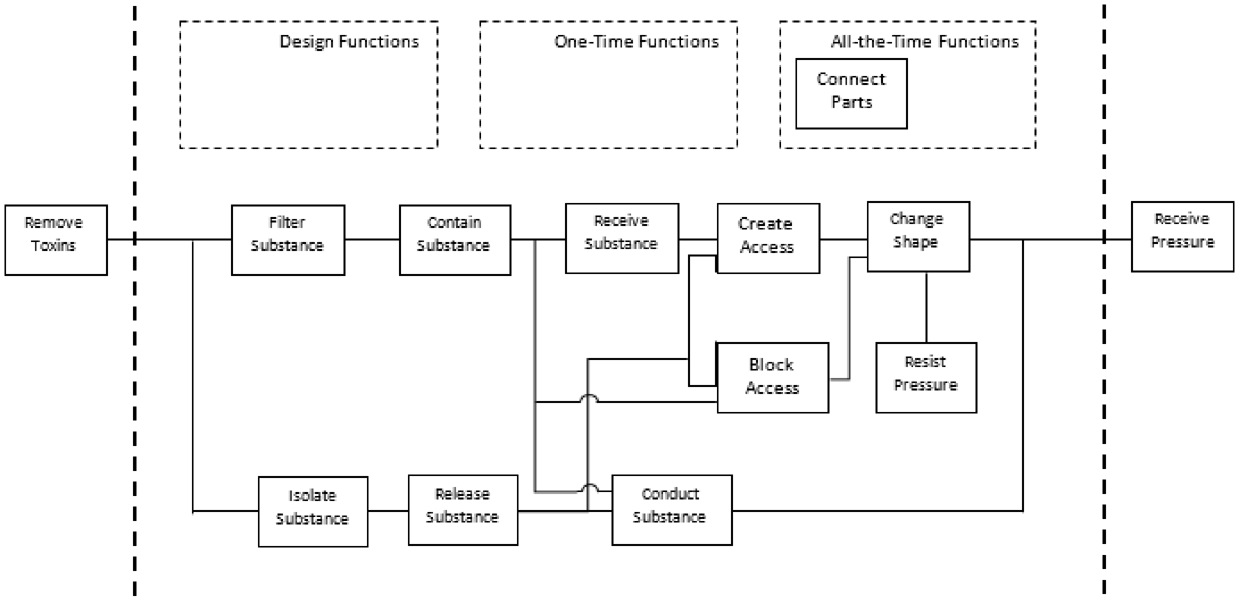

Figure 3. Lymph node FAST.

This diagram helped the designer determine that even though the basic function of a node is: ‘filter substance’, this function may be performed by the next node, a healthy one. The lack of function that affects the most is the all-time-function: ‘connect parts’, without this connection, flow to the next node is blocked, so the medical device must act as a bridge between the lymph vessels to avoid cauterization.

After understanding the function of nodes, and based in the information Durán had compiled, a list of requirements and specifications was made within the translation of the requirements into functions:

Project: Medical Device		Scope: Medical device that connects vessels & drives fluid to a healthy node.			
Information		Function			Comments:
Area	Requirement	Active Verb	Measurable Noun	Function Type	
Geometry	Diameter: 7mm	store	substance	SF	
	Volume: 0.4ml	store	substance	SF	
		create	volume	SF	
	Venous Connection	create	access	SF	
		connect	parts	BF	
Kinematics	Unidirectional flow	conduct	substance	SF	
	Valve opening	create	access	SF	
		receive	substance	SF	
		ration	substance	BF	
		release	substance	SF	
		block	access	SF	
Forces	Lymph flow depends of external forces, like: muscle contractions and joint pumps	change	shape	SF	
		resist	pressure	SF	
Material	Medical grade	comply	regulations	SF	The material chosen by the designer is TPU, the question is why is this material needed?
		resist	bacteria	SF	
	Shore A80 & Shore D75	change	shape	SF	
		receive	pressure	SF	
		resist	pressure	SF	

Table 3. Function Translation Worksheet for a Medical Device.

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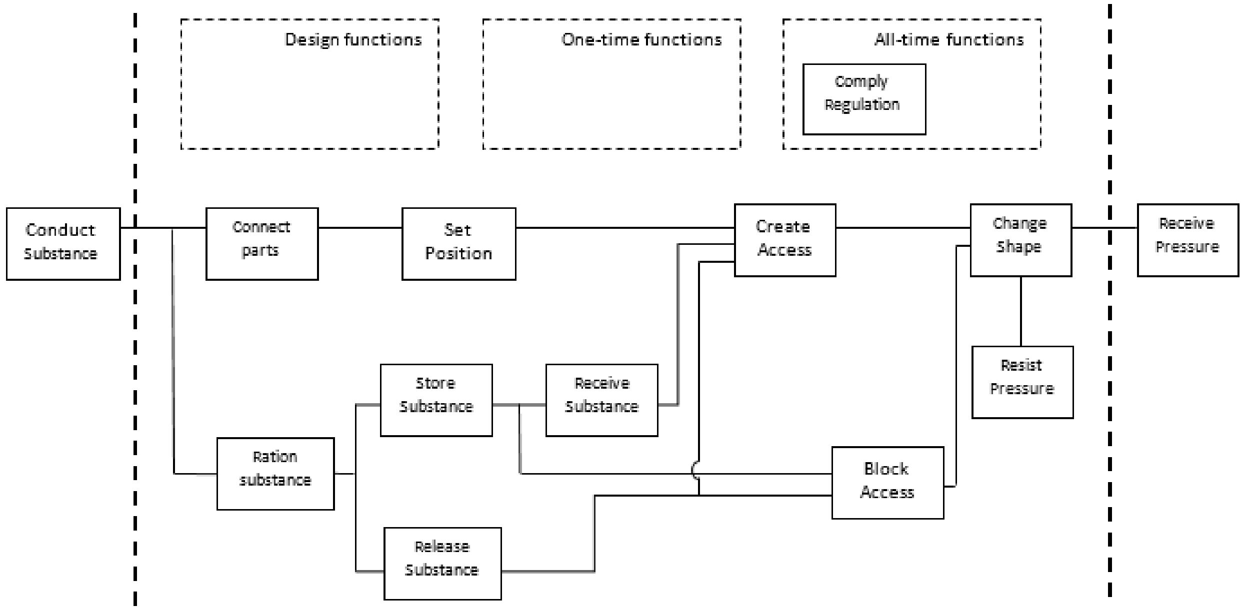

Figure 4. FAST of Medical Device.

With this registration Duran was able to determine the scope of the project and to recognize that the device's specific purpose is to "connect parts" so as to "ration substance" to allow the lymph flow. Results of the function analysis emphasized the importance of finding solutions to this function. The table below shows the evolution of design after function analysis.

Figure 5. Conceptual Design Evolution (Durán-Aguilar, 2019).

The first conceptual design was made before the implementation of Function Analysis. Even though the designer knew what problem to solve, she did not exactly know how to do so.

The second picture shows the result of the conceptual design after the Value Engineering of the ganglion was executed and functions were defined through requisites. In this study it was concluded that the basic functions of the damaged or removed node could be performed by a healthy node. As a result, the valve to filter the substance was removed. Instead of filtering or isolating the fluid, the aim of the medical device transformed into solving how to reach that healthy lymph node.

Note: The design in this second concept does not solve the function: "connect parts", the Value Team emphasized the designer the importance of finding a solution to that specific function.

The last image demonstrates the evolution and differences of the conceptual design when understanding the functions that the project must reach.

Conclusion:

Through the case study it was possible to verify the definition of functions through the requisites and specifications. Merging the Checklist provided by Pahl and Beitz to identify requirements helped in turn to find the functions needed for the product design. Results and changes were also visible at the conceptual design evolution (figure 5), not only for the product but also in the way the designer understood what must the product accomplish.

To help the conceptualization of a product it is useful to extract from requirements and specifications as many functions as possible. Functions will help clarifying the project in an analytical way so after information is correctly ordered, creativity transforms it in visible solutions.

In this specific case (Medical Device) functions were also found through the Function Analysis of the lymph node, which also helped the designer.

Future lines: Cost Avoidance as a consequence of Value Engineering implementation in Conceptual Design Stage, Value Engineering in biomimicry, Value Engineering in Medical Design.

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Title: Necessity is the Mother of Invention – Value Methodology in the Age of Pandemic

Author: Robert B. Stewart, CVS-Life, FSAVE, PMP, PMI-RMP

Abstract

The onset of Covid-19 created widespread change in the daily lives, and in the way they conduct business, for people across the globe. This paper will explore the impact of the pandemic on the practice for a VM professional services company. We will explore the impacts of the pandemic and the shift to virtual VM studies; the challenges and opportunities; facilitative and technological changes that have been made; and an assessment of the effectiveness of these adaptations. Finally, we will offer our conclusions based on the lessons learned and the path forward for the practice of VM in the post-pandemic world.

Introduction

The week before things really locked down due to the pandemic, back in March of 2020, I was conducting a large VM study for a client in Canada. The study had over 20 participants and was held in a large conference room. People from all over North America representing the client's company had travelled to attend the workshop at great expense. There were catered breakfasts and lunches. Some people had laptops. Some did not. Despite the fine meeting accommodations, we faced the typical logistical challenges of conducting a large study - finding enough space for people to sit; organizing the tables and chairs while making compromises about the size and shape of the room; dealing with the lack of sufficient wall space suitable for taping up flip chart paper and Post-It® notes; the headaches of having to move people around in order to mix them into teams of the right size and composition.

Despite it all, it was a successful study and we had good results, however, as I look back on it now (nearly a year later to the day), it seems so different, and, dare I say *quaint*. It was loud, somewhat chaotic, and at times painfully inefficient. And always, there was the challenge of keeping such a large group engaged. People interrupting each other; the ever-present distraction of smart phones; the disruptions of people constantly entering and leaving the room. Looking back, it seems miraculous that we accomplished as much as we did.

Attached are some photographs from the VM study I speak of. I am sure it will strike most of you as very familiar. Notice the size of the room; number of people; Post-It® notes pasted on every available surface and covered with small, barely readable handwritten text; some people are attentive, others distracted; the facilitator at the front of the room in front of a projector screen; people alternately sitting behind tables or crowded around an easel.

All this appears "normal" mind you. However, if you look more closely, you will begin to see some of the physical limitations of the "traditional" study environment. There are significant limits to how much information you can reasonably communicate between all the participants in the room in terms off Post It® notes and flip charts. Even less so if your eyesight isn't good. Participants are at the mercy of the presenter relative to the images that appear on the projection screen and may have difficulty seeing the information from across the room and, if they can see it, may not have enough time to fully process it.

Lastly, it is important consider the expense of hosting on-site, in-person studies. For the referenced VM study, the cost to the customer was over $40,000 CAD for travel, lodging, food, and meeting room accommodations. This accounted for approximately 30% of the total VM study cost.

Scenes from a "Traditional" VM Study – How Quaint!

Initial Fears

When the first COVID-19 lockdowns began, me and my colleagues were worried. What would happen to our business? Would things screech to a halt? How would we conduct our work which had traditionally been gregarious, in-person affairs? Would our clients want to engage with us? We all had our doubts. In my company, we began to immediately move into action, both planning for the worst while figuring out how to adapt our services to the virtual world of the internet.

For the first few weeks, there were indeed many cancellations that lead to an initial lull. Our team came together and figured out how we would adapt to the new environment through a combination of technology and alternative facilitation techniques while convincing our clients that we could continue to support them. We were confident that we could get the job done, however, our clients needed convincing.

Some of the common concerns that were frequently voiced were:

- People won't be productive.
- People will disengage.
- Some people don't have webcams – how will we know what they are doing?
- People will get bored – 8-hours of virtual meetings is too much!
- People will talk over each other on virtual meetings – it will be impossible to have meaningful discussions!
- People will struggle with the technology.
- How could a virtual meeting ever be as effective as a face-to-face one?!?!

These were all challenges to be sure and were not unfounded. As VM facilitators, it was up to us to allay the fears of our customers and develop approaches to virtual studies that would address these issues. The very nature of the pandemic forced everyone's hand to at least try it out as there was no immediate alternative. Everyone had to change all at once, which made the normal psychology of resistance to change less problematic than it otherwise would have been.

Adaptive Technologies

Prior the pandemic, my company frequently used virtual meeting platforms such as Webex®, Zoom®, and Microsoft Teams®. Normally, the use of this technology was secondary. For example, we might conduct preparatory meetings virtually and/or use them to augment presentations when key individuals were unable to attend VM studies in person. There had been only a handful of occasions where we conducted a complete study in a virtual environment.

During the pandemic, the use of these technologies has expanded dramatically as almost everyone at some point was prohibited (and for some still are) from attending large, in-person gatherings. In the first months, many organizations struggled to get essential technology into the hands of their employees. For many government agencies, the standard issue equipment had been a desktop PC. It took some time for laptops to be deployed and, many of them did not have the needed peripherals like webcams and microphones.

It also took some time for people to become accustomed to the etiquette of virtual meetings. The early days were painful; however, it was surprising how quickly adapted and moved through the learning curve.

Some of the key features that we have found to be indispensable in the use of virtual meeting technology include:

- Breakout Sessions - the ability of the platform to host multiple, simultaneous "breakout" sessions while the main meeting is in progress. This allows room to accommodate the need for more detailed discussions between small group of interested parties.
- Individual and Private Chat - the ability of the platform to support group and private chats. We have found that it is often more useful to request people to type out questions or make comments in the chat. It allows documentation to occur while providing another mode of communication – a kind of quiet "crosstalk."

- Meeting Recording – most virtual meeting platforms allow for the recording of both audio and video (as well as chats). This can be invaluable, especially during group decisions and discussions. Having the ability to go back and review key information has proven to be extremely valuable.
- Emotes – most platforms provide for a small set of emotes which can be used to communicate a variety of information. The “raise hand” emote is extremely useful when the facilitator asks questions to the group and needs a quick response or poll of the group’s collective feelings about activities or discussions.

The proliferation of this software and widespread use has made the use of this technology common nowadays. Further, there is tremendous pressure for the competing platforms to innovate and improve performance.

Another important technological adaptation has been the use of shared drives such as Google Drive and OneDrive®. These applications allow users to work off a common document in parallel. This technology has improved invaluable for the secure sharing of information and the ability to provide version control over documents such as VM proposals. Multiple individuals can work on a document at once and see what everyone is working on. This has proven to be far more efficient than relying on email to transmit documents.

Lastly, and perhaps most important, is the use of collaborative whiteboard to share information visually. These platforms, such as Miro® and Mural®, have proven to be complete game changers in terms of enhancing the effectiveness and engagement of virtual studies.

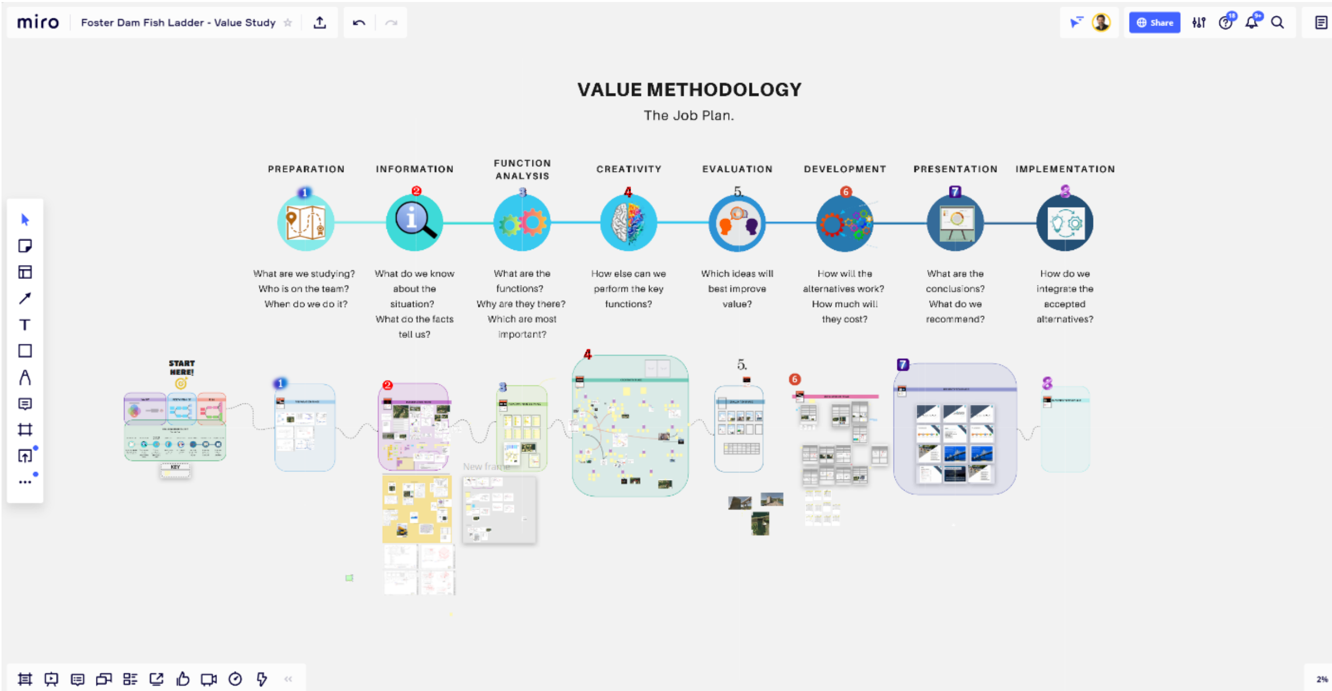
Attached are several screenshots from Miro® related to a virtual VM study that was facilitated in November 2020. Miro® essentially acts as an “infinite” whiteboard that allows users to zoom in and out at different levels of magnification. Objects such as virtual Post-It® notes, arrows, shapes, text, images, and even documents such as MS Word® files and Adobe Acrobat® files can be placed on the whiteboard and manipulated in any number of ways. It emulates a physical whiteboard but is far more useful and flexible. Users log into the whiteboard and can work together on the board collaboratively in real-time. Couple with a virtual meeting platform such as Webex, the ability to engage and communicate far surpasses anything in my experience of 30+ years of facilitating VM studies.

Tools like Miro® afford massive advantages over traditional meeting spaces and conventions. For one, the availability of the information on the whiteboard is immediate. Individual participants can peruse the information on the whiteboard, and contribute to it, at their leisure. The fact that participants are taking an active role in contributing to the group’s knowledge and are aided by graphic tools that are easy to use, makes for a powerful means of engaging with people. In fact, I have seen levels of engagement that have never occurred in the past in conventional, in-person settings.

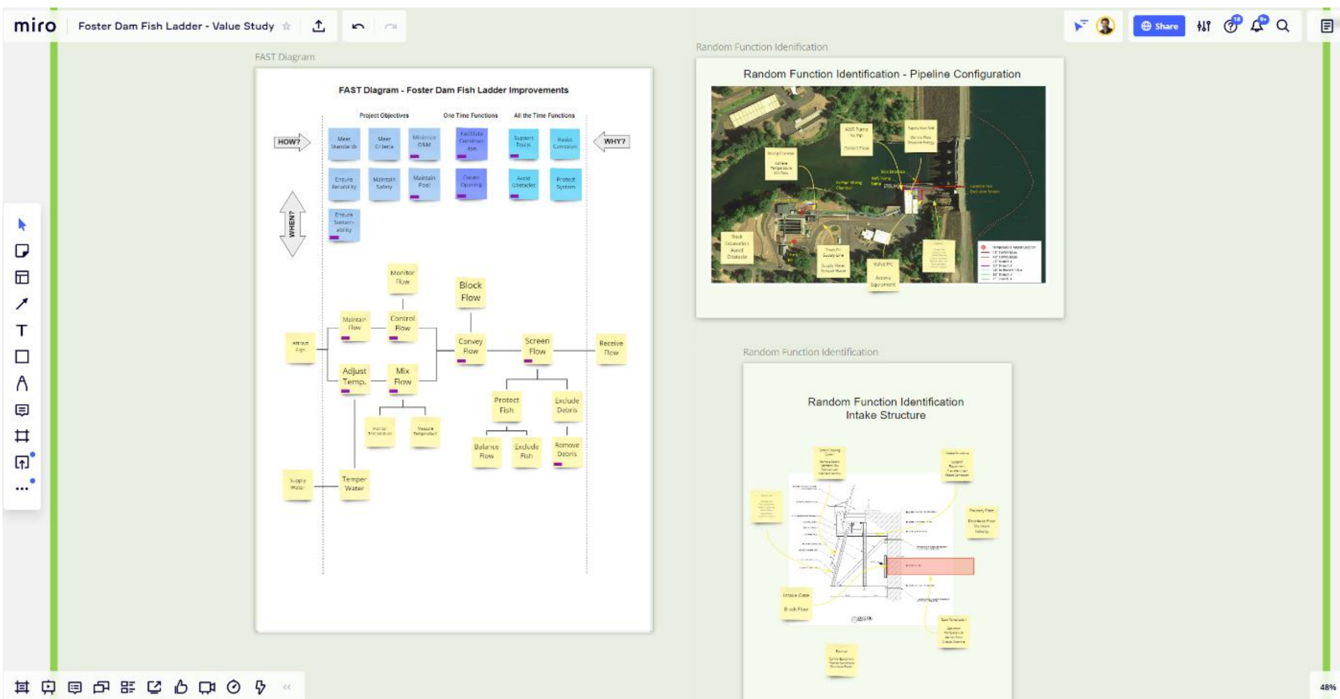
For example, on a recent virtual study I had a young engineer who was very self-conscious about her inexperience. The use of tools like Miro® allowed her to express herself without the fear of having to get up in front of a large group and put something on a whiteboard. She was able to contribute confidently, and even anonymously if she chose to, without fear of embarrassment. As a designer, she could call upon the graphic nature of the tools to eloquently articulate herself. In my experience, there is tendency for technical people to tend toward introversion. The use of these virtual tools has proven to be very empowering for such people.

Another important benefit of virtual whiteboards is that they provide a living record of the group’s efforts. Any participant can view any part of the board at any time. During group activities, the facilitator can “call” all participants to his or her location on the board to focus the team as needed.

Finally, there is an entire library of visual “templates” that can be called on in Miro® to help organize the groups thinking. This includes things like Kanban frameworks, mind maps, Ishikawa (fishbone) diagrams, and flowcharting. Finally, there is a tool that facilitate nominal group technique style voting. It really is an ideal tool to support activities throughout the VM Job Plan.



A Miro® board for a VM Study – 2% magnification



Detail of the Miro® board of the Function Analysis Phase at 48% magnification

Adaptive Facilitation

The change in study environments necessarily required changes in facilitation approach. In the initial stages, virtual facilitation was more limited to sharing the facilitator's screen in the virtual meeting. Discussions would take place primarily through this mode. The facilitators would lead activities and capture information from participants using typical software applications such as MS Word®, or in the case of my firm, through proprietary VM facilitation software. In many ways, this approach was simply a weak analog of the traditional in-person VM study. This seemed to work reasonably well but was not equal to traditional, in-person VM studies.

One of the major disadvantages of performing VM studies in a virtual environment is the loss of non-verbal communication. There have been many studies that have looked at the breakdown of different types of communication modes and the majority are non-verbal. Two early, famous studies on this subject (Mehrabian & Wiener, 1967 and Mehrabian & Ferris, 1967) together concludes that 55% of communication is body language, 38% is the tone of voice, and 7% is the actual words spoken. Other studies have suggested different breakdowns; however, the point is that we typically rely on a large part of our communication non-verbally. In the virtual environment, even with the benefit of webcams, we lose a lot of the gestures and facial cues. This poses a significant challenge to the facilitator to better understand the nature of the communication occurring during a VM study.

Numerous techniques can be employed to compensate for this problem. One is to use frequent group feedback checks. The facilitator can ask the participants what they think about certain pieces of information or group decisions by asking for an emote – perhaps a thumbs up or thumbs down, to quickly poll the group. Dissenting or negative responses can then be followed up on and discussed to improve understanding and to ensure that key issues or concerns are surfaced.

Another technique is called "chatterfall" whereby the facilitator asks about how they are feeling about a certain situation or question. Participants are asked to type of one word that best describes their emotions concerning the subject. When the facilitator says "go," everyone hits "enter" at the same time. The effect is a cascade of the groups consciousness that appears in the chat window for the virtual meeting platform application. This technique is a substitute for facial cues that might otherwise be noticed by others were the study an in-person affair.

Some other facilitation considerations relative to virtual studies is that they allow for much greater flexibility in terms of scheduling. Traditional studies invariably required travel for some or all participants. This means that studies must be concentrated over a narrow timeframe to maximize the costs related to travel. Virtual studies remove this constraint and allow studies to be broken out into smaller sessions spread out over more days. This allows for participants to tend to other matters and provides for "mental breaks" to process the information shared in between study sessions. Another benefit related to this is that a broader selection of VM team members can be considered since geography plays less of a role. This, coupled with the flexibility of providing shorter sessions, increase the capacity to accommodate the participants' busy schedules.

Site visits can be accommodated through a variety of means. On a recent virtual study, the study sponsor was able to record drone footage for a large, civil works project prior to the start of the study workshop. The video footage was shared with the participants on the first day of the study. Site photos and videos can also be made available as well. Finally, the power of Google Earth allows, including both three dimensional and "street views" in many ways can be superior to in-person visits as they take less time and provide information that can be immediately accessed at any time.

Finally, one of the more important observations in comparing traditional and virtual VM studies is related to engagement. As was mentioned in the introduction, traditional studies are heavily reliant on the facilitator to moderate activities and call on individual participants to share information. This essentially makes the facilitator the "bottleneck," meaning, the pace and flow of information is restricted to the ability of the facilitator and individual contributors that share information one at a time. By leveraging virtual whiteboard technology, this constraint can be removed by allowing participants to share information in parallel with ongoing discussions.

For example, during the Creativity Phase, we have found that engagement can be increased dramatically by devoting the first half of a creativity session to individual brainstorming. Each participant is afforded quiet time to offer ideas on the whiteboard by adding Post-It® notes, sketches, or other information at their own pace. The second half of the creativity session then turn to group brainstorming where the facilitator reviews and reads each idea for clarity and invites other to hitchhike on existing ideas by adding new ones. This dual approach has proven to be extremely effective in increasing both the quantity and quality of ideas. Generally speaking, we have seen about a 50% increase in the number of ideas using this approach than we would in traditional studies. As mentioned earlier in this paper, much of this likely has to do with the psychology of the indirect nature of the virtual environment (i.e., more conducive to introverted personality types) as well as the ability easily add graphic information to the board.

Similarly, Miro® and Mural® both support activities through a nominal group technique tool that allows participants to vote on ideas and options much like the in-person "dot voting" technique which has been used for decades. The key benefit is that it allows voting to occur quickly and easily. Further, it can be segmented into smaller voting sessions to drill down into specific topics.

There are many other facilitation benefits and techniques that could be discussed and we are discovering new ones all the time.

Effectiveness

The real question is are virtual studies achieving the success of their more traditional brethren? There are many ways to measure "success" so we will discuss on multiple levels.

- Improved access to information – The use of digital whiteboarding, in conjunction with shared drives, allows enhanced access to information. Not only does this improve access, but these technologies support simultaneous and synchronous access, thereby facilitating collaboration and engagement.
- Increased engagement – As has been discussed throughout this paper, we have seen increased engagement as witnessed by the uptick in quantity of ideas; richness of discussion; and the ability of the virtual environment to allow information to be shared. Many people are visual thinkers, and this mode supports that communication style which is more apt to draw people into discussions and group activities.
- Reduced cost – As mentioned in the introduction, the large traditional study that was held for a client cost over $40,000 CAD in indirect costs related to travel, lodging, food, and meeting rooms. The same client conducted a virtual study later in 2020 with the same group. This cost was eliminated, thereby increasing the VM study ROI significantly. In the author's experience, it is not uncommon for over 20% of the VM consultant fee to be for travel and living expenses.
- Improved study flexibility – Virtual VM studies can be more easily scheduled to accommodate participants. Geographic constraints are removed, allowing for the participation of individuals that may have been either cost or time prohibitive.
- Improved quality control – The use of shared drives allows for version control and enhanced team access for editing and quality reviews. Subject matter experts can contribute more easily to the work of primary authors due to improved accessibility.
- Improved study results – We have seen comparable, if not improved, acceptance rates of VM proposals for virtual studies. It stands to reasons the more ideas and increased engagement will lead to better VM proposals. The author has seen implementation rates increase relative to traditional studies as well as the degree of value improvement related to the VM proposals.
- Participant feedback – Anecdotal feedback has been universally positive. Participants largely prefer this mode, especially with addition of virtual whiteboards.

Finally, the VM study sponsor who has been highlighted in this paper provided his direct feedback in comparing the two studies performed, traditional and virtual, and had this to say:

> *"Reflecting on my experience with virtual VM studies in 2020 I was pleasantly surprised with the success we had. The ability to conduct virtual workshops with a lower total cost is always a welcome benefit, however there are other reasons why they are more appealing to my organization.*
>
> *The increased convenience when travel is not required makes a virtual workshop easier to "sell" internally. Our company has such a large geographic footprint that an in-person workshop typically requires at least half of the participants to travel to the meeting location, and tacks on two unproductive travel days on either side of the workshop. People are more likely to be willing and able to attend in a virtual setting, despite the challenge of managing different time zones. With virtual sessions, you are also not as committed to conducting the workshop over consecutive days – this provides greater flexibility when trying to accommodate challenging schedules.*
>
> *Our workshop participants have also enjoyed the more relaxed conditions that virtual sessions provide. By breaking the day into two segments, we are able to give participants time in both the morning and afternoon to attend to other (non-workshop) matters. There was always a bit of guilt with in-person*

sessions, where taking calls, stepping out for an important meeting or responding to emails may be viewed by some as disruptive and/or disrespectful.

The use of virtual collaboration platforms such as Miro® or Mural® is a great improvement for storing, sharing and manipulating information. The amount of material that can be made available to the participants is unlimited, and having it in a digital format makes our creativity and development phases more impactful – a far cry from hand sketches! In our experience, having the collaboration boards accessible to participants around the clock allowed individuals to go back in on their own time (early mornings, evenings, etc.) to add content or soak in ideas, which is great.

There are some perceived downsides to virtual sessions. One aspect of an in-person workshop that we miss are the side discussions that often take place between participants during meals, breaks, or evening dinners – which often bring particular ideas to light. We are also less able to gauge the level of active participation in a virtual setting. Some people get the hang of it really quickly, while others struggle and then tune out.

Generally speaking, I'm a fan of virtual workshops and would expect that to be the preferred approach at Enbridge most of the time."

Michael Tozer, P. Eng, VMS – Specialist, Value Management Projects, Enbridge, Inc.

Conclusions

Virtual studies have been very effective and will become more so over time as people become accustomed to them and the technology and facilitation techniques evolve and improve. There are significant benefits to facilitators, customers, and participants as outlined in this paper.

Virtual studies add value. They are less costly to conduct and more flexible to meet the valuable resource of people's time. It is our hope that virtual studies become the new "tradition" among VM practitioners and that the increased value proposition will make the application of VM more attractive to customers and owners.