Combining Capability Assessment and Value Engineering: A BOOTSTRAP Example

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Abstract. Process improvement is a challenging task for software engineering. As Kuvaja [7]. has stated it:" It is difficult to find a unique way to identify a common improvement path suitable to all kinds of organizations." The BOOTSTRAP method gives an assessor tools to evaluate processes. As a method it evaluates processes with low capability and a high effect on an organization's goals the most important, and with high capability and a low effect on the organization the least important. It takes into account the organization's needs and goals, capability profiles of its processes and industry as the main drivers of process improvement. Value Engineering (VE) is a systematic method to improve the value and optimize the life cycle cost of a function or a facility. VE generates cost improvements without sacrificing the capability levels needed. By combining these two processes, process improvement work can be tailored to take into consideration, not only the capabilities of software processes but also the values of the same processes. This article discusses how to enhance the BOOTSTRAP assessment method to include new value characteristics and phases. Same principles can be applied also in other capability based assessment methods (for example CMM, CMMI or SPICE).

1 Introduction

Software has become more and more important in recent years. The number of companies producing software has grown constantly and we need software in our everyday lives. Therefore, the importance of good quality software has increased and it affects many people and most companies today. The processes producing software are important and from the customers' point of view they should produce cheap, reliable and usable help for everyday life. From the industry's point of view they should be cost effective and reliable. The paradigm of the software process proponents is that the quality of the software development process has a close relationship with the quality of the resulting software [4]. Krasner [6] points out that: "In a mature software organization, the following holds:

- Quality is defined and therefore predictable
- Costs and schedules are predictable and normally met
- Processes are defined and under statistical control"

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Because software process improvement and development is expensive to companies, capability based improvement only, is not enough to start process improvement work. To be effective, software process improvement and development methods also need to take into account costs created in processes. The goal of this study is to help to create an enhanced assessment method, which measures capability and value of processes. This is seen as important because if a process is not valuable to a company and its capability is low, the company should not worry about the situation [11]. On the other hand, if the capability of process is high and the value is high, the situation is in control, because the company is creating value by using a good process [11]. Problems arise when the company is creating quality with high capability processes, which do not create value, or processes are valuable but their capability is low (Figure 1.). These situations are not cost effective and profitable enough. In these situations the company either wastes resources in keeping up high capability processes which create a lot of costs and low value, or does not probably know that by increasing capability could probably increase also value significantly.

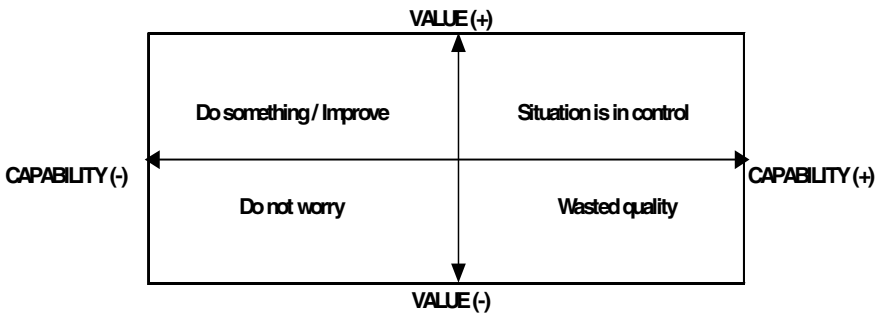

Fig. 1. Capability and value based process evaluation.

In this study value, cost and worth concepts are adopted from Value Engineering (VE) (synonymous with the terms Value Management and Value Analysis) which is a professionally applied, function-oriented, systematic team approach used to analyze and improve value in a product, design, system or service and process – a methodology for solving problems and/or reducing costs while improving performance/quality requirements. By enhancing value characteristics, VE is understood to increase customer satisfaction and value to investments.

Lawrence Miles describes Value Analysis as "a disciplined action system, attuned to one specific need: accomplishing the functions that the customer needs and wants". [11] Crum [2] calls Value Analysis (in the broadest sense) "a disciplined procedure directed towards the achievement of necessary functions for minimum cost, without detriment to quality, reliability, performance and delivery. It also means the application of the VA techniques to existing products." Crum describes Value Engineering as "the application of the VA techniques to existing products [2]."

VE can be understood also as a systematic method to improve the value and optimize the life cycle cost of a function or a facility [1, 3]. However, VE can be used also in improving the value and optimizing the life cycle cost of a process and a base- or a management practice [11].

In this study Value (V) is a measure usually in currency, effort or exchange or on a comparative scale, which reflects the desire to obtain or retain an item, service or ideal. Cost (C) is the price paid or to be paid. It can be divided into elements and to some extent functions (or processes). Worth (W) is defined as the least cost to perform the required function (or process) or the cost of the least cost functional equivalent. Using a formula V=W/C.

Dell' Isola [3] has also described value by using a formula. In his formula:

$$\text{Value} = \frac{\text{Function} + \text{Quality}}{\text{Cost}}$$

Where:

Function	=	The specific work that a design/item must perform.
Quality	=	The owner's or user's needs, desires, and expectations.
Cost	=	The life cycle cost of the product.

Therefore, he says that: Value = The most cost-effective way to reliably accomplish a function that will meet the user's needs, desires, and expectations.

Practically, in his formula Function + Quality is the same as worth.

2 BOOTSTRAP and Value Engineering Processes

The objective of BOOTSTRAP is to characterize the current practice, identify strengths and weaknesses and the ability of the process to control or avoid significant causes of poor quality, cost and schedule performance [8]. In this paper it is used as an example of capability assessment method to be enhanced by VE.

2.1 The BOOTSTRAP Assessment Process

Three different types of BOOTSTRAP assessments exist. Self assessment (Boot Check) is a starting point for process improvement. It is especially useful for small and medium -size companies). The assessment scope in the second type includes a full assessment. It is performed by two external assessors and it evaluates the capability of the software producing unit (SPU) and projects in terms of the organization, methodology and technology. This assessment includes all main processes. The third assessment scope is a focused assessment. It evaluates the capability of a selected set of processes. These processes are in the SPU or at the project level. (about assessment methods see [7])

All three types of BOOTSTRAP assessment cover or can cover SPU and project assessments. SPU assessment of the processes focuses on processes that are in the scope of the SPU. It also evaluates project processes based on managers' interviews. Project assessment includes assessment of the project processes based on interviews and evidence of practice capability.

The assessment process is performed in three main phases: preparation, assessment execution and action plan derivation (figure 2). The preparation phase has six steps:

Pre-Assessment briefing, Initialization, Assessment team identification, Collecting supporting material, Planning and scheduling and Defining confidentiality.

The second phase focuses on executing the assessment process. It includes five different steps: Opening briefing, SPU assessment, Project assessment, Evaluation and Feedback sessions.

The third phase, improvement planning and execution, focuses on documenting and presentation. It includes three different steps: Assessment report preparation, Final report preparation and On-site final meeting.

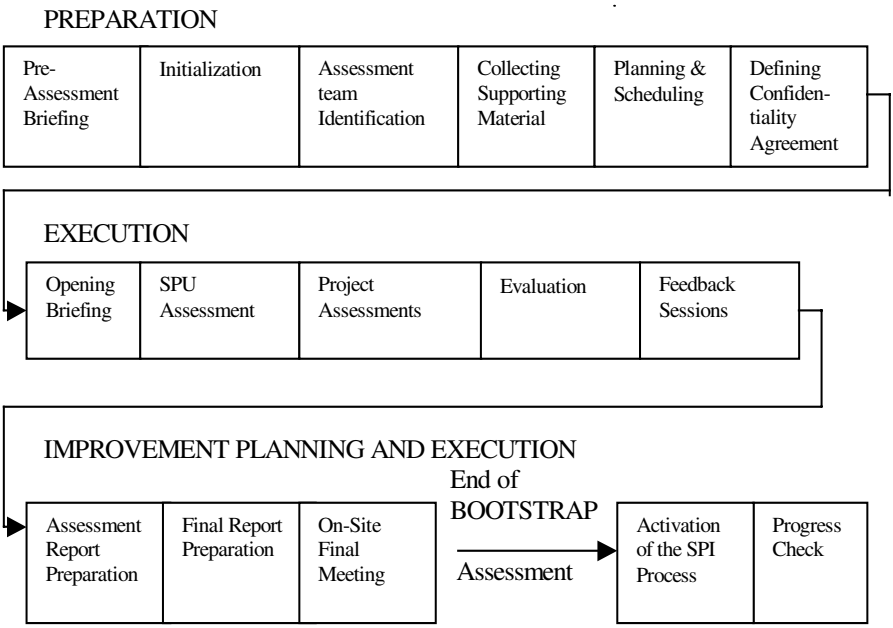

Fig. 2. BOOTSTRAP assessment process

2.2 Value Engineering as a Process

VE process consists of three main phases that are: pre-study, value study and post-study. The VE job plan is a systematic plan to make sure that the VE analyzing team understands customer requirements and develops a cost-effective solution.

Even though there are several job plans in the literature they are basically alike. The process of VE is the same. Park [12] has said: " No matter how many steps there are, the process is always the same, analysis, creativity, evaluation and development. In the following chapters the VE phases are categorized in three main classes, pre-study (tasks before value study), value study and post-study. Figure 3 shows the phases used in this study.

Pre-study activities should always be considered carefully before starting the VE process. The success of a VE study depends largely on preparation and coordination. In a properly established Value Engineering situation, orientation would include the

selection of appropriate areas to be studied and the appropriate team to accomplish the study.

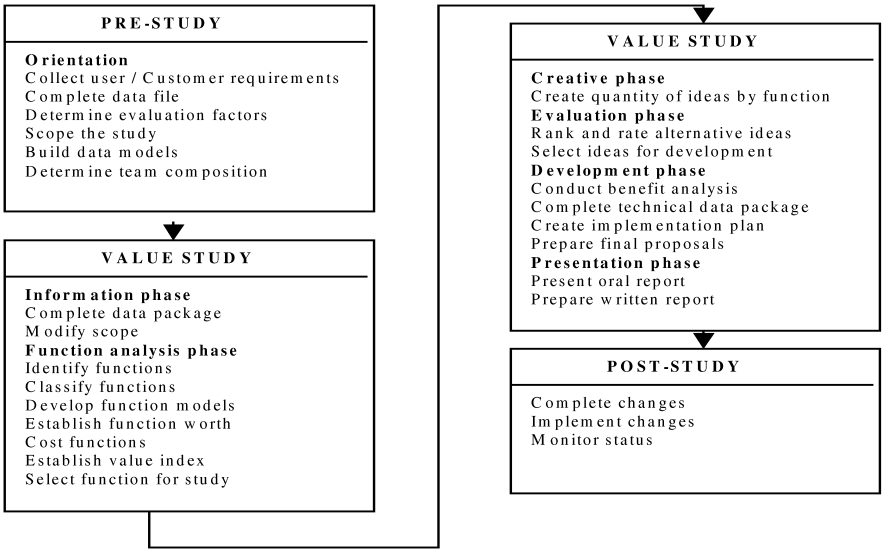

Fig. 3. VE process phases

A key point in organizing the VE effort is the use of the job plan or value study. The information phase is a fact-finding phase. The purpose is to accumulate all the factual information available in regard to the proposed area of study. The function analysis phase is the heart of the Value Methodology. Mudge [10] has formulated that function analysis is based on two major parts: define a function and evaluate the function relationships. He emphasizes that: "within defining the functions lies the keystone of the Value Engineering systematic approach". He continues that the evaluation of function relationships, is accomplished by taking the above technique and the information and data secured in the information phase and establishing a relationship between them. In the creative phase the VE team puts forward suggestions to answer the functions that have been selected for study. The VE team evaluates the ideas generated in the creativity phase using one of a number of techniques, many of which depend upon some form of weighted vote. This stage forms a crude filter for reducing the ideas generated to a manageable number for further study [5]. The accepted ideas, selected during the evaluating phase are investigated in detail in the development phase for their technical feasibility and economic viability. The refined ideas supported by drawings, calculations and costs, are presented by the VE team to the body who commissioned the VE exercise.

The purpose of the post-study is to assure the implementation of the approved value study change recommendations. Implementation tasks are made by the VE team, the organization's own personnel or together.

Practically, successful VE depends highly, upon which kind of techniques are used in the Value Analysis process [3, 9]. Right techniques identify unnecessary cost,

remove obstacles, and provide a course of action that will ensure the development of value alternatives of merit. These techniques can be divided into key techniques, techniques to test value, costing techniques and different kinds of screening and selection techniques [3, 9].

3 Towards a VE-Enhanced Assessment Method

In the previous chapters this study presented a discussion of what are the basics of BOOTSTRAP and VE. This chapter combines capability and value based methodologies together and outlines the enhanced BOOTSTRAP assessment methodology. Same principles can be applied also in combining VE and other capability based assessment methods like CMM, CMMI or SPICE. However, each combination needs specific definition work for example in defining relationships for existing processes and VE processes which is seen out of scope of this study.

3.1 Assessment Types

Using VE in the assessment process does not necessarily create new types of assessment. In some aspects their content changes partially. Self assessment (Boot Check) can be the starting point for process improvement or assessment and it can be done two ways. The company can carry out a complete self assessment or it can do a guided self assessment. The second type of assessment can be a full assessment. It can evaluate the capability of the software producing unit (SPU) and projects in terms of organization, methodology and technology. This assessment can include all main processes. The use of VE brings new steps into full assessment and it can be used to find out which processes give the biggest value [11]. The third assessment type can be focused assessment. It can evaluate the capability of a selected set of processes. These processes can be at the SPU or project level. Using VE brings new techniques to the selection part of focused assessment [11]. By doing first VE analysis for processes it is easier for an assessor to pick up a process with poor value to be assessed also from the capability point of view.

3.2 VE Enhanced Assessment Methodology

VE study bases on functions which assessor has formed himself using a verb and a noun and therefore method has been flexible in analyzing different physical product parts, which has to be defined individually. Later on cost accounting tools have been used strongly to assign costs as well as possible to defined functions. From the methodological point of view there does not seem to be any reason why this could not be done also to SW components thinking that they are SW parts. By doing so company would be able to classify its SW product into components and their subcomponents and finally also calculate value, worth and cost for each of them.

In literature there has been presented comments on that capability -based assessment methods are often too big and difficult to handle. They include a lot of processes and practices and they are not necessarily always related to existing process

descriptions used in a company. Sometimes company might be interested in to assess capabilities for those practices which are in their process descriptions not to those practices which are defined in the reference model like BOOTSTRAP or CMMi. However, assessing capabilities for these practices is time-consuming job, because there is no clear reference model for all situations which have been defined to companies process descriptions. From VE point of view value, cost and worth can be assessed easily also for processes and practices defined in company's own process description. In this situation there is just no reference model and functions are defined as processes and subfunctions as practices.

However, if capability assessment is done using a reference model arises question that why value assessment could not be done using the same model. By calculating also values, costs and worth to all processes and their practices could company get much more detailed data of its processes. It is clear that if company knows capabilities, cost, worth and value for all processes it can make better decisions in developing them too. Not all the processes necessarily give the same value if same amount of money is used to develop them.

From capability assessment point of view VE processes can be defined as own process cluster in existing reference model. In this enhancement the new processes have own practices, relationships to other processes and defined capability levels. On the other words in this assessment the focus would be to solve how capable company is to collect, analyze, develop and improve its value. In this study this possibility is examined further using BOOTSTRAP as a reference model.

3.3 Capability Assessment for VE Processes Using BOOTSTRAP

The BOOTSTRAP process model has three dimensions. The process dimension is called the BOOTSTRAP process model. The process dimension and capability dimension form together with the technology support dimension, the full BOOTSTRAP model [7].

In the VE enhanced BOOTSTRAP process model VE processes are included in the model as a new fourth dimension. This is seen justified because value analyzing and improving processes (VE processes) are independent combination with own methodological background. They are also directly related to all other processes and they do not seem to belong to existing process categories. They use own tools and the scope of VE study is also different basing on value.

However, because cost, worth, value and capability can be calculated to all processes in the enhanced process model it seems justified that VE processes can be included to process model. [11]. The enhanced BOOTSTRAP process model is shown in figure 4.

BOOTSTRAP assessment evaluates processes by measuring process capabilities. In the Bootstrap model process capability is the ability of each process to achieve its goals in the context of the assessed organization [7]. The enhanced BOOTSTRAP assessment evaluates capabilities also for VE processes. It includes also calculations for cost, worth and value for all processes (about value, cost & worth calculations see [11].). The enhanced method includes the same six levels as basic BOOTSTRAP method (these are compliant also with ISO 15504):

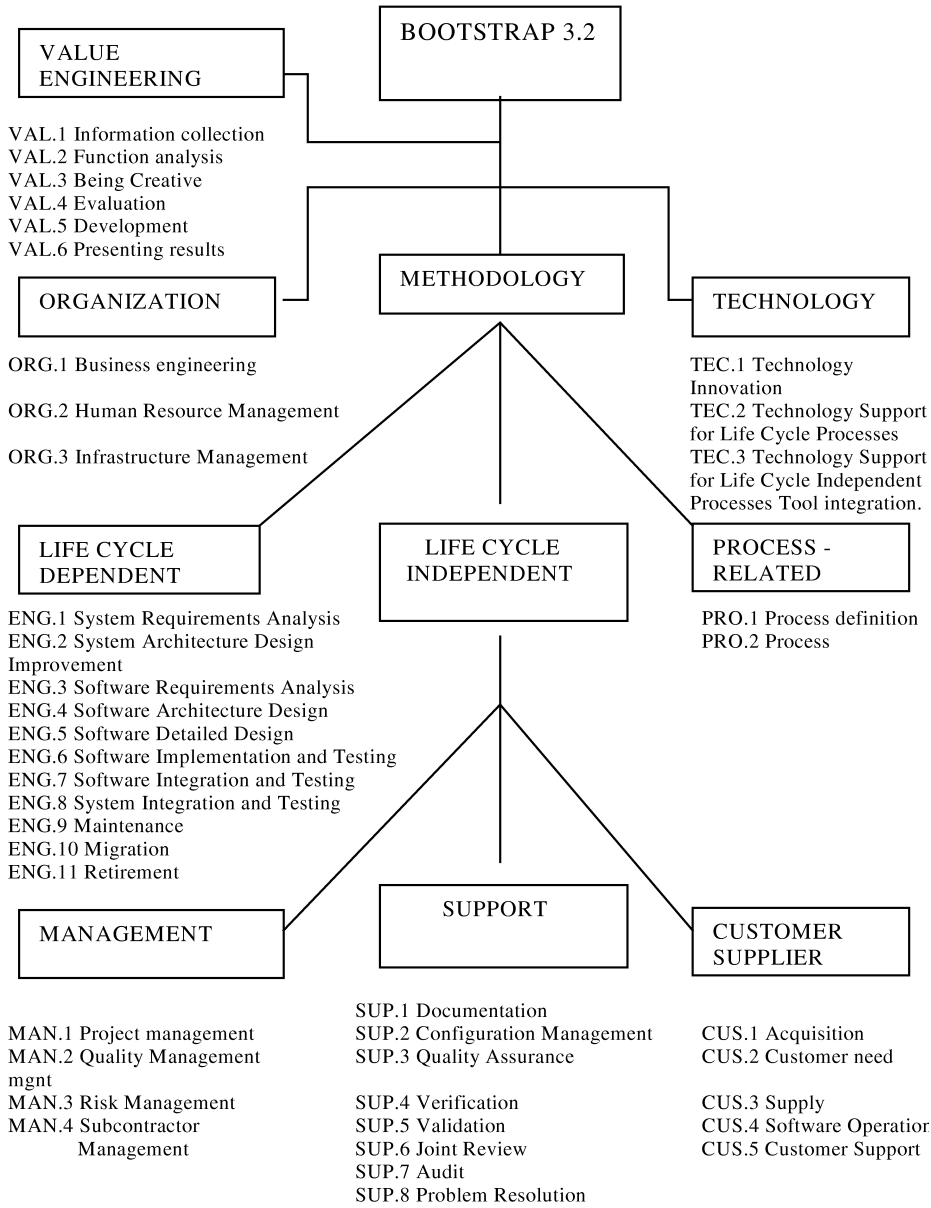

Fig. 4. The VE enhanced BOOTSTRAP process model

Level 0:	Incomplete process: The process does not fulfill its purpose.
Level 1:	Performed process: The implemented process achieves its defined purpose by utilizing a set of practices (base practices) that are initiated and followed and that produce identifiable work products.
Level 2:	Managed process: The performed process delivers work products of acceptable quality within defined time scales and resource needs.
Level 3:	Established process: The process is performed according to a standard process definition that has been suitably tailored to the needs of the process instance. The process is performed with qualified and available resources.
Level 4:	Predictable process: The execution of the established process is supported by process goals and measures which are used to ensure that the implementation of the process contributes to the achievement of the business goals.
Level 5:	Optimizing process: The predictable process optimizes its capability to meet current and future needs and achieves repeatability in meeting defined business goals.

In the VE enhanced assessment methodology the capability levels are divided into quartiles so that the evaluation can show how close or far the process is from the next level. The basic idea is to show and evaluate the processes by using the categorized six levels with the quartile prezision.

The final results of the enhanced assessment can be presented as a figure with quartile levels, or in the case of a SPICE rating with normal 0-5 level rating. As the assessment includes two levels, there are two figures. The SPU level presents results of organizational processes and the project level shows results of the individual projects.

The SPU level profile shows the capability of organizational processes and it reflects the management's point of view. The project level profile shows the process capability of the individual projects. Comparison between SPU and project profiles also provides valuable information to support improvement planning [7].

In the assessment process the assessors also collect information, which is not directly included in the rating. This information is used to explain the overall results with examples. Considering VE processes this information is mainly cost related information which is used later on for calculating cost, worth and value for processes and their basepractices and management practices [11].

3.4 Assessment Process

The enhanced assessment process is performed in four main phases: preparation, assessment execution, action plan derivation and making VE study (figure 4). The preparation phase has six (or seven) steps: [11]

1. Pre-assessment briefing
2. Initialization
3. Function analysis (in case of assessor is using value based focusing)
4. Assessment team identification
5. Collecting supporting material

6. Planning and scheduling
7. Defining confidentiality

The pre-assessment briefing justifies the importance of taking part in enhanced assessment. The new process developed also gives in this phase reasons why the VE process is taken along to the assessment work. Initialization concentrates on selecting project and processes to be assessed or decides that function analysis is used for value based focusing [11]. In the enhanced initialization phase the assessor can use the VE techniques to make a decision why some processes are more important to be assessed than others.

The assessment team identification selects the assessment team and interviewees. This step should evaluate also whether assessors are capable of taking responsibility of the VE parts of assessment or not. In many cases it would be worthwhile to use VE specialists or persons who know VE. Collecting supporting materials gives the possibility to see previous assessment results, quality manuals, etc. This step, in the enhanced assessment process also collects new information depending on which selection techniques are used in selecting processes or in focusing assessment work.

Planning and scheduling schedules time, makes resource definitions and interview planning as before. Defining the confidentiality agreement focuses on determining who is allowed to see the assessment and what kind of results. This phase does not change in the enhanced assessment process. In the company, SPU and project level confidentiality can differ. This should also include determination of the VE proposals confidentiality level.

If the company is interested in focusing BOOTSRAP assessment on areas where value creation is the biggest, the assessor could use value-based focusing. Value-based focusing can select the processes, which give the biggest value for the BOOTSTRAP assessment process. In the case of value-based focusing the VE function analysis is placed after the initialization phase, because focusing should be done before assessment team nomination [11].

The second phase focuses on executing the assessment process. It includes five steps: [11]

1. Opening briefing
2. SPU assessment
3. Project assessment
4. Evaluation
5. Feedback sessions

The purpose of the opening briefing is to make contact with people to be interviewed and explain them how the assessment will be done. If possible, in this step top-level management could show commitment to this assessment by taking a part in the briefing. SPU assessment includes manager interviews and evaluation of SPU documentation. Project assessment includes interviews and evaluation of practice capability evidence. In evaluation, assessors create preliminary assessment profiles and in feedback sessions, assessment findings are presented to interviewees, feedback is collected and errors are corrected. In this phase it is possible that an assessor uses VE techniques to get some tasks done more easily. For example creative techniques can be used in opening briefing to create an open atmosphere for assessing work.

The third phase, improvement planning and execution, focuses on documenting and presentation. It includes two different steps: [11]

1. Assessment report preparation
2. Final assessment report

The assessment report preparation is included in the enhanced assessment process, which mainly contains the facts of assessment results and calculated capability levels. Possible improvement actions are presented only after the fourth phase. In the final report all assessment results, strengths and weaknesses are documented.

The fourth phase, making the VE study, concentrates on finding out which functions or processes create the biggest value. In case of calculating values to the processes, VE functions are considered to be processes and secondary functions are considered to be practices (base-, or management practices). In case of calculating values also for product parts, VE functions are assigned to be product parts. For example, it is possible to calculate capabilities and values for VE enhanced BOOTSTRAP processes and their practices [11]. On the other hand, to get more product-related point of view it is also possible to calculate value for the product parts in question. In this case, improvement work has two dimensions, which are SW process improvement and product development.

Fourth phase includes all seven steps of the VE process [11]. It is only partially needed, if the assessment is based on value based focusing, where all process values are already calculated after the initialization phase. In this case the needed phases are the creative, evaluation, development and presentation phase [11].

1. Orientation
2. Information phase
3. Function analysis phase
4. Creative phase
5. Evaluation phase
6. Development phase
7. Presentation phase

Orientation is mainly needed for preparing the data file, determining evaluation factors and focusing the VE part of the study. In this step the assessor should build data models and determine team composition. Orientation can be considered as a pre-study.

During the information phase a data package is completed and the scope of the VE study is modified. The function analysis is the most important part of the VE process [3, 9]. It concentrates on: Identifying functions, Classifying functions, Developing function models, Establishing function worth, Costing functions, Establishing value index and Selecting functions for study.

In this study and in earlier research it has been shown to be possible to calculate values, worth and costs directly for processes [11]. From VE point of view, this shortens VE process, because there is necessarily no need to identify and classify functions and form a function model any more. Practically, in this case all functions have a correspondent process from the process model in question. More detailed cost, worth and value information can be calculated by defining secondary functions as certain base- or management practices [11].

The creative phase creates a quantity of ideas by function and evaluation phase ranks and rates alternative ideas and finally selects ideas for development. The development phase conducts benefit analysis, completes a technical data package, creates an implementation plan and prepares a final VE proposal for presentation. The development phase also prepares software process improvement plan. In this phase it would be recommended to take into account also the main findings of the rated processes and their capability levels reported in the phase final assessment report preparation. This should be done because, when company has a list of rated processes and their capability levels it would be worthwhile to compare this information to the VE proposals improvement activities, before giving presentation (about comparison see [11]).

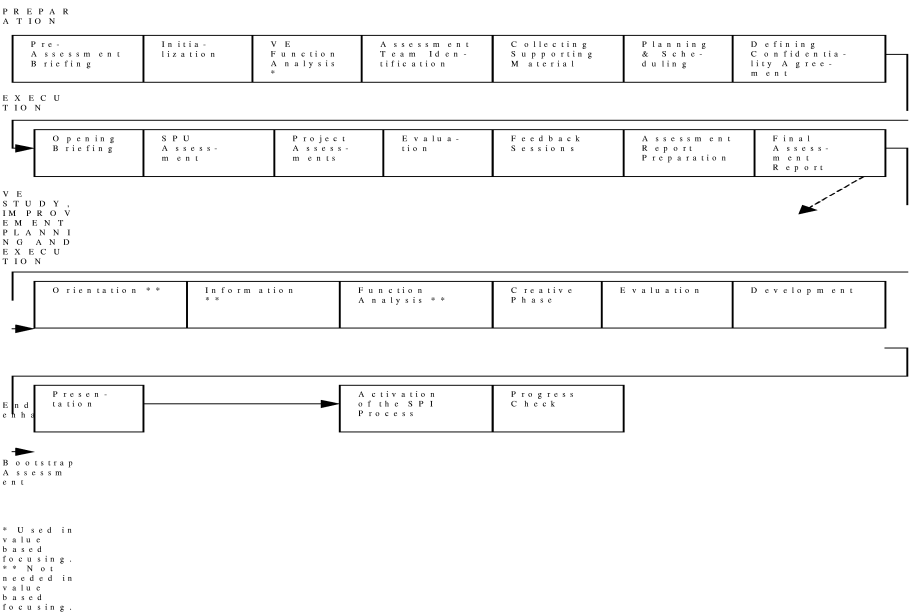

Fig. 5. The enhanced BOOTSTRAP assessment process

After the VE enhanced BOOTSTRAP assessment process all changes decided need to be completed and implemented. After changes it is also important to monitor the status of developed new situation. The VE enhanced BOOTSTRAP assessment process (as well as new process model), which includes some characteristics and techniques of VE, is the main idea and thrust of this article. The VE enhanced BOOTSTRAP assessment process with the new fourth phase is presented in the figure 4 (see also [11]).

4 First Assessment

The first assessment using enhanced BOOTSTRAP assessment method was done in summer 2003. It was a full assessment and it included capability level calculations for

all processes described in enhanced process model (figure 2). Cost, worth and value were calculated as an ad hoc basis for certain processes.

Experiences of the first assessment showed that the enhanced BOOTSTRAP assessment model works in practice. Capability levels can be calculated for VE processes as well as cost, worth and value to examined processes. However, in calculating cost, worth and value practical problems might arise if a company does not have sophisticated cost accounting systems, which can assign costs to processes and their practices.

In the final meeting a new enhancement opened up a many sided discussion. Managers vs. designers and technical vs. economical personnel seemed to find a topic which they all were able to discuss. This topic was value. They started to discuss process by process about their possibilities to create more value, cut costs and develop better worth to customer.

The enhanced BOOTSTRAP assessment model still needs more development work. The relationship between Value Engineering processes and existing BOOTSTRAP processes need more definition work as well as capability levels definition for new processes.

5 Conclusion

In broadest sense this article wanted to open up a discussion of concept of value for SPI. By calculating cost, worth and value for processes including their practices and finally, also to their improvements or improvement proposals, it is obvious that SPI has stronger value also for those who see that it is a waste of money or it has a little value. This is because by doing so it can clearly show in which areas the improvement efforts are worth doing.

The basic statement of this article claimed that capability and value are both as important in measuring and improving software processes. Therefore, combining capability assessment method and VE creates more efficient tools to everyday assessment and software process development work. As an example, this article presented how to combine typical capability based assessment method, like BOOTSTRAP, and VE.

Firstly, this article presented the basics of BOOTSTRAP assessment process, assessment types and VE process. The purpose of this was to reveal the possibilities to combine these different processes and methods, no matter whether they have the same kind of aims and characteristics or not. Both methodologies respected same basics. BOOTSTRAP respected companies' business goals and the VE process identified areas where unnecessary costs were possible to be removed while assuring that quality, reliability, capability, and other critical factors were met or exceeded the customer's expectations. So, basically VE respected the same basic idea of customer's expectations and satisfaction as BOOTSTRAP was doing, when it emphasized the company's business goals as an assessment's cornerstone.

Secondly, this article outlined VE enhanced assessment types, method and process. The capability based assessment types were seen possible to be used also in VE enhanced assessment. The VE enhanced assessment method was defined to include enhancements like 1) value assessment for products, 2) value assessment for processes without reference model, 3) combined capability and value assessment using reference

model and 4) capability assessment for enhanced process model including VE processes.

Thirdly, the fourth possibility was examined further and VE processes like information collection, function analysis, being creative, evaluation, development and presenting results were included to reference model. The capability scoring principles to VE enhanced assessment method were suggested to be same as they are in normal capability based assessment methods. The defined VE enhanced assessment process was tailored to include three parts: (1) preparation, (2) execution and (3) VE study, improvement planning and execution.

Fourthly, this article shortly presented the results of the first industrial assessment. According to this assessment, VE enhanced assessment method and process were seen usable and worth for further development.

Further writings in this area should present more empirical evidence of industrial assessments and a discussion about advantages and disadvantages of suggested VE enhanced assessment process and method. Practically, it would be interesting to combine this enhanced idea of assessment also to other capability based assessment methods like CMM, CMMi or SPICE. More research should be made also in evaluating VE techniques and selecting the most suitable ones to enhanced assessment work.

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