



VALUE ENGINEERING IN CONSTRUCTION BUSINESS IN SRI LANKA

BY

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Abstract

Value Engineering concepts have been in the Sri Lankan construction industry for many years even though it has not been practiced effectively. The industry practitioners still rely on these concepts mainly in situations when their project cost exceeds the budget. Therefore, it has been more popular as a cost-cutting tool rather than a vital concept for value improvements.

Related literature however, reveals that Value Engineering (VE) concepts are very popular in other countries and are being used frequently in construction business to achieve improvements in value. Previous researchers have revealed that absence of a proper VE procedure is one of the main constraints for an effective VE practice in the Sri Lankan construction industry.

This study attempts to derive a procedure for establishing an effective VE practice for the Sri Lankan construction business. As a result, VE methodology and guideline / workbook were developed. Various VE manuals and guidelines that are being used in other countries were analyzed in order to determine a tailor-made VE methodology for the country.

The survey results revealed that people's awareness of VE methodology in these construction companies is not very satisfactory. However they are in favour of having a proper VE methodology and a guideline for a better practice in future. The ICTAD's latest move to include VE clauses into the 'Standard Bidding Document' were highlighted as clear indication of the future prospects for VE.

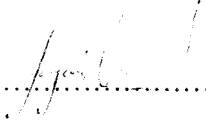
The methodology and the guideline / workbook developed has however, not been field tested. Therefore, another industrial survey consisting of presentations and discussions need to be carried out to find out, if any changes are needed for improvement. The ICTAD could be of help for further improvement of this



methodology and guideline in the aim of creating a standard VE methodology for the construction industry in the country.

DECLARATION

“I hereby declare that the work included in this dissertation as part or as whole, has not been submitted for any other academic qualification at any other university or institute. The material included in this document contains the findings of researcher and elsewhere abstracted of previous publications where references are provided accordingly.”

W.M.J. Wilegoda 

23rd January 2009

Approved By .. ***UOM Verified Signature***

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ABBREVIATIONS

BPR	-	Business Process Re –engineering
BPVE	-	Business process Value Engineering
CBA	-	Costing, Choosing by Advantages
DFAS	-	Defense Finance and Accounting Service
FAST	-	Functional Analysis System Technique
FMEA	-	Failure Measurement Error Analysis
GE	-	General Electric
ICTAD	-	Institute of Construction Training and Development
IDA	-	Institute of Defense Analysis
INVEST	-	Indian Value Engineering Society
IT	-	Information Technology
NCASL	-	National Contractors Association of Sri Lanka
O & S	-	Operation and Support
QA	-	Quality Assurance
SAVE	-	Society of American Value Engineering
SBD	-	Standard Bidding Document
SOJVE	-	Society of Japanese Value Engineering
SWOT	-	Strength, Weaknesses, Opportunities and Threats
UDOT	-	Utah Department of Transportation
US	-	United States
USA	-	United States of America
VA	-	Value Analysis
VE	-	Value Engineering
VECP	-	Value Engineering Change Proposal
VM	-	Value Management
VP	-	Value Planning

1.0 INTRODUCTION

1.1 BACKGROUND

In today's context construction is one of the highly competitive and high-risk business in Sri Lanka and in most other countries. Any significant change in global and or national economy can directly influence the construction sector due to its significant contribution to the national economy. Prevailing global economic turmoil have influenced many industries around the world and construction industry of Sri Lanka have also been affected. According to an industry analyst, other than the above reason "shortage of new jobs, soaring prices of constructional raw materials, the security situation in the country and high interest rates have all contributed to the situation" (Sakalasooriya, 2007) in Sri Lanka.

"The construction boom which started during the year 2004 is destined to come to a juncture by now as the Tsunami re-construction work is being almost completed. Hence this slowing down in the industry is expected and it is quite natural" (Sakalasooriya, 2007). As a result new opportunities in the market are comparatively less and this situation leads to severe competition among the construction companies in obtaining new jobs.



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According to the Institute for Construction Training and Development (ICTAD), there are over 10,000 registered construction companies in the country for various construction disciplines. These companies are being graded under various classifications based on their expertise, capabilities and financial strengths. Companies within a particular grade have to compete with the other members of the same grade and at times with lower grades to obtain new jobs. Industry inherent common and typical strategies that have been adapted by most of the companies have made 'winning of a new job' more difficult through competition.

The 'design-bid & build' system has become the most popular project delivery method in the country among other methods such as 'design & build' and 'turn-key' methods. In this common method, it employs design consultants or such organizations to do the designs. Thereafter construction companies participate in a competitive bidding process to assess their

chances for securing a new job. Competitive bidding therefore has become more attractive in the construction industry.

The objective of most competitive bidding models is to find the optimum mark-up to maximize the expected profit of the company. However, the bidding success mostly depends on company's long-term interactions with the market, and strengths & weaknesses of its competitors. Also "the research results have shown how difficult it for any company to acquire a long-term competitive advantage by means of only the bidding & marketing strategies in a competitive environment" (Kim, Jin, Reinschmidt & Kenneth, 2006)

Therefore, it is evident that the traditional methods and strategies that are being adapted by these companies to survive and maintain the competitiveness would not be effective in the long- run. Because, new challenges that emerge day by day make these existing strategies less powerful to remain in business. Therefore, construction companies need to explore and derive strategically important and innovative systems and approaches that would guarantee the long-term competitiveness.



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"Innovation, quality, efficiency and catering to the clients requirements would be the most attractive aspects that would need much attention with regards to the long-term competitiveness of construction companies" (Lemos, Almeida, Betts & Eaton, 2003). Hence, exploring of new concepts and philosophies that can improve the existing systems and processes of companies is very vital for business success.

In addition, it has also been found that, business success is also achievable through the improvement initiatives and development of intangible assets such as people and reputation in addition to other accepted norms. Even the long standing and established organizations need constant improvement if they are to survive in this fast changing, fiercely competitive global economy. Therefore, concepts or philosophies that focus on innovation, quality improvements, customer care and cost effectiveness need to be recognized in time for business success.

Therefore, Value Engineering would be a better concept in construction business, due to the fact that its capability in focusing all the above highlighted aspects. . “With the rapid growth of competition and shrinking product life cycle, value engineering has become an essential tool for attaining the competitive advantage” (Kumar, Singh & Jha 2005).

Evidence for use of Value Engineering (VE) in Business

Value Engineering concepts have been widely using by various businesses globally as a very effective management tool to achieve business objectives. According to the Society of American Value Engineers (SAVE) International, “VE services return a saving of thirty percent of the estimated cost for constructing a project or providing a service”.

In addition, Younker (2003) in his book has identified various US Government departments that use VE practices frequently. According to him, the US agencies for Environmental Protection, Department of Transportation, Federal Highway Administration, Department of Energy, Department of Defence, Bureau of Prison, Corp of Engineers, Navy Facilities Engineering and the City and Country Governments are the frequent users who encourage the use of VE in their contracts with contractors.



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Male, Kelly, Gronqvist & Graham (2005) has highlighted that “some early adopter countries in the field of manufacturing such as Japan and Korea have taken forward a franchised version of VE/VM (Value Management) from US methodology, while other countries took up the methodology and subsequently blended it into their national markets and cultures”.

The Indian Value Engineering Society (INVEST) consider “VE as one of the time tested and most powerful technique towards cost competitiveness in business”.

In their research report, Cheah & Seng (2005) has highlighted that, “there is a strong belief that future prospects of VE in the Southeast Asian construction industry are positive, even though there are a number of impediments still standing in the way”.

“VA/VE was introduced to Mainland China later than Taiwan, but the achievements in Mainland China are more exceptional than Taiwan. VA/VE had been introduced to Taiwan 30 years back, and is popularly utilized in the Construction Industry and the Construction Engineering of the Government” (Chin-Wen, 2001).

Through, the literature survey, it was found that VE is a well spread concept that gives very positive inputs for any kind of business anywhere in the world and the extent of uses however are varying from country to country due to many reasons.

Sri Lankan VE practice

In 1998, in his research report Karunaseelan has revealed that Value Analysis (VA) has not been very popular among the industry due to the reasons such as restricted time, conflict of interests and unavailability of cost data.

After that, in year 2003, Perera, Karunasena & Selvadurai have highlighted that “compared to the other countries; the application of Value Management (VM) by the Sri Lankan construction companies is relatively new”. Here the term VM covers the whole range of value techniques available such as Value Planning (VP), Value Engineering (VE) and Value Analysis (VA).

In their report, Perera, Karunasena & Selvadurai (2003) have also revealed, that “there was very little evidence on application of VM in the construction industry of Sri Lanka”. Various reasons for such low level of application have also been disclosed. Other than that, number of main constraints in application of VM in the construction industry was identified. However, out of all constraints that were identified, following two can be taken as the most important for better VE practice in the future.

- Unavailability of standard procedure for VM process in Sri Lanka
- The absence of active encouragement by the construction industry regulatory body of Sri Lanka, that is Institute for Construction Training and Development (ICTAD) to practice VM in construction.

Comparison of Global and Sri Lankan VE practice

As discussed above, the concept of VE are being used in number of other countries in various industries including the construction industry. Various VE applications in different industries are discussed in more detail in Chapter – 2. However, as discussed above, previous researches have highlighted that the VE practice of Sri Lanka has not yet matured and as a result, it has not been very popular in the construction industry. This comparison therefore reveals the existence of VE practice gap when compared to that of other countries.

1.2 THE RESEARCH PROBLEM

The reasons for such low level of VE practice in the Sri Lankan construction industry have been revealed by previous researches. Therefore, now it is required to find answer to the important question of “What should be done to establish an effective VE practice among the Sri Lankan construction companies for enabling them to improve their various business processes and practices to gain the competitive advantage?”.

1.3 RESEARCH OBJECTIVES

Main objectives of my research are,

- 1) To develop a methodology for application of Value Engineering for the Sri Lankan construction companies.
- 2) To develop a Value Engineering guideline / workbook for the Sri Lankan construction companies.

1.4 SIGNIFICANCE OF THE STUDY

As elaborated in section 1.1 of this chapter, researchers have found that “absence of active encouragement by the construction industry regulatory body of Sri Lanka (ICTAD) to use VM in construction” as one of the constraints for proper and effective VE practice in the Sri Lankan construction industry.

However, as a means of overcoming this problem the ICTAD have now recognized the importance of including VE concepts into the construction business. As a result, ICTAD has revised the Standard Bidding Document [SBD/2 – Major Works/2007] to include, required

contractual provisions in contracts. This latest contractual provisions provide the facility of proposing effective VE solutions for the projects, components, equipments, systems and procedures which may not be the best in terms of functionality, value, cost, quality, safety and other subjective criteria of the project. Therefore, construction companies need to look at this new development as a good opportunity opened for them to gain competitive advantage in the market.

The benefits and improvements that the construction companies can gain by having an effective VE programme could be enormous. The value improvements or less-cost solutions would be very attractive to most of the clients who are undecided in the present volatile and uncertain economic situation. As a result, construction companies would be able to gain the long-term competitive advantage that is essential in the challenging business environment.

1.5 METHODOLOGY

For the attainment of the research objectives, following methodologies were selected.

A detailed literature review was carried out to understand the concept and principles of VE and its various applications in different industries and businesses. In addition, various past VE applications and potential new areas in construction business were identified.

An industry survey was carried out to evaluate the level of VE awareness of construction companies in the country. Awareness in terms of VE concept, various benefits and correct methodologies were tested. The intention of this evaluation was to identify the best industry inputs for the development of a tailor-made VE methodology and the guideline for the Sri Lankan construction companies.

In addition to that, for developing a tailor-made VE methodology and a guideline / workbook for Sri Lankan construction companies, various VE manuals and handbooks were studied and analysed in more detail. Proposed workbook would provide a step-by-step approach for a correct VE practice for the construction companies.

1.6 LIMITATION OF THE RESEARCH

Initially, it was intended to interview as many as 18 companies representing the three top most categories (M1, M2 & M3) of the country. In addition, the study was limited to only for companies, which have been registered under the buildings category to manage the research scope within the fixed time frame.

According to ICTAD contractors' registry, there are seventy-five companies in M1, M2 & M3 grades. Therefore, targeted 18 companies were considered as a proper sample for the study. However, the number of interviews was limited to twelve companies due to unavoidable circumstances such as time restrictions, busy schedules of the targeted company representatives and logistic difficulties in arranging interviews.

Furthermore, rejection or avoiding of discussions by the representatives in higher-grade non-prominent companies due to unfamiliarity and lack of interest in the subject area was also a reason to limit the number of interviews. Four of such companies commented that they do not practice VE in their jobs.



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The selection of only the top three categories of companies can be justified by the fact that they are the companies that have the capability of investing on such practice in the country. Other than that, it is a known fact that, only these companies possess the required human skills that need for a VE practice.

1.7 RESEARCH FINDINGS

The related literature and previous research studies have elaborated on the value improvement and other benefits that any business can derive from a better VE practice. Improvement in quality, communication, efficiency, productivity, standards and specification were found as the other important aspect that companies could expect from VE, in addition to the value improvement. Furthermore, various potential areas that construction companies can employ VE for value improvements, such as internal production lines, maintenance areas, procurement & logistics and operational areas were also identified.

Various tools and techniques that are used in each phase of the VE methodology and number of custom-made formats and matrixes developed by different practitioners were identified.

The industry survey results also confirmed the facts revealed by previous researchers that, 'VE practice of Sri Lankan construction companies is in a low level'. In addition, the results also show that, big and reputed companies use VE concepts in difficult situations to find solutions on ad-hoc basis. However, none of these companies has a well-established VE practice, which has a proper VE methodology or guideline. The survey further revealed that, professionals of these companies normally determine the methodology that company should adapt in ad-hoc VE applications. The risk here is that, such practice and VE methodology would end when that particular person left the company. In addition, 62.5% of the responded companies appreciated the availability of a proper VE methodology and guideline for them to establish a proper practice in the future.

1.8 ORGANIZATION OF THE REPORT

Most of the literature as well as previous researchers have emphasized on significant benefits that can be achieved through application of VE in business. The focus of this study is to see how VE could be effectively applied in construction companies. This study primarily analysed various VE manuals and guidelines that successfully guide the practice today in other countries. The aim of this analysis is to develop a tailor-made VE methodology and a VE guideline / workbook for construction companies in the country.

Chapter 1; of the report has discussed areas such as the significance of VE in business, extent of VE practice in Sri Lankan and other countries, research problem, research objectives and the methodology adapted in the study. In addition, the significance of the study and the limitations of the research were also discussed.

Chapter 2; the concept of VE, its expansion around the world, benefits of VE practice for construction companies, examples of VE practice in both construction & other industries and other potential areas of VE application in construction business were discussed.

Chapter 3; would discuss the methodology adapted for the study in detail. In addition to that, it discusses the results of the industry survey carried out for determining the attitudes, awareness and knowledge of VE of the people and management of construction companies. Other than that, this chapter analysed the survey results, which were meant for the determination of requirement of tailor-made VE methodology and a guideline / workbook for construction companies.

Chapter 4; discussed and analysed various generic and custom-made VE job-plans and methodologies in the world in relation to their various phases, scope, common activities, tools and techniques in determining a tailor-made VE methodology for Sri Lankan construction companies.

The availability of VE methodology itself will not make any sense, unless it is properly integrated into the existing business practices of the company. Therefore, Chapter 5; discussed ways of integrating VE into existing business by considering it as an ‘enterprise change model’.

Chapter 6; was for the conclusion and recommendation of the research.



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Appendix - A, proposed VE guideline / workbook developed for the Sri Lankan construction companies for effective and efficient application of VE in business.

Appendix – B, Analysis of survey results

2.0 HISTORY, EXPANSION AND APPLICATIONS OF VE

2.1 WHAT IS VALUE ENGINEERING?

“Value Engineering (VE) is an organized effort directed at analysing the function of goods and services for the purposes of achieving basic functions at the lowest overall cost, consistent with achieving essential characteristics” (Younker 2003).

This is further elaborated in VE handbook of the Institute for Defence Analyses of the United States of America as VE; “VE is an organized / systematic approach directed at analyzing the function of systems, equipments, facilities, services, and supplies for the purpose of achieving their essential functions at the lowest life-cycle cost consistent with required performance, reliability, quality and safety”. Also, VE is performed to eliminate or modify elements which contribute to the overall project cost without adding any value to the overall project performance and quality.

2.2 INVENTION OF VE CONCEPTS

During the World War II, shortage in material made manufacturers to look for alternative materials and designs, which provided equal or better functional performance without any quality compromises. Lawrence D. Miles, an engineer of General Electric (GE) started to look for solutions for the materials shortage problems encountered by the GE. As a result, Miles and the team focused on functions that a product was meant to perform and experimented with alternatives to achieve the same functions without compromising in quality. “Originally, their main emphasis was not to reduce the cost, but to improve the value without sacrificing the intended function or the purpose”. (Charles & Seng, 2005)

2.3 IMPORTANCE OF VE CONCEPTS

By definition and nature, VE is far more than a measure of simply reducing existing cost. VE is a tool whose strength lies in the ability to clearly delineate design alternatives and to suggest choices based on the necessity and desirability of the function. “In its application, it also considers economic means of achieving the functions and also looking at the cost-worth relationship that assure growth and prosperity” (WVDOH, 2004).

“Value Engineering is a procedure enabling one to exercise underutilized human creative potentials to solve problems. This is accomplished through adherence to a sequence of steps known as Value Engineering Job Plan” (WVDOH, 2004).

According to Younker (2003) “VE methodology consists of a well-structured job plan technique, which helps in providing assessment and evaluation of the product, process, system and service”. The job plan basically divide specific problem or subject tasks into functions and then provide adequate time periods to come up with essential creative works or solutions. This job plan helps to establish an effective programme, aiming at the selection of best alternatives which gives the highest value to the product, process, system and service.

The VE methodology has also been strengthened by various other key concepts and techniques, further to the well-structured job plan technique. “The Functional Analysis System Technique (FAST) is the other commonly used tool in VE” (Charles & Seng, 2005). It is believed that VE could function as an indirect tool to pursue other objectives of the firm and organization as well. VE can be used for promoting inter-disciplinary teamwork, nurturing an innovative culture within an organization, or even serving as a marketing tool.

The FAST diagram can also be used as an effective communication tool because it facilitates discussions among the VE team members. In addition, forming of VE teams and then coordinating such teams become very essential in VE methodology and this creates the requirement of having a good leadership. This leadership leads to improve the ability of trust building and conflict resolution within the organization.

“The VE is a function-oriented systematic team approach that can provide more value for a program, process, product service, system or technique” (Younker 2003). Therefore, “this methodology has the ability to solve problems, reduce cost, increase profits, improve quality, expand market share and finally improve the performance to increase customer satisfaction” (www.pkcoe.com, 2007).

2.4 VARIOUS VE APPLICATIONS IN BUSINESS

Reference to the Value Standard and Body of Knowledge of SAVE International (2007), value methodology where value engineering is a component, can be applied to various areas and disciplines of an organization. Accordingly, VE has been recognized as a 'problem solver; in many of the processes in numerous businesses and industries.

Following are the different areas or processes of VE applications as identified by SAVE International (2007),

A). Construction projects - could benefit by identifying improvements in any of its various phases such as concept development, preliminary design, final design, procurement and construction.

B). Manufactured products - whether consumer or industrial products, they may be studied with a focus on either the design or manufacturing process of that product. A product may be the subject of value engineering at any time during the product's life. Value engineering can be applied at the onset of the product development to better understand the customer's needs, identify the functions necessary to satisfy those needs and then to develop the initial concept for value improvement. Throughout the design development, value methodology can be used to refine and enhance the concept, based on the latest facts. Even after a product has been introduced and is in production process, value engineering can still be used to further enhance the product and respond to changing customer requirements and economic conditions.

In addition, VE methodology can be used to either develop new ways to manufacture a product or change an existing process.

C) Business systems and processes – these may also be the subject of value engineering. Many elements of a business or an organization may be improved through the application of a value methodology. This may be from the development of business plans and organizational studies in improving existing business processes.

D). Service organizations - can benefit from the use of value methodologies. In the past value methodologies have been used to improve processes and procedures in the medical industry (operating rooms, emergency rooms, etc.) and the legal system (police systems).

Value Standard and Body of Knowledge of SAVE International (2007) also highlighted that value methodology can be used as a quick response study to address a problem or as an integral part of an overall organizational effort to stimulate innovation and improve performance. Value methodologies may be used to enhance an organization's quality programs, new product development activities, manufacturing processes, and architectural and engineering design as well.

2.5 SUCCESS STORIES OF VE APPLICATION IN VARIOUS BUSINESS / PROCESSES

Success stories of value engineering in various types of businesses can be seen the world over. Initially it has been more popular in the manufacturing industries, but with the effective results of application in other industries the popularity expanded. Following are some of the success stories that were extracted from the "Value Engineering Handbook of the Institute of Defense Analysis" (2006).

2.5.1 Examples of VE for Product Development

1) Battery Elimination On-line Device in US Army

Expendable, risk-prone and difficult to dispose type of batteries were used in power training devices at the National Training Center and the Joint Readiness Training Center in US Defense. VE was used to develop the Battery Elimination On-line Device, which provides non-interrupted power with a life expectancy of 20 years. Elimination of stock and disposal of batteries were expected to save \$9.8 million over just 3 years; lifetime savings will be proportionally higher.

2) Machine Gun Barrel for US Air force

The M134 Mini-gun was an air-cooled, six-barrel Gatling gun capable of firing 3,000 rounds of 7.62mm ammunition per minute. Originally M134 barrels have been replaced after each 100,000 rounds fired and typically still have significant life remaining. VE was used to identify an alternative process. A barrel wear/erosion gauge was identified in assessing remaining barrel life safely, accurately and inexpensively. This gauge was expected to extend the life of a

barrel past the 100,000-round interval and generated an estimated annual acquisition savings of \$462,000.

2.5.2 Examples of VE for Product Maintenance

1) UH-60 Tail Rotor Blades for US Army

Fifty-seven new UH-60 tail rotor blades were scheduled for purchase to replace units deemed irreparable because of trailing edge bond separation. VE was used to initiate action to analyze and inspect the units deemed irreparable to determine possibility for repairing. As a result, engineers designed a repair tooling and developed technical data in the form of a Maintenance Engineering Order, authorizing repair of trailing edge bond separation. All assets classified as repairable were then sent to the Defense Logistics Agency for induction on current repair lines. Total savings was estimated to be \$6 million.

2.5.3 Example of VE for Process Improvements

1) Demilitarization

The US Army had used VE to develop a less expensive means of destroying an estimated 600,000 tons of captured enemy ammunition in Iraq. As a result, M42/M46/M67 sub munitions obtained from munitions in the Resource Recovery and Disposition Account were defused and repackaged for use in lieu of Comp C4 blocks to initiate the open detonation of the captured enemy ammunition. Savings were estimated to be \$2.7 million, not including the additional benefit of reducing demilitarization inventory in the continental United States.

2.5.4 Example of VE for Procurement Improvements

1) Circuit Card Assembly

Defence Logistic Agency of US has found that a critical application card assembled with only one approved manufacturer appeared to be overpriced. As a result of VE, additional companies with the same manufacturing capabilities and a willingness to fabricate the assembly were identified. An engineer worked with a new source to compile a technical data package for

engineering support activity evaluation. After final approval of the new source, procurement costs were reduced by \$300,000.

2.5.5 VE for Internal System Improvements

1) Electronic File Room

VE was used to reduce storage costs and to improve the response time on customer requests for Defense Finance and Accounting Service (DFAS). The project converted contractual documents to indexed electronic images, thereby eliminating the cost of maintaining of a file room to store and retrieve documents. It allowed DFAS to vacate a 58,000-square-foot file room and reduce the staff from 21 to 2. It also reduced the turnaround time for fulfilling a contractual request from 24 hours to nearly instantaneous. Net savings were approximately \$3.3 million.

2) Audit Command Language

DFAS-Columbus had been using a manual examination process for commercial payment vouchers for defense agencies, the Army, and the Marine Corps. VE was used to formulate a project to automate the process by designing edit scripts that matches the data with other systems, ensuring the use of legal and regulatory data elements, and validate “voucher-to-system” information. It was the first time that the off-the-shelf software program (Audit Command Language) was adapted to this problem. Net first year savings exceeded \$376,000.

2.6 VE IN CONSTRUCTION BUSINESS

VE within construction was pioneered by Alphonse Dell’ Isola in the 1960s. He focused on the same goals as Miles in developing value analysis process for construction. Dell’ Isola identifies “improving project value” as the main objective of VE. “In addition to improving project value, he states that the project team should utilize VE to overcome poor project value and quality standards” (Moser 2004).

Moser has also pointed out that, with the use of VE it is possible to overcome the following problems that are common in the construction industry.

- 1) Lack of shared project information - insufficient data on the function of stakeholder requirements. This includes building materials and processes.
- 2) Lack of ideas, or failure to develop alternative solutions and then making choices based on economics and performance.
- 3) Temporary circumstances - urgent delivery, design, or schedule circumstances can force decisions that, while quick, are often incomplete without regard to value.
- 4) Honest but wrong beliefs - decisions based on what is believed to be correct rather than on facts.
- 5) Habits and attitudes - response in doing the same thing, the same way, under the same circumstances.
- 6) Changes in stakeholder requirements - new requirements may cause costs to increase without awareness.
- 7) Lack of communication and coordination - issues of communication and coordination has been determined to be reasons for unnecessary costs.
- 8) Outdated standards and specifications - VE helps to isolate and to focus new technologies and standards in areas where high costs with poor value may incur based on wrong or legacy information.

(Moser 2004)



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From the qualitative perspective, VE creates opportunities for construction firms to achieve long-term benefits in,

- Cost reduction
- Improvement in communications
- Improvement in procedures
- Waste reduction
- Performance improvement
- Improved efficiency
- Reliability
- Productivity & quality
- Effectiveness & Readiness
- Business capabilities and cycle time and so on. (IDA, 2006)

In addition to the above, from a contractor's perspective, following benefits can also be achieved through an effective VE practice,

- a) Share the savings by means of making profits that the client may get from a successful application of VE. This is normally called Value Engineering Change Proposals (VECP)
- b) May increase the work to be performed on the contract due to the savings received from VE.
- c) Establish a reputation as a cost-conscious contractor or solution provider.
- d) Obtain usable technology for other projects.
- e) Enhancing the retention and growth of corporate technical expertise through advanced technology insertion and thereby creating a positive working environment within the organization.

2.7 POTENTIAL VE APPLICATION AREAS FOR CONSTRUCTION COMPANIES

To achieve business success and gaining of the benefits discussed, construction companies need to establish a proper in-house VE practice. Having established, such a VE practice, these companies would be able to look for potential VE application areas in their projects. Value Engineering Handbook of the Institute of Defense Analysis (2006) have highlighted that due to following reasons VE application in construction business is highly potential,

- Due to advancement of technology, materials and processes, the specifications used in the industry might have been already outdated. Therefore, updated contractors may have a better chance for going for updated and advance systems, products and materials that can attract the consultants and clients in the industry.
- When designers go for "old & reliable" components or sub systems in new project designs due to very limited time frame, a modern, less expensive and more reliable alternatives may have been developed and proven since the original system development. When this situation arises, submission of a VECP to incorporate the improved items or subsystems can be considered.

- Diminishing manufacturing sources and material shortages automatically arouse the look-out for alternative solutions.
- Typical opportunities for VE projects will be derived from a known problem, a cost driver study, or anything that indicates a product or a process improvement would motivate the use of VE.

In the construction industry, the VE approach of a company can vary due to the variation of procurement systems used in contracts. For example, companies that involve with 'design & build or turn-key' projects can start the VE practice from the design stage and continue up to the completion. The companies that only get jobs through competitive bidding would normally have the option of value engineering change proposal (VECP) approach during the project implementation stage.

With the effective use of value engineering methodologies, construction companies can improve the value of all the internal systems, procedures and processes as well. Such improvements would lead to potential cost savings in each of the element and this will help them to reduce the total production and operation cost. As a result construction companies would be able to gain the competitive advantage in the market.

"Numerous opportunities are frequently available for VE to offer substantial benefits such as eliminating high cost drivers,; improving performance, reliability, or reducibility; or resolving executive management interest issues" (Contractor's Guide to Value Engineering: Office of Defense Systems, 2006)

Contractor's Guide to Value Engineering: Office of Defense Systems have listed potential areas for VE applications in any aspect of a contract or program. General listings of these aspects are as follows:

- a) Construction
- b) Design or equipment modifications
- c) Equipment and logistics support

- d) Facilities and hardware
- e) Manufacturing processes
- f) Materiel handling and transportation
- g) Packaging/packing and preservation
- h) Procurement and re-procurement
- i) Publications, manuals, procedures, and reports
- j) Quality assurance and reliability
- k) Parts obsolescence
- l) Salvage, rejected, or excess material
- m) Site preparation and adaptation
- n) Software (computer) programs and flow charts
- o) Software architecture development
- p) Specifications/drawings
- q) Technical and logistics data
- r) Testing, test equipment, and procedures
- s) Tooling
- t) Training



Adaptation of a VE program by construction companies on above aspects would guarantee the improvements of capabilities in the construction companies and finally the industry in the long-run.

2.7.1 VE Change Proposals

During the project implementation stage, construction firms can propose alternative products or designs to attain the originally intended functional requirements. In this context, companies can constructively challenge the stated needs and recommend alternatives within a lesser cost. With these proposals the company can make changes in the contract plans and specifications that may reduce the project cost, increase cost effectiveness or significantly improve project quality without degrading performance, maintainability, or safety. The prerequisite for this is to have the required contractual provision incorporated to the contract. Any proposal submitted under

such clauses that reduce the project cost without changing the work substantially which is new to the contract documents should be considered as a VECP.

2.7.2 VE during Production

Other than the construction output, VE can be applied for any production processes undertaken by the construction companies. There may be various items, building materials or components that are manufactured directly by the company. Hence, VE can be easily used for value improvements of such productions. “VE has been extensively applied to evaluate and improve manufacturing processes, methods, and materials. These include support equipment, technical data and facilities as well as the supply, transportation and handling, maintenance and training functions” (IDA, 2006).

2.7.3 VE for Operation and Support

VE can be applied to provide a satisfactory operational requirement and sustainment needs in a most cost-effective manner during the operation and support (O&S) phase as well. . For this purpose, data can be collected and analyzed to determine the root cause of any problem encountered. Correct functional analysis gives the result of best corrective actions taken by the companies.



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In this phase, VE studies will help to make decisions on modifications, upgrades, and future increments of the existing systems and machineries etc. “Interoperability or technology improvements, parts or manufacturing obsolescence, aging issues, premature failures, changes in fuel or lubricants, joint or service commonality, and so on may all indicate the need for system upgrade” (IDA, 2006). The cost involvement for these changes might be justified based on the potential savings from operation, maintenance and related other logistic functions. Also according to the Value Engineering Handbook of the Institute of Defense Analysis (2006) VE can be used to formulate initiatives such as,

- a) Extend item life by applying state-of-the-art designs, materials or processes.
- b) Reduce repair costs by achieving the repair function in a more economical manner.
- c) Reduce packaging costs by improving packaging procedures or materials.
- d) Remanufacture and replace legacy systems.

- e) Improve reliability and maintainability.
- f) Use commercial processes, technologies, and commercial off-the-shelf items to reduce cost and improve reliability.
- g) Replace aging engines and engine parts.
- h) Improve supply-chain response time and reduce logistics footprint using Direct Vendor Delivery, Commercial Maintenance Agreements, and Virtual Prime Vendor support.
- i) Initiate reliability-centered maintenance and condition-based maintenance to reduce preventive maintenance costs without affecting corrective maintenance needs.
- j) Reduce the number of people required to operate and maintain by improving usability and maintainability.
- k) Eliminate sole-source procurement.



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3.0 RESEARCH METHODOLOGY & ANALYSIS OF RESEARCH DATA

3.1 RESEARCH METHODOLOGY

For the attainment of the research objectives, following methodologies were selected.

- A detailed literature review was carried out to understand the concept and principles of VE and its various applications in different industries and businesses. In addition, various VE application areas and potential new areas in construction business were identified.

- In the aim of developing a tailor-made VE methodology and a guideline / workbook for Sri Lankan construction companies, following VE manuals and handbooks were studied and analysed in more detail. This proposed workbook would provide a step-by-step approach for a correct VE practice for construction companies.
 - Value Standard and Body of Knowledge (2007) of Society of American Value Engineers (SAVE International)
 - Guidebook for VE Activities - Society of Japanese Value Engineering (1981-English version)
 - Value Engineering handbook (2006), of Institute of Defence Analysis of United States of America
 - Value Engineering Manual of Instruction (1998) of Utah Department of Transportation of United States of America

Under this study VE phase structure of each methodology, scope, objective and expected outcome of each phase of these methodologies were thoroughly analyzed.

- An industry survey was carried out,
 - To evaluate the level of VE awareness of construction companies in the country. Awareness in terms of VE concept, various benefits and correct

methodologies were tested. The intention of this evaluation was to identify the best industry inputs for the development of a tailor-made VE methodology and the guideline for the Sri Lankan construction companies.

- To measure the desire levels of construction companies for having a proper VE methodology and a guideline for better VE practice in the future. The purpose of this measure was to justify the significance of this research study.
- To study and analyse of any existing VE methodologies that construction companies use in their ad-hoc VE practices. The purpose of this analysis was to identify various methods, tools & techniques that these companies are using in their VE studies in the aim of incorporating them into the new methodology as appropriate.

For the data collection, construction companies registered under ICTAD grades M1, M2 & M3 of the building category were selected. Department heads and / or senior positions of both estimation and construction departments were interviewed along with project managers. Companies for the interviews were randomly selected.

Both semi-structured direct interviews and telephone conversations were carried out for the data collection. Interview questions were designed to collect the data and information that were expected from the industry survey. The following Value Engineering definition of the Institute of Defence Analysis of USA (2006) was referred as the basis of the interview questions.

"VE is an organized / systematic approach directed at analyzing the function of systems, equipments, facilities, services, and supplies for the purpose of achieving their essential functions at the lowest life-cycle cost consistent with required performance, reliability, quality and safety".

(IDA, 2006)

3.2 OVERVIEW OF DATA COLLECTION AND ANALYSIS

Previous research findings have revealed that VE practice of the Sri Lankan construction companies is relatively low when compared to other countries. Lack of awareness, absence of contractual provisions and unavailability of proper VE procedure or methodology has been identified as the main reasons for this. However, under this research it was not intended to test those research findings by going for bigger sample sizes.

Main objective of the industry survey was to identify if any ad-hoc VE methodologies or procedures that were practiced by these companies in applying VE in their projects. Understanding of such industrial practices was considered very useful in developing a good methodology and guideline for the Sri Lankan construction companies. However, during the data collection, additional data were also collected to verify the VE awareness of the people & the management and their attitude towards VE practice to identify areas that need to be considered in designing a tailor-made methodology.

Number of companies planned for the data collection as discussed in Chapter – 1, was further reduced as the survey progressed due to logistic problems in arranging interviews with in the fixed time frame. Since the targeted representative were the head of estimations, construction units and project managers the task become more difficult. Ultimately, the number of companies was reduced to sixteen of them, four companies responded by saying that they do not practice value engineering.

However the validity of the data collected could be guaranteed, because they were collected from the targeted professionals in these companies who did have a better understanding of the things happening in the company as well as in the industry. The quantity surveyors and engineers who were used for this purpose were having over ten or more years of experience in the industry both locally and internationally. Therefore, even though the sample size was relatively small, the perspective and the vision they had on current VE practice of the country would still be very valid even to represent the total population.

The following interpretation of the survey results therefore, can slightly deviate, if the sample size becomes bigger and grading representation of the sample varied among M1, M2 & M3.

However, the chances of changing the conclusions of these results analysis could be remote and would represent the population as a whole.

3.3 SELECTION OF DATA ANALYSIS TECHNIQUES

Due to limited number of samples, advance statistical tools could not be used meaningfully to analyze the survey results. Therefore, statistical significance of the data collected was not checked, as they fall beyond the objectives of this study. Descriptive statistics such as averages, percentages and ratio were utilized to summarize the results. Frequency counts and percentages were mainly used to describe the response of construction companies' for various aspects that were tested.

3.4 VE AWARENESS

VE awareness of the companies was tested in four key areas. They are,

i) Past and current VE experience

As per the data analysis, it was found that only 19% of the responded companies have had some previous experience in VE. Out of that percentage, 43% of the responded were belonging to the ICTAD M1 grade. Table – 1A of the Appendix – B shows the data analysis.

When, the current practice was concerned, it appears that the companies have just started to change. As per Table – 1B of Appendix – B, about 31% of the responded companies are currently using VE at least as an ad-hoc measure to find solutions in difficult situations. Again, 57% of this responded percentage represents the M1 category. These results reveal that, still the popularity of using VE remains mainly with the top category of the construction companies.

However, there can be deviations for these percentages when the representative samples increase.

ii) VE knowledge of the people and management

Data analysis of Table – 2A & 2B of Appendix – B, reveals that 19% of the professionals and 33% of management level persons of the responded companies have a better understanding of the concepts. The results also shows that 38% of the professionals and 44% of management level persons of the responded companies were not familiar with the subject of VE. The

professionals who are having the VE knowledge to a certain extent as in the above tables can be recognized as the best team to be given training for establishing a better practice in the future.

iii) Various benefits of VE

VE benefits would be the most interesting area which the top management of a company would look at before its implementation. Awareness of a vast range of benefits and improvements that VE can produce will impress the management. However, as per the research results only 6% of the professionals of the responded companies have a good understanding of the benefits that VE can provide. 56% of the professionals and 38% of the management level persons of these companies have recognized VE as a cost cutting tool. Table – 4A & Table – 4B of Appendix – B shows that 38% of the professionals and 63% of the management level persons do not have a proper understanding of the benefits and improvements that VE can produce. This unfamiliarity of the concept can be considered as the reason for ‘unpopularity of the concept in the industry’.

iv) Correct VE methodology / practice

Use of correct methodology is the key for proper VE practice in a company. Such a correct approach would create successful VE results when companies need to achieving their objectives. The survey results revealed that, in the selected sample, there is no single company with people who are fully aware of correct VE methodology to follow. As per Table – 5 of Appendix – B, people of 56% of the responded companies are unaware of the VE methodology. However, people of 44% of the responded companies have had the understanding to a certain level. With this level of understanding, these companies have been successful for few occasions in the past.

3.5 ATTITUDE ON VE

Positive attitude of the people and management of companies can produce good results for the success of those companies. Similarly, positive attitude on VE would ensure proper VE practice within the company, which would guarantee better results at the end. However, as per the survey results 36% of the professionals of the responded companies have a positive attitude



about the VE. The rest, i.e. 64% of the professionals of these companies do not have a positive attitude on VE. Lack of proper understanding of the concept, its methodologies and benefits can be recognized as the main reasons for such an attitude among this large number of professionals. When the management level is concerned, only 25% of them have a positive attitude on VE, while the rest, i.e. 75% of the management of the responded companies do not have a positive attitude about VE. This can be highlighted as the most applicable reason for low usage of the concept in their business practice in the past and still today. Table – 3A & 3B of Appendix – B shows the results analysis.

Again, professionals and management of the highest grade (M1) possess a much better attitude on VE when compared to the other grades such as M2 & M3. 57% of the total positive responses were from the grade M1 as shown in the Table 3A & 3B of Appendix – B.

3.6 AVAILABILITY OF VE METHODOLOGY / GUIDELINE

With the results of this survey finding, the revelations made by previous researchers were re-confirmed, i.e. ‘there is no proper VE methodology in the industry’ as of today. As per the results of the survey none of the responded companies have knowledge on the ‘availability of a proper VE methodology and a guideline’ for them to refer when applying VE in their business practices. Table – 6 of Appendix – B illustrates the findings of the survey. So, with this result, it is clear that the other most important reason for low level of VE practice in the industry is the lack of proper methodology and a guideline for companies to refer when required.

3.7 REQUIREMENT OF A VE METHODOLOGY/ GUIDELINE FOR BETTER PRACTICE

As discussed in above section 3.4, a key problem that the industry, especially the construction companies experiencing is the unavailability of a proper methodology and a guideline for them to practice. Hence, companies’ requirement or desire to have such a methodology and a guideline were tested in the survey. As per the survey results, as many as 62.5% of the respondents proposed to have a proper VE methodology and a guideline which covers all the aspects in real practical applications.

As disclosed in the data analysis two companies from M2 category and two companies from M3 category have rejected the discussions on VE quoting that they do not practice it and these comments were included in the data analysis as negative responses. However, it is very likely that even these companies would agree for having a proper document for them to refer in the future. Hence, still there is a possibility that, this result, i.e. 62.5% response be increased to propose a proper VE methodology and a guideline. Table – 7 of Appendix – B shows the research results in more detail.

This survey results very firmly confirmed validity of the author’s intention of developing a VE methodology and guideline for Sri Lankan construction companies for motivating them for an effective VE practice in the future.

3.8 INTEGRATION OF VE INTO EXISTING BUSINESS PRACTICE

Availability of a guideline and a methodology itself will not be sufficient for establishing a good VE practice within companies. Therefore, other key concerns needed to be checked during the survey. These key areas are discussed in three sections below,



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i) Implementation barriers

From the survey results it was found that there are key aspects that need to be looked at in integrating VE with other business activities. If, they were not addressed in appropriate manner and at the correct time there is a possibility that they become barriers for implementation. The table below shows the summary of the survey results that were received for the question “With a correct approach, do you believe that you can establish a proper VE practice in your company?”

Response	Total
Will be difficult, but possible with top management involvement	50%
Possible, but will take some time to people to get familiar	6%
Not very clear	25%
Incentives for people would attract people	19%
Total	100%

This results, therefore reveals that ‘Involvement and the commitment of the top management’ is the key for an effective VE practice in construction companies. 50% of the responded companies have this opinion and therefore need to put this on a high priority list, if an effective VE practice is expected.

Incentives for the team that involves with VE, was highlighted by various respondents as another positive area to look in order to establish a better VE practice. 19% of the responded companies were on this opinion and this clearly reveals that without such an incentive scheme, practicing of VE would not be effective in the long run.

The considerably high percentage, i.e. 25% on ‘not very clear’ is again mainly due to the negative comments made by four companies and this results can vary with correct responses from them. Table – 8 of Appendix – B shows the data analysis on this area.

ii) Unavailability of required resources such as information on various construction materials, methods and systems, finance and technology can become barriers in implementing VE in the construction companies. The financial capabilities of the companies and technology they use, the plant and machineries they possess, are determined by the ICTAD grading system and therefore re-testing on these areas considered not important under this survey. However, valid information is again a key area in VE practice, because VE study phases requires a lots of different information in working out solutions for the selected problem areas. Availability of a well-maintained data base which is resourceful with cost data; details on various types of materials, components and systems; their properties, advantages and disadvantages; is very vital in preparation of VE proposals for seeking approvals from the consultants and the clients. However, according to the research findings around 19% of the responded companies have been maintaining proper databases for retrieving required data and information. 63% of the companies were recorded as not maintaining databases and therefore in a very unfavorable position for VE practice. Table – 10 of Appendix – B provide the detail analysis of the data collected.

3.9 ICTAD RECOGNITION OF VE

As discussed in Chapter – 1, VE concepts have now been accepted by the ICTAD by inclusion of relevant contractual clauses into the bidding documents. Therefore, future prospects in this subject area would be very attractive to the companies who are ready to capitalize on this. According to the result analysis, 69% of the responded companies have suggested that this move would encourage the construction companies to practice active VE in projects in the future. The 31% of the companies, who were not very firm of the future prospects of VE trend in the industry, are the ones who have comparatively low level of understanding and awareness of the concepts.



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CHAPTER – 4: ANALYSIS OF VE METHODOLOGIES / GUIDELINES

Following VE manuals, handbooks and guidance were extensively analysed here for tailoring a suitable VE methodology and a guideline for the Sri Lankan construction industry.

- Value Standard and Body of Knowledge (2007) of Society of American Value Engineers (SAVE)
- Guidebook for VE Activities - Society of Japanese Value Engineering (SOJVE) (1981- English version)
- Value Engineering handbook (2006) of Institute of Defence Analysis of United States of America (IDA)
- Value Engineering Manual of Instruction of Utah Department of Transportation of USA (UDOT)

4.1 PROJECT SELECTION CRITERIA FOR VE

The first step of conducting a VE study is the selection of a project, product, system or process. For this purpose, criteria such as the type of project, the budget allocation, the cost, complexity and other related aspects would be considered. In order to standardize the selection process, the companies can establish a unique set of selection criteria for them to follow in applying VE. Various VE study section criteria proposed in the above VE manuals and guidelines were analyzed below in more detail.

4.1.1 Analysis of SAVE International Project Selection Criteria

The Value Standard of the SAVE is a generic methodology proposed and it does not elaborate on the project selection criteria to be used. However, the scope of the 'pre-workshop activities' of the SAVE can expand to include the requirement of a criteria for that matter.

4.1.2 Analysis of UDOT Project Selection Criteria

According to the UDOT's *Manual of Instruction: Value Engineering*, projects are selected at the UDOT based on the construction cost and its overall complexity. Higher-cost and more complicated projects are given higher priority. All projects over US\$ 2 million are considered for the VE study.

It also highlights the 'areas or causes of high cost, which may indicate poor values' as the potential areas for VE study. Therefore the UDOT list contains the following,

complexity in design; advancement in the state-of-the-art; accelerated design (tight design schedule); a component or material that is critical, exotic, hard-to-get, or expensive; overly long material haul (excessive borrow, excessive waste); long foundation piles; excessive reinforcement; cofferdam; de-watering; architectural embellishment; record-seeking design; large safety factors; specially designed components that appear to be similar to off-the-shelf items; sole-source materials or equipment; highly-skilled or time-consuming labor; items with poor service or cost history; items with maintenance and field operation problems; project costs that exceed the budget; standard plans in use more than 3 or 4 years; and possible solutions or benefits in areas other than cost, such as noise, safety, maintainability, time, quality, energy use, reliability, fire protection, standardization, performance, weight, aesthetics & simplification,.

However, there isn't a point system developed to rate the projects, but projects with many high-cost indicators are given higher priority than those with only a few numbers.

When extensive analyzes of the above is performed, it appears that the UDOT have a very sophisticated set of criteria for selection which is acceptable for a company or department that has a well established VE practice.

4.1.3 Analysis of SOJVE Project Selection Criteria

The Guidebook for VE activities: A Basic VE Manual – of Society of Japanese Value Engineering have identified list of items that need consideration in selecting projects for VE studies. As per this manual 'the nature of the product will greatly influence the results achieved. Unless a product with a significant high cost or a product with a low value is chosen, the efforts expended will not reap their just rewards'. It is generally recommended to select a product with a low value or high cost. It suggests reference to the following aspects as in Table 4.1, when selecting a project for VE study.

When compared with the UDOT criteria this (SOJVE) is much more advantages to be used in the Sri Lankan context if it is required to have a set of criteria for selection.

Table – 4.1, SOJVE – project selection criteria

Design Aspects	<p>A product that was designed in a hurry.</p> <p>A product in which an unreasonably high level of technology is required</p> <p>A product with complex functions</p>
Sales Aspects	<p>A product for which there is a customer demand for VE</p> <p>A product whose sales the company desires to expand</p> <p>A product that has attracted too many customer complaints</p>
Manufacturing Aspects	<p>A product with a high manufacturing cost</p> <p>A product with a high deficiency rate</p>
Ease of application aspects	<p>A product about which information can be easily gathered</p> <p>A product to that lends itself naturally to application of VE</p>

(Summarized from Guidebook for VE Activities – Society of Japanese Value Engineering)

4.1.4 Analysis of IDA Project Selection Criteria

As per the IDA, “any profitable endeavor, in a successful project is based on an adequate return on the investment and almost any activity is a possible VE opportunity. Therefore, selecting VE projects should be based on the potential yield from the time, talent, and cost that will be invested”. Hence, the IDA emphasized that ‘typical opportunities for VE projects will be derived from a known problem, or a cost driver study, or anything indicating that a product or a process should be improved’. It also highlights that in the early stages of VE application within an organization, sophisticated project selection criteria are not usually needed.

4.1.5 Proposed Selection Criteria for Construction Companies

By the above analysis it is clear that a company can go for very sophisticated selection criteria if it is really required. Also any aspect can be made an element of the criteria. However in the Sri Lankan context of VE practice, it will not be very sensible to go for such a sophisticated system in this very early stage of adaptation. Therefore, the author is in view that it is very sensible to go with the facts that were emphasized by the IDA “typically

opportunities for VE projects will be derived from a known problem, a cost driver study, or anything indicating that a product or a process should be improved”.

However, a set of sensible factors could be looked at in determining the VE study for project selection when the VE team needs guidance. Table 4.2 proposes some of such factors that can be looked at when the guidance is needed for the determination in project selection.

Table – 4.2 – Proposed VE study selection criteria for Sri Lankan construction companies (Author)

Selection Criteria		Where to Apply				
		Project	Product	Internal Systems	Internal Procedures	Internal Processes
COST	High cost	√	√	√	√	√
	Restricted budget allocation	√	√	√	√	√
	High maintenance cost	√	√	√	√	√
	High manufacturing cost		√			√
	High elemental cost	√	√	√		√
	Expensive materials	√	√			
	High labour and management cost			√	√	√
COMPLEXITY	Complex design	√	√	√	√	√
	Major changes or modifications	√	√			√
	Selection of complex or 'hard to get' materials	√	√			
	Multiple construction phases	√	√			
	High-tech components/systems					√
	Non-standard items	√	√			
	Sole-source materials / components	√	√			
Accelerated development program	√	√				
IMPACT	Too many customer complains		√	√	√	√
	Product whose sales the company need to expand (core business)	√	√	√	√	√
	Higher market competition	√	√	√	√	√
	Expensive / extensive environmental or geotechnical requirements	√	√			√

4.2 VE JOB PLAN

According to the SAVE International (2007) “The value methodology is a structured, disciplined procedure aimed at improving value. This procedure is called the ‘Job Plan’. The job plan outlines sequential phases that are to be followed which support team synergy within a structured process, as opposed to a collection of individual opinions”.

The activities carried out in each phase of the job plan will stimulate the VE team to identify and then to develop various ideas into potential alternatives to the original concepts or designs. In doing that, the most important thing is to ‘identify and understand the primary

and secondary function of the product, project, system or procedure' by the VE team and the stakeholders.

For the accomplishment of the VE study goals, the primary functions must be maintained. Then, the secondary functions need to be analyzed and evaluated with regards to their contribution towards the overall objectives. For the identification and evaluation of the functionality of each selected unit, 'functional analysis or functional analysis system techniques (FAST)' need to be carried out. "By making functional explicit, organizations can manage innovation to provide a sustainable competitive advantage that leads to success" (SAVE, 2007).

VE job plan / methodologies of various VE manuals and guidelines are analyzed in sub sections below.

4.2.1 Analysis of SAVE VE Job Plan

Figure – 4.1 illustrates the generic job plan process and the flow proposed by the SAVE International. Each of the phases in this job plan must be performed in a sequence because each phase provides inputs, information and the basic understanding required for the successful execution of the next phase. Also each of the previous phases can be reviewed, as the VE team becomes more knowledgeable and familiar about the project.



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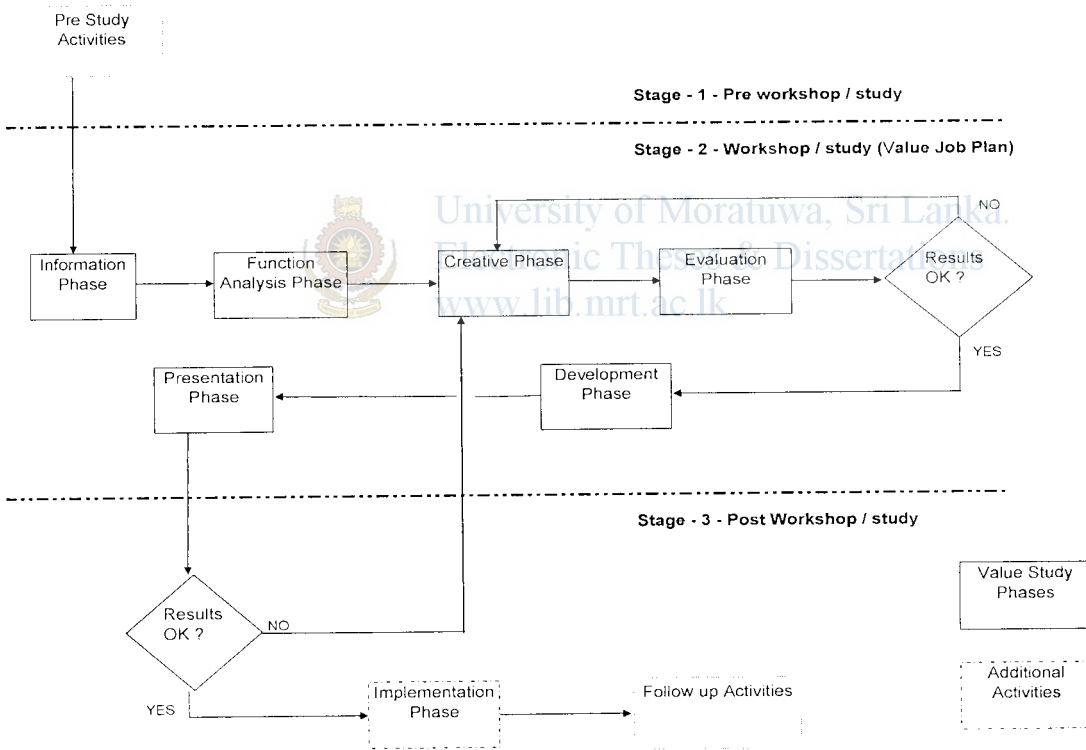
Figure – 4.2 illustrates 'SAVE Value Management Job Plan' with more details on scope and activities in each phase (Clark 1999).

According to this job plan, during the 'pre-study stage' all the preparatory work for the VE study need to be done by the VE leader or the manager responsible. In most of the other tailor-made VE job plans this stage has been identified as 'orientation phase'. The next major phase after the 'pre study stage' is 'work-shop stage'. The work-shop stage consists of all the VE phases such as information, function analysis, creative, evaluation, development and presentation. The final part of the study is 'post work-shop stage' and it consists of 'implementation phase' of the VE proposals.

The sequence starts with the 'Information phase' in which the team will review and define the current condition of the project and identify the goals of the VE study.

In the 'functional analysis phase' the team defines the project functions using a two-word 'active verb and measurable noun' context. In here the team reviews and analysis these functions to determine which need improvement, elimination, or creation to meet the project's goals. In the 'creative phase' the team employs creative techniques to identify other ways to perform the project's function.

In the next phase, which is the 'evaluation phase' the team follows a structured evaluation process to select those ideas that offer the potential value improvement while delivering the project's functions. The 'development phase' is for the team to develop the selected ideas into alternatives with a sufficient level of back-up documentation to allow decision makers to determine implementation. The last phase which is the presentation is for the team leader to develop a report and present the alternatives developed by the team.



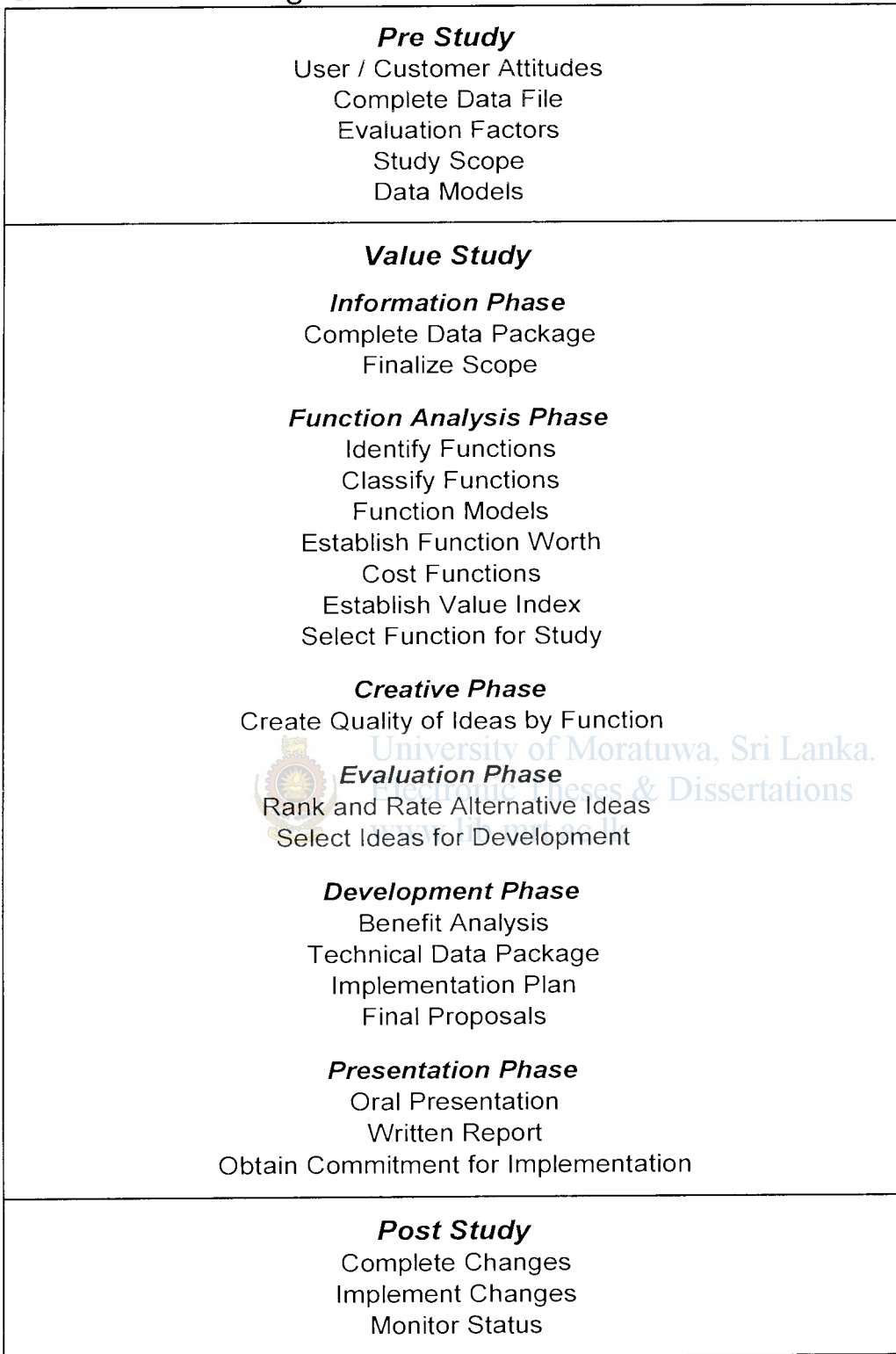
Value Study Process Flow Diagram (SAVE International)

(Source: Value Standard and Body of Knowledge (2007) of Society of American Value Engineers

Figure – 4.1 SAVE International Generic VE Job Plan



SAVE Value Management Job Plan



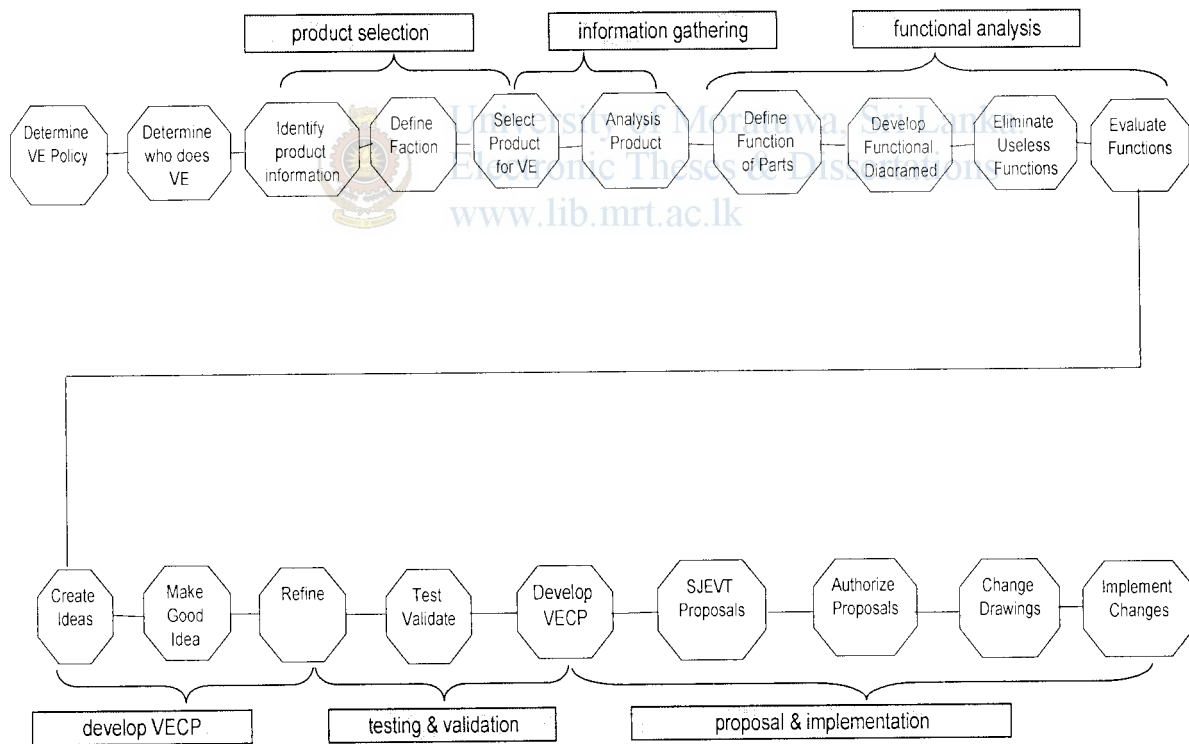
(Source: Value Engineering for Small Transportation Projects – Thesis by Clark J.A. (1999))

Figure – 4.2, SAVE Value Management Job Plan with details

4.2.2 Analysis of SOJVE VE Job Plan

Figure – 4.3 illustrates the VE job plan structure proposed by the SOJVE. The first step of this job plan is the ‘product selection’ and there is no clear stage for a ‘pre-study stage’ as in the SAVE job plan. However, ‘determining of the VE policy and determination of who does the VE’ still needs to be done before the first step. The other significant difference in this job plan is that, a ‘testing & validation step’ has come in between ‘development & implementation steps’ which is not available in the SAVE job plan.

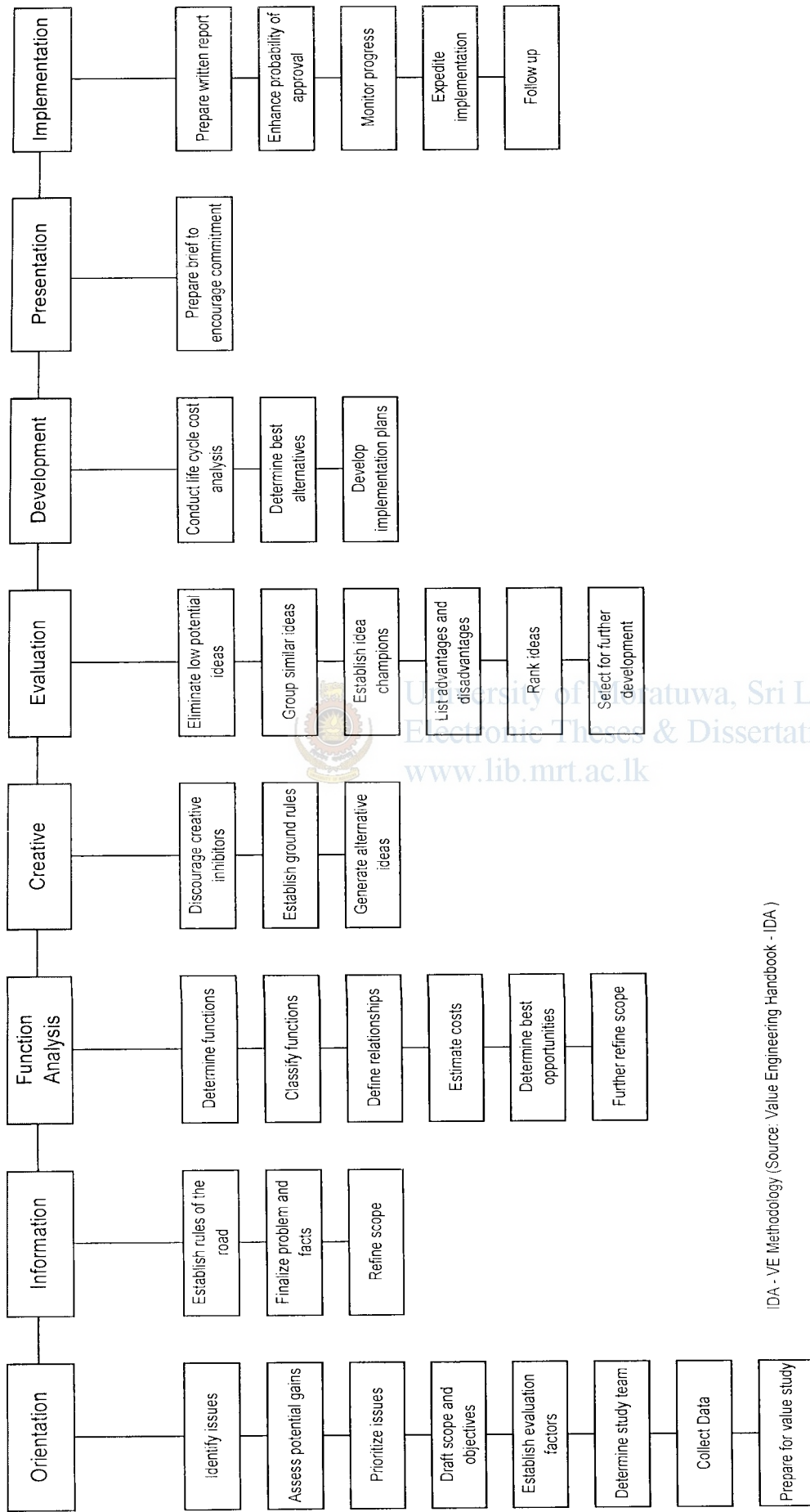
When this job plan is compared with the SAVE job plan, it was found that SAVE job plan is more comprehensive than the SOJVE. Introduction of the activity ‘test and validate’ in between activities ‘refine and develop VECP’ is not very clear, it appears that, it is required to ‘test and validate’ the refined ideas before going to the development process as a VECP. The purpose of this would be to rank the refined ideas for further development as a VECP.



VE Job Plan (Society of Japanese Value Engineering)

(Source: Guidebook for VE Activities – Society of Japanese Value Engineering)

Figure – 4.3, VE Job Plan – Society of Japanese Value Engineering



IDA - VE Methodology (Source: Value Engineering Handbook - IDA)

(Source: Value Engineering handbook (2006) of Institute of Defence Analysis of United States of America
 Figure – 4.4, IDA VE Methodology

4.2.3 Analysis of IDA VE Job Plan

Figure – 4.4 illustrates the tailor-made VE job plan proposed by the IDA for its VE studies. In this job plan, there are eight sequential phases which are very similar to that of SAVE. This similarity in phasing of the job plan suggests that, the IDA's tailor-made job plan has been adapted from the SAVE job plan. The only difference in the IDA job plan when compared with SAVE job plan is the absence of three clear stages in it.

Value Engineering Handbook of Institute of Defense Analyses describes the VE methodology used. This structure of the job plan has been adapted from the value methodology standard of the SAVE International.

The Orientation Phase is conducted to prepare for the value analysis. This phase would last for several weeks and would also lay the foundation for an efficient and productive VE study by refining the problem, collecting required data and organizing for the efforts to follow.

The real value study commences in phase two and runs through to phase seven of the job plan. These phases are typically performed in a workshop setting involving all stakeholders. Systematic following of the methodologies within these phases leads to recommendations for improving the existing situation and thereby increasing value for each item involved. The value study ends with a presentation of recommendations for improvement to the decision-maker.

The Implementation phase occurs after the value study is over and decisions have been made. The purpose of this phase is to monitor the approval process and implementation of the action plan. Project approval is normally not given solely on the basis of the brief presentation that occurs at the conclusion of the workshop. Approval will usually be obtained after the completion of follow-up actions such as providing more data and meeting with others. Therefore, implementation itself begins only after the final approval is granted.

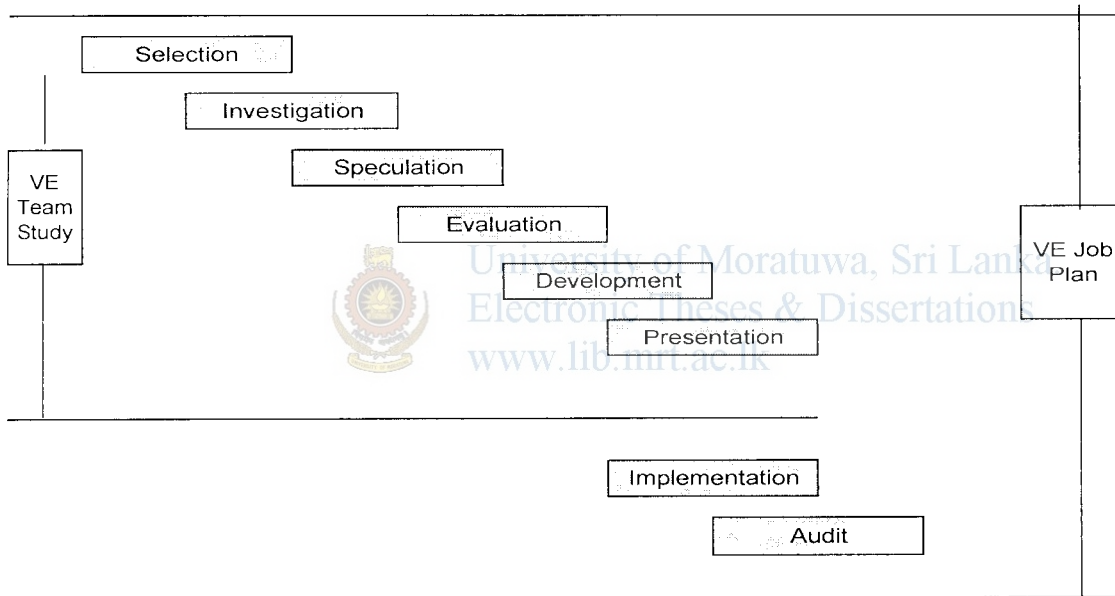
4.2.4 Analysis of UDOT VE Job Plan

Figure – 4.5, illustrate VE job plan structure of the UDOT. The investigation, speculation, evaluation, development, and presentation phases make up to be what is generally termed the VE study. In this job plan there is no separate orientation phase or a pre-study stage for VE study preparation as in the SAVE and the IDA job plans. Those activities need to be carried out in the selection phase. However, during the investigation phase, the VE team collects project

information, determines the functions and their cost, worth and value, and analyzes the project for potential areas of savings.

The functional analysis consists of defining and classifying functions and their relationships, identifying high-cost functions, and identifying areas of poor value. The team also considers life cycle costs in their choice of elements for further study. When analyzed, it was found that the scope of this phase is equal to that of the two phases in both the SAVE and the IDA job plans making the workload very much for the VE team. Therefore, in developing a tailor-made methodology, the avoidance of very broad scopes would help the VE team to develop a manageable work load in each phase.

Value Engineering Job Plan Phases



(Source: Value Engineering Manual of Instruction of Utah Department of Transportation of USA)

Figure – 4.5, VE Job Plan of UDOT

The speculation phase consists of selecting creative techniques and conducting creative sessions to generate more alternatives. In the evaluation phase, the team screens and evaluates these alternatives. Also, criteria and objectives would be developed, and the alternatives would be weighted and ranked to make it ready for the next phase.

Only the best alternatives continue on to the development phase, where they are developed into detailed design ideas. The VE team collects data to assess the technical and economic feasibility of the alternatives, and then implementation plans would be developed.

Finally, the selected alternatives would be presented to the decision-makers in a written proposal and oral presentation for seeking the approval for implementation. Then comes the implementation and auditing phases to make sure better implementation and to analysis the return achieved respectively.

4.3 ANALYSIS OF PHASES OF VARIOUS VE METHODOLOGIES

Under section 4.2 above, basic feature of various known VE job plans were briefly discussed. The differences in VE phasing were observed. Now it is required to identify and analyze the scope and activities in each phase of VE study in various methodologies in order to determine the scope and activities for the proposed methodology for the construction companies. The same scope of these VE methodologies would not be fitting to the construction business without any change. Hence to develop a customized methodology, each phase of these various methodologies need to be analyzed in detail.

It is seen that the scope, common activates, expected out come and fundamental questions raised in each phase are not the same in each of above selected VE methodologies and these differences are discussed in following sub-sections.

4.3.1 Pre-Study Preparation Phase

The key features of the first phase or stage of the various VE methodologies are compared below. The Table – 4.3 gives the summary of complete scope for ‘pre-study preparation stage’ of the SAVE, VE methodology. According to the SAVE, preparation for VE study need not to be a team effort and it can be done by the VE leader before appointing a VE team.

The answer to the ‘fundamental question’ is all about scope of work in this stage as determined by the SAVE. In other methodologies, these specified activities are falling to the ‘orientation phase or selection phase’ of the VE study.

As per Figure – 4.3 above, the determination of ‘who does the VE’; that is selecting the VE leader and ‘determination of a VE policy’ are the very first steps in the SOJVE methodology.

In this methodology there is no 'pre-study preparation stage' as in the SAVE methodology. The main six VE study steps starts after the above two steps. Key activities, purpose of the steps and the expected outcome were not clearly defined. However, it appears that, these two steps basically cover a scope similar to the pre-study stage of the SAVE methodology.

Table – 4.3. SAVE Pre – Workshop Stage

		Pre - Workshop Stage	
Purpose	Plan and organize the Value Study		
Fundamental Question	What has to be done to prepare for a Value Study?		
	Common Activities	Tools	Typical Outcome
	Obtain senior management concurrence and support of the job plan, roles, and responsibilities. Develop the scope and objectives for the Value Study Obtain project data and information Obtain key documents such as scope of work definition, drawings, specifications, reports, and estimate Identify and prioritize strategic issues of concern Determine the scope and objectives of the study Develop the study schedule Undertake competitive benchmarking analyses Identify Value Team members Obtain commitment from the selected team members to achieve the project objectives Review the project costs Gather appropriate customer/user information about the project If appropriate, invite suppliers, customers, or stakeholders to participate in the Value Study Distribute information to team members for review Develop informational models and diagrams about the project Determine the study dates, times, location and other logical needs Clearly define, with senior management, the requirements for a successful Value Study results		Clear understanding of what senior management needs to address, what the strategic priorities are, and how improvement will increase organizational value.

(Summarized form - Value Standard and Body of Knowledge (2007) of Society of American Value Engineers)

The summary of full scope of the 'orientation phase' of the IDA methodology is shown in the Table – 4.4 and it clearly identifies the activities needed to perform in this phase with regards to the customary requirement of the department. Eight steps of this phase facilitates the organization of activates within the phase.

Table – 4.4, IDA Orientation Phase

ORIENTATION PHASE	
1	Identify the Specific Issues To Be Addressed
2	Assess the Potential Gains for Resolving Each of These Issues
3	Prioritize the Issues
4	Draft a Scope and Objective for the Value Study
5	Establish Evaluation Factors
6	Determine Team Composition
7	Collect Data
8	Prepare Logistically for the Value Study

Summarized form Value Engineering handbook (2006) of Institute of Defence Analysis of USA

With the UDOT, the first phase is once again the 'selection phase' as with the SOJVE, and it basically covers the preparatory works for the VE study. Table – 4.5 & Table – 4.6 clearly indicate the main functions, techniques that are included in this phase.

Table 4.5, UDOT – VE Job Plan – Detail-1

VE Job Study Plan		
Phase	Objective	Key Questions
Selection	Select Project	What is to be Studied? Who is Best Able to Study the Problem? What must be Known to Start?
Investigation	Investigate Project Analyze Function and Cost	What is the Project? What is the Problem? What is the Cost? What is now Accomplished? What is the Basic Function Worth? What are the Secondary Functions Worth? What are the High Cost Areas? Can Any Function be Eliminated?
Speculation (Creative)	Speculate on Alternatives	What Else will Perform the Function? Where Else may the Function be Performed? How Else may the Function be Performed?
Evaluation (Judgment)	Evaluate Alternatives	How Might Each Idea Work? What Might be the Cost? Will Each Idea Perform the Basic Function?
Development	Develop Alternatives	How will the new Idea Work? How Can Disadvantages be Overcome? What will be the Total Cost? Why is the New Way Better? Will it Meet the Requirements? What are the Life Cycle Costs?
Presentation	Present Alternative	Who Must be Sold? How Should the Idea be Presented? What was the Problem? What is the New Way? What are the Benefits? What are the Savings? What is needed to Implement Proposal?
Implementation	Implement Alternative	Who is to Implement the Change How Will Plans/Contract be Changed? Is There Money for the Change?
Audit	Audit Results	Did the New Idea Work? How Much did it Cost? How Much Money Was Saved? Did the Change Meet Expectations? Who is to Receive Recognition?

(Source: Value Engineering Manual of Instruction of Utah Department of Transportation of USA)

Table 4.6. UDOT – detail VE Job Plan – Detail - 2

VE Job Study Plan		
Phase	Techniques	Tasks
Selection	Solicit Project Ideas Identify High Cost/Low Value Areas Plan the Project Obtain Authorization to Proceed Allocate Resources	Speculate on Sources of Projects Develop Plan to Identify Project Analyze Projects for Applying VE Evaluate Projects for Potential Present Project to Management Select Projects for VE Study Implement Study Plan
Investigation	Get Information From Best Sources Get all Facts and Available Costs Work with Specifics Identify the Function Challenge Everything Evaluate by Comparison Put \$ on Specs and Requirements Put \$ on Key Tolerances & Finishes Put \$ on Key Standards	Speculate on Sources of Project Data Dev. Plan to Gather Project Data Implement Data Search Plan Investigate the Project Audit Data Speculate on Functions Performed Analyze Cost Analyze Functions Evaluate Function Cost/Worth Evaluate Project Potential Select Specific Study Areas
Speculation (Creative)	List Everything, be imaginative Use Creative Techniques Defer Judgment, don't criticize Be Courageous	Select Techniques to be Used Speculate Alternatives Select the Best Alternatives
Evaluation (Judgment)	Weigh Alternatives Choose Evaluation Criteria Refine Ideas Put \$ on Each Main Idea Evaluate by Comparison	Speculate on Evaluation Criteria Evaluate Alternatives Select the Best Alternatives
Development	Use Search Techniques Get Information for Best Sources, Specialists & Suppliers Consider Specialty Materials, Products & Processes Consider Standards Use New Information Compile all Costs - Work with Specifics Gather Convincing Facts	Speculate on Information Needed Speculate on Information Sources Develop a Plan of Investigation Develop Selected Alternatives Select Preferred Alternative Develop Implementation Plan Audit Data
Presentation	Make Recommendations Use Selling Techniques Be Factual Be Brief Give Credit Provide an Implementation Plan	Develop a Written Proposal Speculate on Possible Roadblocks to Acceptance Present Recommended Alternative
Implementation	Translate Plan Into Action Overcome Problems, Expedite Action Monitor Project	Develop Change Documents Implement Approved Alternative Evaluate Process
Audit	Verify Accomplishments Make Awards Report to Management	Audit Results of Implementation Evaluate Project Results Present Project Results Present Awards

(Source: Value Engineering Manual of Instruction of Utah Department of Transportation of USA)

4.3.2 Proposed Pre-Study Preparation Phase for Construction Companies

For the proposed VE methodology, having a 'pre-study' stage as in the SAVE would be more appropriate than having a separate phase. Because, it is really in this pre-study stage that everything need to be initiated and organized. According to the industry survey results, as discussed in Chapter – 3, most of Sri Lankan construction companies do not have a proper and strong VE study procedure in place. Therefore, VE initiator will have more responsibility in planning VE study practices within the company. Having a separate 'pre-study stage' will therefore allow the VE initiator, or the leader to carry out all preparatory work for the VE study. Figure – 4.6 illustrates the basic scope suggested for the 'pre-study stage' of the proposed VE methodology.

As discussed above VE project selection activities should also be carried out during this proposed 'pre-study stage'.

4.3.3 Information Phase

The scope of this phase as proposed by the SAVE methodology is shown in the Table – 4.7. As per this table the main purpose of this phase is to understand the current state of the issue or the project and its constraints that can make influences in decision making. The activities proposed for this phase make sure the collection of all data and information required for the VE study progress.

Table – 4.7, SAVE Information Phase

Information Phase		
Purpose	Understand the current state of the project and constraints that influenced project decisions.	
Fundamental Question	What is really going on in the tactical and operational contexts?	
	Common Activities	Tools
	Obtain project data and information and key documents such as scope of work definition, drawings, specifications, reports, detailed project cost information, quality data, marketing information, process flow charts, etc. Identify and prioritize strategic issues of concern. Further define the scope and objectives (management expectations) of the study	Quality Function Deployment, Voice of Customer SWOT (Strengths, Weaknesses, Opportunities and Threats), Project Charter
	Project Team presents the original and/or present design/product/process concepts Perform competitive benchmarking analysis Determine the study schedule: dates, times, location and other logistical needs	Benchmarking, Tear Down Analysis, Pareto Analysis, Design for Assembly
	Distribute information about the project for team member review Understand project scope, schedule, budget, costs, risk, issues, non-monetary performance. Confirm the most current project concept Identify high-level project functions Visit site or facility Confirm success parameters	
		This phase brings all team members to a common, basic level of understanding of the project, including tactical, operational, and specifics of the subject. The functional understanding establishes the base case to identify and benchmark alternatives and mismatches and set the agenda for innovation.

(Summarized form - Value Standard and Body of Knowledge (2007) of Society of American Value Engineers)

In the SOJVE methodology this phase has been named as ‘gathering of information’. Unlike in SAVE methodology, selection of product for VE has been delayed to this stage, in this methodology. Other than that, analyses of functions of the selected products have also been included into this phase making the scope more difficult to manage.

Establishing ground rules, finalizing of issues and related facts and refinement of the study scope of the IDA methodology, make a firm foundation for the study. Activities shown in Table – 4.8, appear to be more appropriate to this phase even than those of the SAVE methodology.

Table – 4.8, IDA Information Phase

INFORMATION PHASE	
1	Establish Workshop Rules of the Road
2	Finalize the Problem and the Associated Facts
3	Refine the Scope

Summarized from Value Engineering handbook (2006) of Institute of Defence Analysis of USA

In the UDOT methodology there is no separate phase for information collection, hence the required data and information with regard to the issue or project should be included in the first phase, that is the ‘selection phase’. However, having a separate phase for information collection as in the SAVE methodology would facilitate the management aspects of the study process. Table – 4.5 & Table – 4.6 clearly indicate the main functional, techniques that are included in this phase.

4.3.4 Proposed Information Phase for Construction Companies

The scope of work for this phase as proposed by the various methodologies seems to be very comprehensive and adequate for companies or entities that have an established set-up for VE studies with knowledgeable and capable people around.

But, in the context of Sri Lankan construction industry, even higher grade companies have faced the problem of finding the resources persons with the required caliber. In addition, the collection of the required data and information with regard to previously completed projects, systems or product developed, innovations created, lessons learned and results achieved is not a easy task due to the non-availability of duly maintained data bases. The survey results

discussed in Chapter -3 shows that only few companies are maintaining proper databases for storing of critical data and information.

Therefore, having a separate information phase as in the SAVE and the IDA methodology would be more appropriate for construction companies to make sure that the required data and information are collected effectively. Also, having a defined scope for the phase will facilitate the management of activities of the phase. Proposed scope for this phase for construction companies are shown in the Figure – 4.6.

4.3.5 Functional Analysis Phase

This is the key area of the VE study. A product is analyzed to determine what functions it possesses and what functions are required of it. If the product is found to have functions that are not required by the user, these may be designated as ‘unnecessary functions’ and the product may be considered as over-designed. “The most important thing here is to identify a function so as not to limit the ways in which it can be performed” (UDOT).

Table – 4.9, illustrate the key activities proposed for this phase by the SAVE methodology. Following of these activities provide a more comprehensive understanding of the product by focusing on what the project does or must do rather than what it is. The VE team is to identify value-mismatched functions on which to focus in order to improve its value. Identification and classification of project functions and development of functional models can be identified as the key aspects in this phase in SAVE. Also, it strongly encourages team effort towards these activities.

Table – 4.9, SAVE Function Analysis Phase

Function Analysis Phase		
Purpose	Understand the project from a functional perspective; what must the project do, rather than how the project is currently conceived.	
Fundamental Question	What are the functions and how are they related?	
Common Activities	Tools	Typical Outcome
Identify the project functions (team format strongly encouraged) Classify project functions Develop function models Dimension the model with cost drivers, performance attributes and user attitudes to select value mismatched functions to focus the creativity phase Estimate worth of functions to select value-mismatched functions on which to focus the creativity phase.	Random Function Identification Function Analysis System Technique Cost to Function Analysis (Function Matrix), Failure Measurement Error Analysis (FMEA), Performance to Function Analysis, Relate Customer Attitudes to Functions Value Index (function cost/function worth)	This phase focuses the team on validating that the project satisfies the need and objectives of the customer. It provides a more comprehensive understanding of the project by focusing on what the project does or must do rather than what it is. The team identifies value-mismatched functions) on which to focus in order to improve the project.

(Summarized form - Value Standard and Body of Knowledge (2007) of Society of American Value Engineers)

In the SOJVE methodology, there is a separate phase for functional analysis as well. Definition of functions, development of functional diagram, and elimination of ineffective functions and evaluation of these functions has been identified as the key function of this phase. The scope proposed for this phase is very much similar to that of other methodologies discussed.

The six steps of the IDA function analysis phase provide a better structure for carrying out key activities of this phase. Therefore, in developing a methodology for construction companies the structure of this methodology would be more suitable to consider as the basis. Table – 4.10 illustrates the overall scope of this phase.

Table – 4.10, IDA Function Analysis Phase

FUNCTION ANALYSIS PHASE	
1	Determine the Functions
2	Classify the Functions
3	Develop Function Relationships
4	Estimate the Cost of Performing Each Function
5	Determine the Best Opportunities for Improvement
6	Refine Study Scope

Summarized from Value Engineering handbook (2006) of Institute of Defence Analysis of USA

In the UDOT methodology, Table – 4.5 & Table – 4.6, the functional analysis is falling into the investigation phase. Selection of the product or project for VE study and related task is the other key area in this phase of the methodology. Accordingly, the scope assigned for the investigation has become comparatively high in the UDOT methodology.

4.3.6 Proposed Functional Analysis Phase for Construction Companies

As discussed above the structure of the functional analysis phase of IDA methodology would be more appropriate for construction companies of the country. This is because it fully details the process of carrying out the functional analysis. The tools and techniques proposed in SAVE and UDOT methodology would enhance the effectiveness of the phase. Figure – 4.6 illustrates the key aspects proposed for this phase of the new methodology.

4.3.7 Creative Phase

The purpose of this phase is to develop a large number of ideas of alternative ways to perform functions of the original product selected for study. Proposal of conducting ‘creative warm-up exercises’ and ‘employing of group idea stimulation techniques’ make the SAVE methodology

superior in this phase when compared with other methodologies. The Table – 4.11 illustrates the common activities proposed for this phase.

Table – 4.11, SAVE Creative Phase

Creative Phase		
Purpose	Generate a quantity of ideas related to other ways to perform functions	
Fundamental Question	How else may the functions be performed?	
Common Activities	Tools	Typical Outcome
Conduct creative warm-up exercises Establish rules that protect the creative environment being developed Employ group idea stimulation techniques Generate alternate ideas that may improve value.	Creativity “Ground Rules” Brainstorming, Gordon Technique, Nominal Group Technique, TRIZ, Synectics	The team develops a broad array of ideas that provide a wide variety of possible alternative ways to perform the functions) to improve the value of the project.

(Summarized form - Value Standard and Body of Knowledge (2007) of Society of American Value Engineers)

Identification of various types of creative inhibitors is one of the important aspects of IDA methodology in addition to the other common activities of this phase. In addition the IDA also proposes various techniques for generation of alternative ideas during this phase. Table – 4.12 elaborate the scope proposed for this phase by IDA.

Table – 4.12, IDA Creative Phase

CREATIVE PHASE	
1	Discourage Creativity Inhibitors
2	Establish Ground Rules
3	Generate Alternative Ideas

Summarized form Value Engineering handbook (2006) of Institute of Defence Analysis of USA

In the SOJVE methodology there isn't a separate phase identified for idea generation. However, creating ideas, making these ideas real, and refinement of the ideas are grouped into the 'develop VECP' step. Other than that, this phase also covers the evaluation of ideas that is normally a separate phase in other methodologies. Separation of 'evaluation of ideas' from this phase would facilitate the management of key activities of the phase for a better VE study practice.

In the UDOT methodology, the above discussed scope is covered in the 'speculation phase'. The activities proposed for this phase is almost similar to the scope proposed in creative phase of SAVE and IDA methodologies.

4.3.8 Proposed Creative Phase for Construction Companies

The survey results show that, only few construction companies have been successful with value improvements in their projects. Most of these improvements have been the results of searching for low cost options due to budget restrictions. Also, it was found that most of the improvements proposed have come from the tender departments of the respective companies. 'No' or "Not possible" was the most frequent answer to the question of 'Do you conduct any brainstorming exercises involving multi-disciplinary team to generate innovative ideas? This reveals that, performance of this phase is not proper in the industry today. Except for a few people in the prominent companies, others have not realized the significance of multi-disciplinary team effort for creating innovative ideas.

The human input required in the construction business is significantly high when compared with other businesses. Use of this human resource towards exploration of creative ideas would help companies to innovate value improvements in various areas within the company. For that matter, the people and management of the company should realize the importance of this phase and different means of achieving that. Figure – 4.6 illustrate the key aspects that need consideration by construction companies in performing this phase.

4.3.9 Evaluation Phase

The purpose of the Evaluation Phase is to refine and select the best ideas for development into specific value improvement recommendations.

The SAVE methodology highlights the need, to clarify and categorize ideas in order to develop a shared understanding, for the effective VE study. Other activities proposed for this phase are much more similar to that of other methodologies discussed. Table – 4.13 illustrate the basic structure of the SAVE evaluation phase.

Table – 4.13, SAVE Evaluation Phase

Evaluation Phase		
Purpose	Reduce the quantity of ideas that have been identified to a short list of ideas with the greatest potential to improve the project	
Fundamental Question	Of all these ideas, which are worth spending quality time to further develop?	
	Common Activities	Tools
	Clarify and categorize each idea to develop a shared understanding Discuss how ideas affect project cost, and performance parameters.	T- Charts
	Select and prioritize ideas for further development	Pugh Analysis, Kepner-Tregoe, Life Cycle Costing, Choosing by Advantages (CBA), Value Metrics
	Explain how ideas are to be written as stand-alone risk-reward investment proposals	
		The team produces a focused list of concepts that warrant quality time to develop into value-based solutions that can be implemented into a project or a project feature.

(Summarized form - Value Standard and Body of Knowledge (2007) of Society of American Value Engineers)

However, the scope identified in the IDA methodology of this phase appeared to be much clearer and useful in framing out a scope for the new methodology. Table – 4.14 illustrates the scope and activities of the IDA methodology for this phase.

Table – 4.14, IDA Evaluation Phase

EVALUATION PHASE	
1	Eliminate Low Potential Ideas
2	Group Similar Ideas
3	Establish Idea Champions
4	List the Advantages and Disadvantages of Each Idea
5	Rank the Ideas
6	Select Ideas for Further Development

Summarized from Value Engineering handbook (2006) of Institute of Defence Analysis of USA

In the SOJVE methodology, there is no clear phase for evaluation of ideas, however the phase named ‘testing & validation’ appeared to be covering most of these activities.

The activities of this phase in UDOT methodology simply covers all the aspects that it should consider for proper selection of ideas for the next phase. Determining criteria and objectives, weighting the alternatives, weighting the criteria and objective of the project, computing numerical ratings, rank alternatives and selecting the best alternative for development are the clear activities proposed for this phase in the UDOT methodology, which appeared to be more appropriate.



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4.3.10 Proposed Evaluation Phase for Construction Companies

As per the industry survey results discussed in Chapter - 3, most of the construction companies do not have a well-established VE procedure. The current practice, exercised by these companies is ad-hoc VE studies. The ideas evaluated are mainly based on a few key aspects such as cost saving, projected life-span and easy maintenance. All other vital aspects have been neglected. Therefore, it is essential for construction companies to have an appropriate evaluation system to filter the best ideas from the team.

The IDA structure of this phase would be more attractive in working out a tailor-made methodology for construction companies in Sri Lanka. Figure – 4.6 shows the proposed steps for this phase in the new methodology.

4.3.11 Development Phase

The purpose of the development phase is to determine the “best” alternatives to be presented to the decision-makers. In this phase, detailed technical analyses are made for the remaining selected alternatives. These analyses create the basis for eliminating weak alternatives. The SAVE methodology elaborate on generic requirements of steps to follow in screening alternative ideas for the next phase. Proposing of assessment and allocation of risk judgments and costs where appropriate have been identified as key activities for this phase of the SAVE methodology. Table – 4.15 illustrate the basic activities in this phase in the SAVE methodology.

Table – 4.15, SAVE Development Phase

Development Phase		
Purpose	Further analyze and develop the short list of ideas and develop those with merit into value alternatives.	
Fundamental Question	What is an informed description of each selected idea? What is the rationale for making this change? Which ones are mutually exclusive and are independent?	
Common Activities	Tools	Typical Outcome
Compare the study conclusions to the success requirements established during the Information and Function Analysis Phases Prepare a written value alternative for each idea selected for further development Assess and allocate risk judgments and costs, where appropriate Conduct cost-benefit analysis Generate sketches and information needed to convey the concept Confirm that an alternative should be further developed Finish initial alternative development Develop an action plan to define implementation steps, dates, and responsibilities for each value alternative		The Value Study team creates alternatives and low-, medium- and high-risk scenarios and offers these alternatives to senior management as options that address the Pre-Workshop strategic objectives.

(Summarized form - Value Standard and Body of Knowledge (2007) of Society of American Value Engineers)

The IDA proposed some practical steps that need to be followed in this phase for the accomplishment of the objectives. Proposal for conducting a life-cycle cost analysis in this phase can be recognized as the key difference in IDA methodology. Table – 4.16 illustrate the specific activities proposed in the IDA methodology.

As per UDOT methodology, in this phase it is required to obtain additional information to ascertain technical and economic feasibility of selected alternatives in addition to the other common activities for the phase.

Table – 4.16. IDA Development Phase

DEVELOPMENT PHASE	
1	Conduct a Life-Cycle Cost Analysis
2	Determine the Most Beneficial Alternatives
3	Develop Implementation (Action) Plans

Summarized from Value Engineering handbook (2006) of Institute of Defence Analysis of USA

4.3.12 Proposed Development Phase for Construction Companies

All the above VE methodologies discuss almost a similar set of activities in this phase. Therefore, the most relevant aspects need to be picked from each of these methodologies that relate to the construction companies, when determining the scope for this phase. Cost-benefit analysis and risk assessment as suggested by the SAVE would be very attractive in proposing valued alternatives. The scope and the activities proposed for the new methodology is illustrated in Figure – 4.6.

4.3.13 Presentation Phase

The purpose of the presentation phase is to obtain a commitment to follow a course of action for initiating an alternative within the company. At the end of VE study, a presentation of the results to the decision-maker needs to be planned, to attract their approval to go ahead. This presentation is normally the first step in the approval process. However, a decision to implement would not be made at the end of the presentation and a lot more additional information may require, checking its compliance to other possible aspects brought in by the decision-makers.

Activities as proposed by the SAVE: such as offering of “risk-reward” innovation scenarios to management, cost and value comparisons, risk analysis, present worth analysis and comparison of advantages & disadvantages would be very helpful in getting management supports towards the innovations proposed. Table – 4.17 illustrates the key areas included to this phase by the SAVE.

Table – 4.17, SAVE Presentation Phase

		Presentation Phase	
Purpose	Present value alternatives to management team and other project stakeholders or decision makers.		
Fundamental Question	How can we help the project team and senior managers make more informed decisions so that they can select ideas that fit their strategic plans?		
Common Activities		Tools	Typical Outcome
Prepare presentation and supporting documentation Compare the study conclusions to the success requirements established during the Information and Function Analysis Phases Offer to management “risk-reward” innovation scenarios to select value alternatives for implementation Exchange information with the project team Ensure management has full and objective information upon which they can make decisions Outline an anticipated implementation plan Prepare formal report. Common Value Study products include a briefing document, risk analysis, cost vs. worth comparisons, Present worth analysis, advantages vs. disadvantages			Ensure management and other key stakeholders understand the rationale of the value alternatives. Also generate interest to sanction implementation.

(Summarized form - Value Standard and Body of Knowledge (2007) of Society of American Value Engineers)

The key activities proposed by the IDA, such as preparation of a good oral presentation, identification of roadblocks and overcoming plans, relating benefits to company’s objectives and discussions on collateral benefits of the investment looks very appropriate for this phase. These aspects would help in convincing the management about the validity of the proposals for implementation. Table – 4.18 illustrates the key areas included to this phase by the IDA.

Table – 4.18, IDA Presentation Phase

PRESENTATION PHASE	
1	Prepare the document for decision-maker approval
2	Be ready to answer additional questions of the sponsor
3	Collection of additional data to support the recommendation
4	The sole activity in this phase is preparation of a presentation to encourage
5	Describe the “before” and “after” conditions for each alternative.
6	Present the costs and benefits/advantages and disadvantages/impact of each alternative
7	Identify how to overcome roadblocks.
8	Demonstrate the validity of the data sources, and
9	Suggest an action plan and implementation schedule.
10	Address risk
11	Relate benefits to organizational objectives. If the proposal represents
12	Show collateral benefits of the investment

Summarized form Value Engineering handbook (2006) of Institute of Defence Analysis of USA

The aspects suggested by the UDOT methodology for this phase are also very much in-line with those methodologies discussed above. The SOJVE has not discussed this phase in detail and it appears that some of such activities are covered in the ‘proposal & implementation’ phase.

4.3.14 Proposed Presentation Phase for Construction Companies

This is the most important phase that needs greater attention in the Sri Lankan context in the construction sector. The implementation approval from company management and in the case of VECP such approvals from other stakeholders would be very challenging due to the unfamiliarity of the concept. As highlighted by previous researchers it would be very difficult to convince the project consultants in getting approval to such proposals. This is because, most of the designers would not expect any changes to their design mainly due to conflict of interest and various other reasons. Therefore, companies should concentrate on best presentations which could be accepted by these parties. Such presentation whether oral or written must be comprehensive and have the capability of convincing decision-makers without doubt. Proposed activities for this phase of new methodology are illustrated in Figure – 4.6.

4.3.15 Post Study Stage - Implementation Phase

The purpose of the implementation phase is to obtain final approval for the proposal and to facilitate its implementation. It is also useful to consider factors that contribute to successful change in companies throughout this phase.

Challenges to the implementation can still occur due to individual differences and human interpretation even after the management approvals. Therefore those aspects also need to be assessed in proper manner to make sure successful implementation.

According to the SAVE methodology as shown in Table – 4.19, alternatives that go for implementation are finalized by creating action plans, time schedules and tracking system to see the value improvements are achieved.

Table – 4.19, SAVE Implementation Phase

		Implementation Phase	
Purpose	Ensure accepted value alternatives are implemented and that the benefits projected by the Value Study have been realized		
Fundamental Question	What are the program changes, and how will the project team manage them?		
	Common Activities	Tools	Typical Outcome
	Review the preliminary report Conduct an implementation meeting to determine the disposition of each value alternative. Establish action plans for those alternatives accepted and document the rationale for the rejected alternatives Obtain commitments for implementation Set a timeframe for review and implementation of each value alternative Track value achievement resulting from implemented alternatives Sign off deliverables Validate benefits of implemented change Ensure that new practices become embedded by establishing and managing an implementation plan		The project stakeholders determine what will be changed in the project as a result of the Value Study. These are changes to the original concept or base case of a study, resulting from the value alternatives, that the project development will incorporate in future design or product development activities.

(Summarized form - Value Standard and Body of Knowledge (2007) of Society of American Value Engineers)

With the IDA methodology the phase starts with producing written report to reinforce the oral presentation to enhance the probability of getting approval. Monitoring of implementation progress, expediting of implementation and following –up are the other key aspects that were highlighted in the IDA methodology. Table – 4.20 illustrate the key aspects covered by this.

Table – 4.20, IDA Implementation Phase

IMPLEMENTATION PHASE	
1	Prepare a Written Report
2	Enhance the Probability of Approval
3	Monitor Progress
4	Expedite Implementation
5	Follow-up

Summarized form Value Engineering handbook (2006) of Institute of Defence Analysis of USA

In this phase the UDOT methodology only considers activities such as developing of an implementation plan, executing that plan and monitoring- because in UDOT methodology the auditing part has been separated by creating dedicated a phase for that alone.

4.3.16 Proposed Implementation Phase for Construction Companies

Implementation of approved VE proposal would not be a problem with construction companies, if instructions come from the top management. During the survey carried out, a respondent emphasized that the “ability of the technical staff to do things, and the capabilities of professionals for designing and implementing of changes would not be a problem as long as it gets the commitment and attention of the top management of the company”. Therefore, management support and commitment for VE is a must in the construction business to have a proper VE practice. The Figure – 4.6 proposes the activities for this phase of the new VE methodology.

4.3.17 Proposed VE Methodology / Job Plan for Construction Companies

By incorporating all above proposed phases, a VE methodology can be out lined for the Sri Lankan construction companies. In determining the scope and activities of each phase of this methodology, tailor-made changes were done to some of the aspects discussed in various phases of above selected VE methodologies.

Adapting SAVE generic VE process flow diagram would be more appropriate for Sri Lanka. Because starting the VE methodology from a ‘pre-study’ stage will provide the VE leader with

required time for all preparatory work before the work-shop. Activities from 'selection of a project' to 'determination of VE team' can be done in this phase and if the management approval is not received the project would be abandoned.

The phases in the workshop stage would remain as it is. However, in the post-study stage an additional phase, the 'auditing phase' should come along with the 'implementation phase'. Having this phase at the end would check that desired results have been attained, documented and reported.

The Figure – 4.6 illustrate the phase structure and key areas proposed for the tailor-made VE methodology.

Table – 4.21 identifies the key objectives, questions, task and techniques that can be used in each phase of the methodology.



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Proposed VE Job Plan / Methodology

Pre-Study Stage

Identify and prioritize strategic issues or areas for study
Obtain appropriate data and information on issues or selected area
Assess the potential gains of resolving above issues
Obtain top management approval for VE study
Determine the scope and objectives of the study
Develop the study schedule
Determine team composition
Preparation work for VE study

Value-Study Stage

Information Phase

Develop cost models
Establish ground rules for VE study
Finalize the issue or area for VE study
Finalize the facts need for VE study
Refine the scope for VE study
Share the information / data among team members

Function Analysis Phase

Identify product functions
Classify functions (primary & secondary)
Develop FAST model
Estimate cost of performing each function
Evaluate function cost/worth to determine best ideas for development

Creative Phase

Establish ground rules for the session
Protect the creative environment / discourage creativity inhibitors
Do a demonstration / explain an example
Generate alternative ideas

Evaluation Phase

Classify ideas and eliminate low potential ideas
Group similar ideas
List advantages and disadvantages
Develop evaluation criteria to judge ideas
Rank ideas
Select and prioritize ideas for further development

Development Phase

Prepare a written value alternative for each idea selected
Assess total cost including life-cycle cost
Identify risks and risk mitigation methods
Determined most beneficial alternatives
Develop implementation action plans

Presentation Phase

Develop a written proposal
Ready with a oral presentation / discussion
Prepare additional information that may be required for management

Post-Study Stage

Implementation Phase

Develop change document
Make implementation schedule
Monitor progress

Auditing Phase

Compare actual results with original expectations
Prepare cost savings or other benefit reports to management
Screen all contributors to the effort for incentives / rewards
Present VE results to other departments

Figure – 4.6, Proposed VE Job plan / Methodology (Author)

Pre-Study Stage	Objective	Key Questions	Tasks	Techniques	Responsibility
	Plan and organize the VE Study	<p>What is to be studied?</p> <p>Who is best able to study the problem?</p> <p>What has to be done to prepare for a Value Study?</p>	<p>Identify and prioritize strategic issues or areas for study</p> <p>Obtain appropriate data and information on issues or selected area</p> <p>Assess the potential gains of resolving above issues</p> <p>Obtain top management approval for VE study</p> <p>Determine the scope and objectives of the study</p> <p>Develop the study schedule</p> <p>Determine team composition</p> <p>Preparation work for VE study</p>	<p>Sortout project tasks</p> <p>Identify high cost/low value areas</p> <p>Plan the project</p> <p>Obtain authorization to proceed</p> <p>Allocate resources</p>	VE Leader / Management
	Investigate the project / understand the current state of the project	<p>What is the project?</p> <p>What is the problem?</p> <p>What are the facts?</p> <p>What are the rules?</p>	<p>Establish ground rules for VE study</p> <p>Finalize the issue or area for VE study</p> <p>Finalize the facts need for VE study</p> <p>Refine the scope for VE study</p> <p>Share the information / data among team members</p>	<p>Get information from best sources</p> <p>Get all facts and available costs</p> <p>Work with specifics</p> <p>SWOT analysis</p> <p>Pareto analysis</p>	VE Leader / Team
	Identify most beneficial areas for VE study	<p>What does it do?</p> <p>What is the basic function worth?</p> <p>What are the secondary functions worth?</p> <p>What are the high cost areas?</p> <p>Can any function be eliminated?</p> <p>What are the best opportunities for study?</p>	<p>Identify product functions</p> <p>Classify functions (primary & secondary)</p> <p>Develop FAST model</p> <p>Estimate cost of performing each function</p> <p>Evaluate function cost/worth to determine best ideas for development</p>	<p>Function Analysis System Technique</p> <p>Cost to Function Analysis</p> <p>Value Index function cost/function worth</p> <p>Evaluate by Comparison</p>	VE Leader / Team
Value-Study Stage	Develop large number of ideas for alternative ways to perform intended original functions	<p>What else might to the function?</p> <p>Where else may the functions be performed?</p> <p>How else may the functions be performed?</p>	<p>Protect the creative environment / discourage creativity inhibitors</p> <p>Establish ground rules for the session</p> <p>Do a demonstration / explain an example</p> <p>Generate alternative ideas</p>	<p>Brainstorming</p> <p>Be imaginative</p> <p>Use Creative Techniques</p> <p>Don't criticize</p> <p>Be Courageous</p>	VE Leader / Team
	Refine and select the best ideas for development into specific value improvement recommendations	<p>How might each idea work?</p> <p>What might be the cost?</p> <p>Will each idea perform the basic function?</p> <p>What are the best opportunities for value improvement?</p>	<p>Classify ideas and eliminate low potential ideas</p> <p>Group similar ideas</p> <p>List advantages and disadvantages</p> <p>Develop evaluation criteria to judge ideas</p> <p>Rank ideas</p> <p>Select and prioritize ideas for further development</p>	<p>Weigh Alternatives</p> <p>Life Cycle Costing</p> <p>Choosing by Advantages (CBA)</p> <p>Value Metrics</p>	VE Leader / Team
	Determine the 'best' alternatives for presentation to the decision-makers	<p>How well the new idea work?</p> <p>How can disadvantages be overcome?</p> <p>What will be the total cost?</p> <p>Why is the new way better?</p> <p>Will it meet the requirements?</p> <p>What are the life-cycle costs?</p>	<p>Prepare a written value alternative for each idea selected</p> <p>Assigns total cost including life-cycle cost</p> <p>Identify risks and risk mitigation methods</p> <p>Determined most beneficial alternatives</p> <p>Develop implementation action plans</p>	<p>Use Search Techniques</p> <p>Get information from Best Sources</p> <p>Specialists & Suppliers</p> <p>Use New Information</p> <p>Compile all Costs - Work with Specifics</p> <p>Gather Convincing Facts</p> <p>Make Recommendations</p>	VE Leader / Team
	Obtain approval / commitment to follow a course of action for initiating a change	<p>What is recommended?</p> <p>Who has to approve it?</p> <p>How much will it save?</p> <p>How much will it cost?</p>	<p>Develop a written proposal</p> <p>Ready with a oral presentation / discussion</p> <p>Prepare additional information that may be required for management</p>	<p>Be Factual</p> <p>Be Brief</p> <p>Provide an implementation Plan</p> <p>Give Credit</p>	VE Leader / Team
Post-Study Stage	Implement the accepted value alternatives	<p>Who will implement?</p> <p>How will plans / contract be changed?</p> <p>What action need to be taken?</p>	<p>Develop change document</p> <p>Make implementation schedule</p> <p>Monitor progress</p>	<p>Translate Plan Into Action</p> <p>Overcome Problems</p> <p>Execute Action</p> <p>Monitor Project</p>	Project Manager / Dept. Head
	Audit results	<p>Did the change meet expectations?</p> <p>How much did it cost?</p> <p>Who innovated this value improvement?</p> <p>Who is to receive recognition?</p>	<p>Compare actual results with original expectations</p> <p>Prepare cost savings or other benefit reports to management</p> <p>Screen all contributors to the effort for incentives / rewards</p> <p>Present VE results to other departments</p>	<p>Verify Accomplishments</p> <p>Make Awards</p> <p>Report to Management</p>	VE Leader / Management

Project = product, process, procedure, design or services

Table – 4.2.1, Proposed VE Job Plan / Methodology – details (Author)

5.0 INTEGRATION OF VE INTO BUSINESS PROCESSES

Integration of a VE program with other activities of a construction company would be a challenging task. The management and the people who are not familiar with the VE philosophy might take this as a change that they should resist if implemented. Therefore, the process of integration of VE into a company should expect similar challenges as other similar models have to face when implemented.

In this chapter, VE as a change model would be discussed in detail, also the challenges that other change models usually face would also be discussed.

Typical characteristics that exist in the construction industry, especially with the construction business need to be discussed in adapting new VE 'change model'. Also, practical approaches that are needed in resolving problems encountered and those that neutralize the resistance that emerge would be discussed with regards to good VE practices.

5.1 VE AS AN 'ENTERPRISE CHANGE MODEL'

A VE program cannot be established in a vacuum. It must be fully integrated with other activities in the company. Establishing of VE practice means an introduction of a 'change' to the company and that can possibly make changes and influences to the management structure, the processes, responsibilities and roles played. Hence, it is very appropriate to consider VE as another enterprise change model that can effectively be used in attaining company objectives.

"The role of the value engineer/analyst involves managing change - from developing problem-solving skills of team members to increase the acceptance of change proposals throughout the organization" (Fraser 1984).

5.1.1 What is a 'Change Model'?

"Enterprise change is the change that includes organizational structures, business processes, roles and responsibilities, and technology at the enterprise level (i.e., across multiple business units). This is sometimes referred to as 'third-order change', where 'first-order change'

involves changes to technology only. The ‘second-order change’ involves changes to technology and business processes”. (Hunter, Nunno & Waller 2005)

5.1.2 Examples for Change Models and comparison of their approaches

Following are four of the most popular enterprise change models that are adapted by most of the companies around the world today.

- Lean Thinking
- Six Sigma
- Theory of Constraints
- Business Process Reengineering

There are key differences among these approaches. Each of these change models has different goals, focus, and business model. Some of the models have an enterprise-level scope, while others are narrower. Basically all these change models lead to incremental or continuous change. Despite these differences, all these models provide a positive approach for performance improvement and a change, thereby enabling organizations to drastically improve their bottom lines. Comparison of key aspects of various change models with VE approach is illustrated in the Table- 5.1.

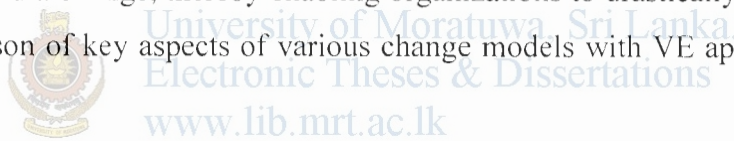


Table – 5.1, Comparison of Key Elements of Enterprise Change Models

Enterprise Change Models					
	Business Process Re-engineering	Theory of Constraints	Six Sigma	Lean Management	Value Engineering
Goal	Breakthrough solutions	Eliminate bottlenecks	Reduce variation in enterprise	Eliminate waste	Increase return on investment
Focus	Business Process	Throughput	All sources of product variation	All enterprise processes and people	Function analysis and function worth
Scope	Business unit	Enterprise	Enterprise	Enterprise value stream	Business unit
Change Process	Radical	Continuous	Process specific, continuous	Evolutionary and systematic	Incremental
Business Model	Increase enterprise performance and customer value	Increase financial performance of core enterprise	Minimize waste and increase customer satisfaction	Deliver value to all stockholders	Increase value to the customer

Source: Value Engineering Handbook, Institute for Defense Analyses

5.1.3 Comparison of VE approach with other Change Models

The Table – 5.1A above illustrate a broader comparison of various important aspects of popular change models along with VE. Also, several papers authored in the VE community have discussed one or more aspects of the relationship between VE and these enterprise change models. They are discussed below,

Cell and Arratia (2003) have discussed opportunities for using VE tools and techniques in the lean process. There, they have argued that the benefits that can be achieved by employing the VE job plan specifically to find and eliminate the seven wastes identified in lean thinking.

Cook (2000) pointed out that Six Sigma can be enhanced by better use of VM techniques such as Function Analysis.

Ball (2003) has highlighted that the theory of constraints and VE work well-together. In his argument, he also pointed out that the functional analysis of VE helps to identify the constraints and the creative, evaluative and development activities are similar to exploiting and subordinating the constraints.



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Rus (1997) has observed similarities between VE and Business Process Re-engineering and proposes integrating the two methodologies. She suggests that the analytical elements of VE would be especially beneficial to the Business Process Re-engineering process.

These various change models are there to serve a purpose. When these models are practiced companies get benefited. In the implementation, the boundaries of these models merge in practice. Also, these models have strengths and weaknesses, it is very unlikely that a single approach be suit for all aspects to a given situation. However, the complementary nature of different approaches can leads to synergistic benefits to a company.

5.1.4 Comparison of VE with Business Process Re-engineering

As discussed above various researchers have emphasized that, there are more similarities in VE and BPR. However, Lenzer (1999) has highlighted that, some big companies like IBM has opted to use the BPR in its introduction and created a significant impact on shareholder equity that subsequently affected their long-standing dividend performance, but within a year after the reengineering IBM has discovered their zeal to streamline their organization. As a result, they have inadvertently eliminated functions that are critical to perform its core businesses. Therefore, it suggests that functional analysis activities of VE methodology would be more attractive in modern BPR applications.

In 1997 Mary J. Rus has suggested that to explore the methodologies and techniques of VE & BPR and mould them into a single process to decrease cost, increase quality, and improve timeliness, to satisfy the customers. Further, she has added that the requirement of embracing change and learning how to manage change, because companies no longer can afford to indulge in comfortable acceptance of the status quo. Therefore companies must go for change and actively shape that change to fit into the customers' future needs.

To face these challenges Mary J. Rus (1997) has proposed a new change model called Business Process Value Engineering (BPVE) which provides an excellent medium for synchronizing customer needs with the business process which the companies needs to support the products and services it offers.

5.2 HOW TO FACE CHALLENGES IN INTEGRATION OF VE INTO BUSINESS PROCESSES

Introducing and establishing VE concepts as a change model will require a lot of attention and preparatory work in a construction company. Convincing of VE benefits to a construction company would be more challenging due to the industry not being familiar of the concepts as quoted by most of the previous researchers. Following sub sections discuss various potential challenges that need to be addressed in the implementation stage. In addition to that various ways for facing and neutralizing them are also discussed.

5.2.1 Industry Awareness

Perera, Karunasena & Selvadurai (2003) have highlighted that absence of guidance or knowledge about the benefits of VM among the clients, developers, and so on, as one of the reason for the absence of proper VM practice in the Sri Lankan construction industry. If the popularity of a concept is less in the industry, it is very unlikely to get the attraction of the masses toward such a concept. This is true to the VE in the construction industry of Sri Lanka as well. The absence of a true understanding of the VE philosophy and its correct procedures by the key players in the industry the consultants, contractors, developers and other clients can be identified as the reasons for low awareness. The research results on this area were discussed in Chapter – 3.

However the author believes that the recent inclusion of VE into the standard bidding document as a clear and positive signal for better VE practice in the future. The construction companies who are ready to take the challenge and have the will to capitalize on VE, can interact with the construction industry regulatory body the ICTAD and make this a compulsory requirement in the projects handled by the Government in the future. The National Contractors Association of Sri Lanka (NCASL) can also play a better representative role in rallying to this effect. However, required initiatives need to be taken by the individual construction companies on their own.

5.2.2 Top Management Support

This is one of the key aspects to consider in implementation of a change in a company. The amount of recognition and attention gained from the top management to a change would guarantee its adherence and acceptance by the others in the company. Therefore the most effective way of creating a VE oriented environment in the company is to get the top managements support and commitment by institutionalizing the VE requirement through a written policy that is adequately resourced.

“The discipline and rigor involved in applying the value engineering usually cannot be sustained in a bottom-up approach. Leadership attention will ensure implementation and continuing support from the entire organization” (IDA, 2006). Therefore, the initiator or the

leader of VE needs to convince the paramount importance of having a change model like VE to prosper and get the competitive edge in the market.

Kirk & Sherwood (2000) have pointed out that 'management involvement by those who stand to gain from VM study is essential'. According to them, it is vital to have commitment of the top manager who has direct responsibility towards the selected aspect for the VE study, as, he is the one who can understand the basis for the study recommendations and finally assist in getting the new value ideas implemented.

5.2.3 Peoples Resistance to Change

There can be a number of reasons as to why people resist to a change in an organization. According to Woldring (1999) there are four fundamental reasons for resistance and they are discussed below.

The first reason why people resist to a change is because they **do not understand** it. They don't have the background of it. They don't understand where you are going and how you are planning to get there. The manager's response for this should be proper and with adequate communication. Such communication or information must be rich with reasonability and clear answers for possible questions such as why, what, when, how and where that can come from the people of the company. The benefits that both the company and people can get from an effective VE practice need to be convinced to the people. Explanation on VE's potentiality to achieve business objective by achieving value improvement can attract the people.

The second reason why people resist to a change is that **they don't have the time** to engage with the change. They cannot both change and handle their current accountabilities. Focusing their energy on the change activity puts them at risk on meeting their routine accountabilities. Therefore, selection of VE team and team leader must be done carefully, also the management should make sure that VE team find required time for the new assignment among other routine works. Lots of non productive functions that management still expect people to do, will have to be reviewed to find required human effort for innovation.

The third reason for why people resist to a change is, because they **do not have the competencies to do what this new changes wants to do**. It makes sense for people to resist under those circumstances, where they are exposed as not competent. Therefore, the first thing that management should do is to figure out is whether or not the resisting individuals have the ability to acquire the new competencies. The department heads can easily identify the people who fit for the VE teams initially, and others can be trained subsequently for future programs. Effective training programs which demonstrate practical VE improvement done in the past in various disciplines by various organizations would attract the people for such a practice with in the company.

The last reason why people resist to a change is because they **don't share the values that drive the change**. This essentially means that they think you are wrong to initiate it. They believe that the “change” is wrong. They have no choice but to resist you strongly in order to preserve their self esteem. In those circumstances, first thing is to educate them about the significance of the change, top manger level briefing would sometimes solve the problem. But in a worse case scenario exclusion of the member from the VE team would be more suitable, because the energy you spend dealing with them is better to spent on implementing the change.

Therefore, integrating of VE concepts into existing practices would not be a very easy task. In addition to the points discussed above, development of positive attitude towards the program by stimulating for continuous participation and interaction would facilitate the process in a construction company set up.

Rae Cook (2000) has pointed out ‘to consciously be persuasive throughout the entire facilitation’ to have an increase personal commitment from the people of the company. Also, she has emphasized that initial need is to identify ‘what is persuasive for a particular group’. Cook’s recommended persuaders are illustrated in Figure – 5.1 and persuaders will help to effectively eliminate the peoples’ resistance to establish VE practice with in construction companies.

Figure 1. Content Types of Persuaders
The first table identifies the top four persuaders for executives⁶.

1. Clear Information	2. Discuss Implications	3. Help with Decisions	4. Respect Constraints
<ul style="list-style-type: none"> ▪ provides facts and figures logically ▪ gives meaningful statistics ▪ makes relevant projections ▪ assigns value or ranking to information 	<ul style="list-style-type: none"> ▪ thinks of implications of the proposed change for the unit, department, division, or corporation ▪ talks about implications of the implications across engineering, marketing, finance, manufacturing, QA, IT, customers, suppliers, etc. 	<ul style="list-style-type: none"> ▪ Knows and discusses decisions to be made ▪ outlines next steps ▪ shows signs of commitment and energy ▪ acts decisively ▪ makes recommendations 	<ul style="list-style-type: none"> ▪ considers regulations & requirements ▪ sensitive to limitations ▪ shows how to do more with less ▪ something missing? ▪ budget limitations ▪ potential negative impact ▪ Are the numbers right? ▪ "holistic worry"

Other persuaders:

<p>5. Prevent Problems</p> <ul style="list-style-type: none"> ▪ analyzes potential problems ▪ provides solutions ▪ provides security by preventing problems ▪ risk averse ▪ takes responsibility/ownership 	<p>6. Unspoken Needs Met</p> <p>needs for:</p> <ul style="list-style-type: none"> ▪ acknowledgment ▪ approval ▪ trust ▪ acceptance ▪ attention ▪ affirmation of their ideas 	<p>7. Achieve Goals</p> <ul style="list-style-type: none"> ▪ connects to their goals ▪ increases promotability ▪ politics: who to influence
<p>8. Give Options</p> <ul style="list-style-type: none"> ▪ presents alternatives/choices or possibilities 	<p>9. Increase Leverage</p> <ul style="list-style-type: none"> ▪ Can generalize learnings ▪ Can influence other departments ▪ Cross-functionality 	<p>10. It's really THEIR idea</p> <ul style="list-style-type: none"> ▪ involves audience in process of choosing methods or conclusions ▪ find something to attribute to them in your presentation
<p>11. Have Precedence</p> <ul style="list-style-type: none"> ▪ describes previous cases ▪ offers benchmarking info ▪ presents new or innovative ideas (no precedence) 	<p>12. Spell Out Reasonable Costs</p> <ul style="list-style-type: none"> ▪ Detailed budget and results ▪ Costs are less than expected ▪ Get more for less ▪ Conservative projections 	<p>13. State Actionables and Impact</p> <ul style="list-style-type: none"> ▪ to-do items ▪ deliverables ▪ metrics/measurements ▪ time frames ▪ impact on people and profits



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(Source – SAVE Conference Proceedings 2000, Lecture by Cook R.)

Figure – 5.1, Cook’s recommended persuaders

Clifford Louie (2000) of Sierra Army Depot in USA has disclosed the following as his success factors for a good VE program.

1) Three Basic Attitudes

- i) Be passionate about VE – be yourself passionate about VE, because it is very interesting and a powerful problem-solving methodology, it can greatly benefit your company and it gives you a much personal job satisfaction.
- ii) Make your company work – understand the way that the company works that is about rules and regulations, people and politics and then you can get the things done.

iii) Create Win – Win Situation – by quoting a statement from Dale Carnegie’s book ‘How to make friends and influence people’ – “one should talk and act in terms of the other person’s interest” it is emphasized that ‘when you talk and act in terms of the interest of management and the employee, you will achieve good results’.

2) The Main attitude - Be Proactive and Opportunistic

i) Have a plan – this will make you proactive towards VE, also will ensure setting up of goals and focus time and energy to achieve them.

ii) Do work other than VE – involving or studying other aspects of the company would help VE leader to understand and explore other potential areas that can improve for better value.

iii) Vigorously promote VE program – practicing VE only in one area would not help to popularize the concept with in the company, therefore every effort should be taken to expand and promote into other areas or departments of the construction company. Details of VE studies completed, value improvement achieved, incentives given and management appreciation gained has to elaborate with the other people of the company.



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5.2.4 Cost of VE

The VE study involves a multidisciplinary team of people working together for potential value alternatives for a given product, system, process or procedure. The cost of the team involved for the study including any other resources used need to be taken as cost of the VE study. In some cases the payments made to the external consultants also need to be taken into account. It is the management’s responsibility to get the required approval for the VE study from the sponsor. The Table – 5.2 illustrate an example of a VE study cost that can be presented to the top management to seek the approval for the study.

As in the above example, cost of the study can be derived from the cost of the staff that plan for the VE study. According to the situation, number of members for the team, time allocations and resource required can be determined by the VE leader and the management. In a contract,

which encourages VECP for value improvement has the facility to get this expenses recovered before sharing the 50% of the saving that contractor make from the innovation.

Table – 5.2. An example for VE study cost calculation

Study Phase/Activity	In-house Staff	Staff Hours	Unit Cost/hour (Rs)	Staff Hours
Pre-study (say 5 days)	1	40	500.00	20,000.00
Team Study (4 days)				
Construction Engineer	1	32	500.00	16,000.00
Senior Estimator	1	32	500.00	16,000.00
Site Manger	1	32	500.00	16,000.00
Procurement / Logistic	1	32	350.00	11,200.00
Presentation (1 day)	1	8	500.00	4,000.00
VE Leader	1	8	500.00	4,000.00
Construction Engineer	1	8	500.00	4,000.00
Site Manger	1	8	500.00	4,000.00
Stationeries / facilities				3,000.00
Other expenses				1,000.00
Assumption - 8 hour days				
Cost of the VE study		Rs.		99,200.00

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When the people get familiarized and management accepts the VE practice as a management tool within the company, as proposed by Kirk & Sherwood (2000) a VE program budget can be allocated by the top management to cover the cost of the VE team leader, incentives for VE team, several VE training sessions and so on.

5.2.5 Company Resources

Resource availability within a company can influence the effectiveness and efficiency of VE practice within it. Kirk & Sherwood (2000) have pointed out that “without doubt, access to abundant, high quality resources increases an organization’s chance of using VM effectively and coping with change”. Here they have discussed resources such as people, equipments, technologies and cash as the key with other less tangible resources such as product designs, information databases, brands and relationship with suppliers, distributors and customers for a successful VE practice. These resources and their impact are discussed in the following sub sections.

5.2.5.1 People

People of the company are the key resources for a better VE program. As discussed in section 5.2.3 above, their resistance can make the program fail in any stage. Requirement of a multi-disciplinary / cross functional team for VE would not be a problem in the construction business, because, most of the construction companies have their own professionals representing various disciplines such as construction engineering, services engineering, quantity surveying and project management. In addition to that representations from other functional areas such as procurement and logistics, marketing, maintenance and operation departments can make the VE team more resourceful and versatile. Sharing knowledge of such a versatile team across a table in a work-shop would produce valued results that can attract the stakeholders involved.

“Selection of a VE leader with expert knowledge of the study methodology and with well honored skills for facilitating a group is important” (Kirk & Sherwood, 2000). Because, at the end he is the one who should plan, lead and facilitate the VE study. The role play of the VE leader as proposed by the SAVE is given below.



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Team Leader's Responsibilities

1. Ensure proper application of a value methodology and follow the Job Plan
2. Guide the team thorough the activities needed to complete the pre-study, the Value Study and the post study stages of a Value Study.
3. Delegate responsibilities as appropriate
4. Schedule follow-up team meetings and prepare the agenda
5. Keep team focused on specific topic
6. Keep team members involved in the discussion and the work that needs to be done
7. Keep all team members together whenever possible. It is desirable that everyone breaks together, to maintain team continuity
8. Be a catalyst to keep team moving and motivated. Be diplomatic; not dictatorial.

(Source: SAVE Body of Knowledge, 2007)

5.2.5.2 Database

As in, any other industry, construction business also experience high labour turn-over in times due to various reasons. Especially with professionals and expertise the potential impact to the company is significant. The knowledge, each of these professionals shared and experts employed in difficult circumstances will not be remembered for years. Lessons learned, materials used, designs done and approaches succeeded has to be recorded for the future use in such situations. Construction business involves thousands of various types of materials, products, components and systems that can vary from project to project. Specific data such as cost, life-span, technical properties, advantages & disadvantages, maintenance aspects and many more of these products would be very useful in the future, especially in terms of VE studies. Therefore, maintaining of an active database would facilitate storage, share, exchange and retrieval of data required for VE studies. Possessing such a resource within the company would be a success factor for a better VE practice within the company.

5.2.5.3 Technology

The existing technology used by various construction companies may not be the most updated one in the industry. New construction materials, components and systems are being introduced day by day. New equipments, tools and techniques are innovated. Cheaper and faster construction methods have developed. Therefore, construction companies should be aware of the technological advancement in the world and especially in the Sri Lankan context, because early adaptation of such innovations will help to gain the competitive advantage in the market. It is not necessary to grab all new technology that comes into the market, but keeping an updated knowledge on such things, their features, properties, advantages and disadvantages would be useful in finding solutions in difficult situations.

5.2.6 VE Methodology

As discussed in previous chapters, non-availability of proper VE methodology and a guideline was one of the major reasons for fewer applications of the concepts among the construction companies. Previous research done on this area has also emphasized on this. The data analysis, in Chapter – 3 has also verified this into a greater degree. Therefore, availability of proper VE methodology and a guideline would facilitate the application of this valued concept in practice.

However, some of the aspects discussed and proposed in new VE methodology for construction companies can further be tailor-made to the specific requirements of a particular construction company. Workbooks and guideline as in Appendix – A, would illustrate the correct way of conducting VE study in a construction company.



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6.0 RECOMMENDATION AND CONCLUSION

6.1 CONCLUSION

6.1.1 Significance of VE for business success

Completion of Tsunami re-constructions and prevailing global economic crises has drastically reduced the number of new projects in the market. The drastic impact of this was commented and admitted by various construction companies which were interviewed for this study. In addition, the changes that are happening in the world in areas of technology, global trade and competition, quality standards and information exchange system also makes meaningful impacts on this business all the time. Therefore, requirement for innovative and cost effective solutions were identified as the key for future business prospects in competitive environments. As a result, VE was emphasized as a better concept for the future business of construction companies which should be ready to face above challenges for survival and success.

By establishing good VE practice or innovative culture, the construction companies would be able to withstand against any future challenge that can come on their way. The value improvements that VE can create on products, project, processes, systems and procedures would therefore help companies to gain the competitive edge in the market.

6.1.2 Findings

The literature on the subject area revealed that, this concept is being successfully used in other countries such as United States of America, Britain, Japan, Thailand, China, India and Korea in most of industries including the construction. Vast range of benefits and improvements that an effective VE program can deliver has been the major attraction for the concept in these countries.

Previous research findings have highlighted that, VE practice in Sri Lanka is still in a low level when compared to other countries due to number of reasons. Unavailability of a proper VE procedure or guideline and absence of an active encouragement to use VE by the construction industry regulatory body of Sri Lanka which is ICTAD have been emphasised as the main

constraints. In addition to that, industry unawareness of the concept, lack of knowledgeable people and absence of contractual provisions has been identified as the other major barriers.

However, in year 2007, ICTAD by revising the 'Standard Bidding Document for Major Work (SBD/2)' has given the due recognition for VE practice in the country. In this revised version, required contractual provisions have been added to the 'Conditions of Contract' by eliminating the contractual barrier that was discussed in past. However, 'unavailability of a proper VE procedure or methodology' still remains as a major barrier. The survey results also reveal that most of the construction companies are in favour of having a proper VE methodology and guideline for them to have an effective VE practice in the future. This acceptance therefore, justified the importance and validity of the objectives of this research as well.

Further, survey results also disclosed construction companies' readiness to accept the ICTAD's move of recognizing VE for a better and effective VE practice in the future. This positive thinking therefore, further justified the significance of the study.

Survey results also revealed that VE awareness of the people and management in terms of its concepts, benefits and correct methodologies was in a considerably low level. Therefore, this results also justified the facts revealed by previous researches on these aspects.

Previous research findings and the latest facts found from the survey revealed that the people and the management attitude, awareness of the concepts and knowledge on VE methodologies are not very satisfactory. Therefore, the inputs that could possible get from these people in developing a new VE methodology for better practice was considered very limited in this very early stage.

6.1.3 New VE methodology

Various VE manuals, guidelines and methodologies that are being practiced in other countries were thoroughly analyzed in determining a proper methodology for the Sri Lankan construction companies. VE methodologies, different phases and their scopes, various tools and techniques used in each phases of these selected VE manuals were separately analyzed in

developing a tailor-made methodology. In developing this methodology, author's field experience and opinions of the experienced professionals who were interviewed were blended as appropriate to determine the scope and other aspects of the methodology & guideline.

The methodology and the guideline / workbook developed were not field tested due to the time restriction. This field testing need another field survey which involve detail presentation of the methodology and guideline and discussions with the field people for their comments and suggestions. If field tested, there may be few changes or modifications to the content. However, these outcomes can be considered valid and acceptable due to the fact that these outcomes were achieved from a deep literature review and detail analysis of existing VE manuals.

6.1.4 Integration of VE into existing practice

Proper understanding of VE concepts and availability of a better methodology and guideline itself would not be sufficient for an effective VE practice in the industry. It is also necessary to understand that, this is a change that is going to be introduced to companies and therefore correct approach of integration of the practice to the existing systems need to be seriously planned for. The integration difficulties however could be minimized by considering this as another 'organization change model' similar to other models such as Six-Sigma, Lean thinking and Business Process Reengineering. With such planning, possible implementation barriers such as people resistance, less management support, resource problems and attitude problems could be effectively controlled and eliminated.

The survey results also disclosed that, securing of top management support is a prerequisite for a better VE practice in construction companies. Keeping the VE team happy by providing incentives and due recognition within the company would be the other most important aspect for a better VE practice in future.

6.2 RECOMMENDATION

6.2.1 Future Research

People and management's awareness and attitudes on VE and their knowledge on correct VE methodologies were tested by using a relatively small sample. Random samples were taken from the top three graded companies registered with ICTAD for 'building' category. Therefore, in future the representative sample size can be increased to include the higher graded companies specialized in other construction disciplines such as roads, bridges and irrigation to check deviations of the variables analyzed in this study.

The methodology and the guideline / workbook developed should be field tested to see their direct applicability to the practice. Detail presentation and discussions with the field people should be planned in this field tests. Illustration of examples would be very effective in this proposed field tests to make people directly focus on the subject. Based on the field test the methodologies and work book can be revised to incorporate the critical findings from the tests.

6.2.2 Promotion of VE practice

Companies need to be made aware of the importance of the VE concepts for a better business future. The institutes such as ICTAD should promote the VE practices within construction companies by providing required awareness, training and guidance. In that effort, such institutes can make use of the methodology and the guideline developed under this study to focus the companies on correct practices. The guideline and specially the VE workbook developed under this research could be effectively used to establish a proper VE practice within the companies.

In addition, such institutes should involve for further improvements of this methodology and guideline / workbook to make it standard documents for the industry to practice proper VE in business.

For a better VE practice in the future, more efforts are required from the top management of the respective construction companies. In particular, their commitment for VE efforts and encouragement of the people for such practice is very vital for an effective practice in the future. People of the companies should be given proper education and training on the concepts as well as on the correct VE methodologies.

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APPENDIX - A

VALUE ENGINEERING FOR SRI LANKAN CONSTRUCTION COMPANIES

GUIDELINE & WORKBOOK

(BLANK)



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Proposed VE Job Plan / Methodology

Pre-Study Stage

Identify and prioritize strategic issues or areas for study
Obtain appropriate data and information on issues or selected area
Assess the potential gains of resolving above issues
Obtain top management approval for VE study
Determine the scope and objectives of the study
Develop the study schedule
Determine team composition
Preparation work for VE study

Value-Study Stage

Information Phase

Develop cost models
Establish ground rules for VE study
Finalize the issue or area for VE study
Finalize the facts need for VE study
Refine the scope for VE study
Share the information / data among team members

Function Analysis Phase

Identify product functions
Classify functions (primary & secondary)
Develop FAST model
Estimate cost of performing each function
Evaluate function cost/worth to determine best ideas for development

Creative Phase

Establish ground rules for the session
Protect the creative environment / discourage creativity inhibitors
Do a demonstration / explain an example
Generate alternative ideas

Evaluation Phase

Classify ideas and eliminate low potential ideas
Group similar ideas
List advantages and disadvantages
Develop evaluation criteria to judge ideas
Rank ideas
Select and prioritize ideas for further development

Development Phase

Prepare a written value alternative for each idea selected
Assess total cost including life-cycle cost
Identify risks and risk mitigation methods
Determined most beneficial alternatives
Develop implementation action plans

Presentation Phase

Develop a written proposal
Ready with a oral presentation / discussion
Prepare additional information that may be required for management

Post-Study Stage

Implementation Phase

Develop change document
Make implementation schedule
Monitor progress

Auditing Phase

Compare actual results with original expectations
Prepare cost savings or other benefit reports to management
Screen all contributors to the effort for incentives / rewards
Present VE results to other departments

(Author)

General Instructions:

Complete each page clearly, legibly, and neatly with a pencil or pen.

Pre-Study Phase

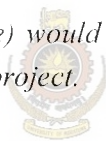
This phase should be completed before the VE team is assembled for the study. While gathering information about the project to be studied, complete the two forms in this section.

Time schedules for the VE study need to be determined in this phase. VE team leader can determine the time frame for the study, subject to the scope and other critical factors.

Time frame for the pre-study phase would be few weeks. However, the significance, complexity of the project and other priorities of the companies would decide the time frame.

Also, during this stage required logistic arrangement for the VE study need to be planned.

The time frame for the Value Engineering study (i.e. from information phase to presentation phase) would be 3 to 5 days, however this can vary according to the complexity of the project.



Completion of Form: VE – 01 [Pre-Study Phase – Project Identification]

The information needed to identify the project or issue is included in this form. By reading this page, an interested party should be able to understand the general nature and scope of the project.

Heading:

Include VE study number

Project Description:

Include as much information as needed to understand the project.

Major Project Elements:

Describe about, what is involved in the project.

Listing of major components of the project would be useful for the VE team to properly understand the project.

Example – foundation, services, architectural features, finishes and so on.



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Site Condition / Geometry:

Describe the project location and any other special features that may be required to know about the project.

Study Goals:

List the major goals of the VE study

Example - Generate alternatives for undesirable project elements.

- Reduce Project Cost



Completion of Form: VE – 01A [Pre-Study Phase – Approval Authority]

Authorizing Persons:

List here the persons, i.e. top management, project managers, department heads and any other people responsible for reviewing and / authorizing recommendations. Their contact details will also be useful during the VE study.

In a construction company, this can consist of either one person or few from a list of company directors, project directors, project managers, construction managers or department heads.

Data Sources:

List all the sources of data to be used for the VE study. Name of the source, date etc... those need to be recorded. The 'data type' would be cost estimates, drawing, standards etc...

In a construction company the data sources would be,

a) People source

- People from the tender department*
- People from the construction management department*
- People from procurement and logistics*
- Experienced engineers / technical staff*

b) Documents

- Detail cost estimates done for previous projects*
- Preliminary cost estimates*
- Drawings, specifications and BOQs of various projects*
- Manufacturers manuals for proprietary methods and systems*
- Printed details of various materials and components*
- Previous purchase orders*

c) Other sources

- Data bases*
- Various records / information from other departments*

VE Team:

List here the persons who make the VE team, their names, position, department and telephone number.

In a construction company following people can make the team,

a) If the team is for making VECP (a change to the final product)

Project manager

Project quantity surveyor

Experienced construction engineer

Experienced service engineer

Construction experts

Structural engineer (if not in-house – hired person)

Designer (if not in-house – hired person)

b) If the team is for making an improvement in 'maintenance department'

Head of the department

Workshop engineers

Person from logistics department

Senior work supervisors

Technical experts



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Prepare Preliminary Cost Vs Saving Calculation:

The purpose of this information is to highlight the significance of this VE study to the management. Convincing of potential value improvement and cost savings would guarantee the management support for the study.

However, at this stage of the study, reasonable estimates will not be available. But, also it may not be too difficult to develop a reasonable understanding of the costs involved and potential saving that can expect based on a 'rule of thumb' analysis. Some information is normally available, even in this early stage

Example - one potential solution for a 'highly decorative architectural plaster work on a building elevation' which requires number of specialize craftsmen, would be the use of 'pre-fabricated plaster mouldings' to make them as pre-cast units by using cheap fiber-glass mouldings. Here the cost and savings can easily be calculated using very rough cost data.

However, during the VE study many more attractive ideas can come. The primary solution discuss here should not inhibit creative activities of the study.

Pre-Study Phase - Approval Authority		Date:
Form No:	VE - OIA	VE Study Number
Project Description		
Project Name:		Project No:
Authorizing Persons		
Name	Position	Contact Detail
Data Sources		
Data Type	Source	Remarks
 University of Moratuwa, Sri Lanka. Electrical & Electronic Engineering VE Team Theses & Dissertations		
Name	Position/Department	Contact Detail
Preliminary Cost Vs Saving Calculation		

Adapted from Value Engineering for Small Transportation Projects - By Clark J.A. (1999)

Information Phase

General Instructions:

Distribute copies of forms completed during the pre-study phase to all members of the VE team prior to VE study. So that team can have more time to investigate about the issue.

Finalize the scope of the issues to be addressed - discuss the problem with the team members to achieve a consistent understanding of the issues at hand.

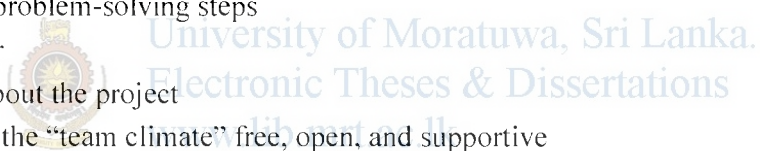
Finalize challenging improvement targets that VE team need to reach at.

Examples – cost savings, value improvements, reduce life-cycle-cost

Encourage team work towards a common goal

Establish ground rules for the VE study

- Whenever possible share workload equally among team members
- Do not be afraid to make mistakes
- Follow the basic problem-solving steps
- Be a good listener
- Be enthusiastic about the project
- Work hard. Keep the “team climate” free, open, and supportive
- Fully use individual and team abilities, knowledge, and experience



Completion of Form: VE – 02 [Information Phase - Cost Model]

Purpose of this cost modeling is to identify the projects elements that deserve the most attention.

Estimate Source:

List here the source and date of estimate that were used here.

Project Cost:

The project costs are normally spread into large number of items, hence grouping them into ten to twelve major categories would facilitate the preparation of cost model

Examples: foundation, services, architectural finishes and so on

For each cost item, calculate the percentage of the project cost it represents (calculate the % by item cost divided by total cost). Also make any important remarks.

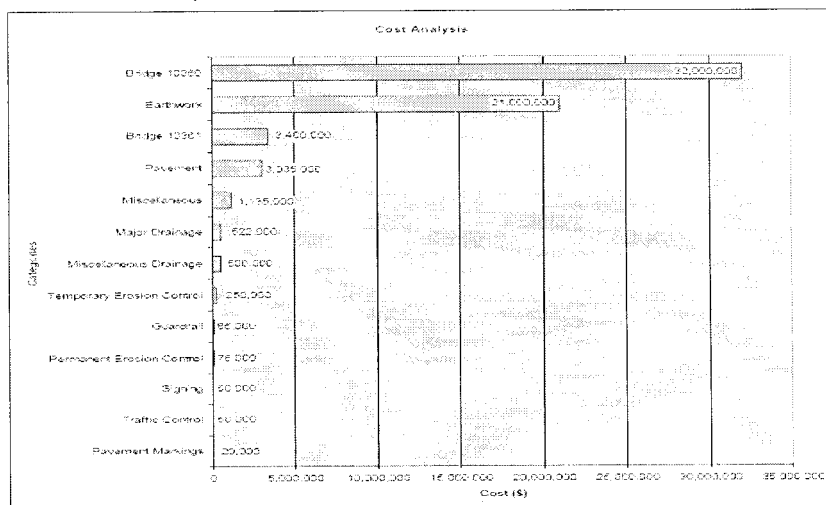
Pareto Analysis - COST MODEL:


For the Pareto analysis, estimate the smallest number of items needed to make up 80% of the total cost. The easiest way to do this is to start with the largest cost item and work down, adding percentages until you reach approximately 80%.

Using a Bar Chart format, show the cost of each item starting with the highest cost item first. [Items in vertical axis, Costs in horizontal axis]

- Draw a horizontal line to show the 80% cost spit of the project items.

Example – Pareto Analysis



Information Phase - Cost Model		Date:	VE Team:
Form No:	VE - 02	VE Study Number:	
Project Description			
Project Name:		Project No:	
Source of Estimate:		Date:	
Project Cost			
Item	Cost (Rs)	% to Total Cost	Remarks
Pareto Analysis			
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Adapted from Value Engineering for Small Transportation Projects - By Clark J.A. (1999)

Completion of Form: VE – 03 [Function Analysis phase– Function analysis]

The items and costs in the Cost Model, need to be transformed into a listing of project FUNCTIONS and their relative costs. It is also necessary to keep in mind that the objective of the function analysis phase is to identify those functional areas that have the greatest opportunity for value improvement.

For each item, identify one or more functions that item perform. Define each function in two words an **active verb & measurable noun**.

Example - one function of a hammer is to 'apply force'

By identifying and naming project functions using an active verb that operates on a measurable noun will communicate what work an item or activity performs. This naming process helps multidisciplinary teams to build a shared understanding of the functional requirements of the project.

Classify each function as '*basic*', '*required secondary*', '*secondary*', or '*unwanted*'. A '*basic function*' is the one that is essential to the project. A '*required secondary*' function is,

- Necessary for supporting a basic function, and
- Must be achieved to meet codes or standards, or
- Must be included to satisfy the owner

Example: the 'basic' function of paint is to 'protect surface' and 'required secondary' function is to 'improve appearance'

A '*secondary*' function is not necessary and has a "worth" of zero.

An '*unwanted*' function is an undesirable effect that may require mitigation.

Items satisfying the same function should be grouped together.

The "cost" for each item comes from the estimate on cost model. If practical, allocate the item cost among its functions.

The "worth" of each function is the estimated cost of the least expensive way to fulfill that function. That is about the least cost that the VE team believes can accomplish the same function. This should be a less costly way of performing the same function, irrespective of its project application.

Example, the least expensive way to "transport water" may be a simple ditch.

Some more examples are,

ITEM	FUNCTION	COST	WORTH	COMMENT
Bridge	Cross Obstacle	Rs. 25 Million	Rs. 10 Million	Use Culvert
Culvert Pipe	Convey Fluids	Rs. 10 Million	Rs. 2 Million	Use open ditch

Record any notes about functions, costs, and worth in the "Comments" field.

Identify the functions of the entire project. Sum the "costs" and "worth" to get the project cost and worth.

The size difference between the 'cost' and the 'worth' of the function is an indication of value opportunity.



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Function Analysis Phase - Function Analysis				VE Study Number:	Date:	VE Team:
Form No:	VE - 03			Project Description		
Project Name:				Project No:		
Item No	Item Description	Function		Cost	Worth	Comments
		Verb	Noun			
Function = Active Verb + Measurable Noun Kind = basic, secondary, required secondary & unwanted						
1						
2						
3						
4						
5						
6						
7						
8						
9						
Total Project						



Adapted from Value Engineering for Small Transportation Projects - By Clark J.A. (1999)

Completion of Form: VE – 03A [Function Analysis – Cost / Function analysis]

Purpose of this form is to continue with the function analysis and to rank the ideas based on their importance.

Function Analysis:

Get the 'function & kind' details from Form: VE – 03

Calculate the percentage of the total cost and worth that each function represent. (Calculate the % by function cost divided by total function cost)

Include any relevant 'comments' as required

Calculate the Cost/Worth Ratio

Value can be quantitatively expressed through the cost to worth ratio. This is also called as the 'Value Opportunity Index'. High ratios indicate poor value. Low ratios indicate good value. The Value Opportunity Index established for a project or a function provides a measurement of its true value and suggests items or functions for further studies.

[(cost/worth) > 1 = poor value, (cost/worth) < 1 = good value], Sri Lanka.



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Based on the cost & worth percentage and cost/worth ratio rank the functions in descending order.

Select the functions to consider for the next phase

Completion of Form: VE –03B [Function Analysis phase – FAST Diagram]

The other technique that can be used to create a better understanding of functional relationship is the 'Function Analysis System Technique'. The outcome expected from the Forms VE – 03 and VE – 03A can be achieved through this technique as well. As per the requirement or the situation suitable technique can be determine by the VE team.

The FAST diagram is a graphical representation of the functional logic applied to the original design, i.e. the FAST basically represents how the functions of a project relate to each other.

The FAST model has a horizontal orientation described as the HOW & WHY dimension. This dimension is described in this manner because HOW and WHY questions are used to structure the logic of the system's functions.

Step – 1, Determine the 'higher order function': A FAST diagram begins with the basic functions on the top and the secondary functions on the bottom. A 'higher order function' is the function which fulfills the overall needs and wants of the user - in other words, is the main reason for the existence of the project. The 'higher order' function need to be separated from the basic functions and it should be pulled to the left side of the FAST diagram. For example 'protect surface' can be taken as the 'higher order function' of the wall paint.



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Step – 2, Identify the primary basic functions: Select the basic functions that directly answer the question "how does the project perform the 'higher order' function?" If direct answers are not among the existing basic functions, it is necessary to create a new one. All of these "primary" basic functions need to be grouped at the top of the first column, but to the right of the 'higher order' function.

Step – 3, Identify the primary supporting functions: The purpose of the 'primary supporting' functions are to assure dependability, convenience, user satisfaction and user attraction. In the FAST diagram, all the primary support functions need to be grouped to the right of the task function, but below the primary basic functions.

Step – 4, Expand the FAST diagram to the right: By asking the question 'how the project does this from the viewpoint of a user?', the diagram need to be expand to the right. Most answers to the question will be found among the existing functions. Add second, third level, and lesser functions as needed, but don't expand a function unless the "how" question is answered by two or more functions. Both primary basic and primary supporting functions should be expanded in this way.

Step - 5, Verify the FAST diagram: The FAST diagram need to be verified by asking "why" as you move across the page to the left. Figure -1, illustrate a typical FAST diagram.

Example: for FAST diagram

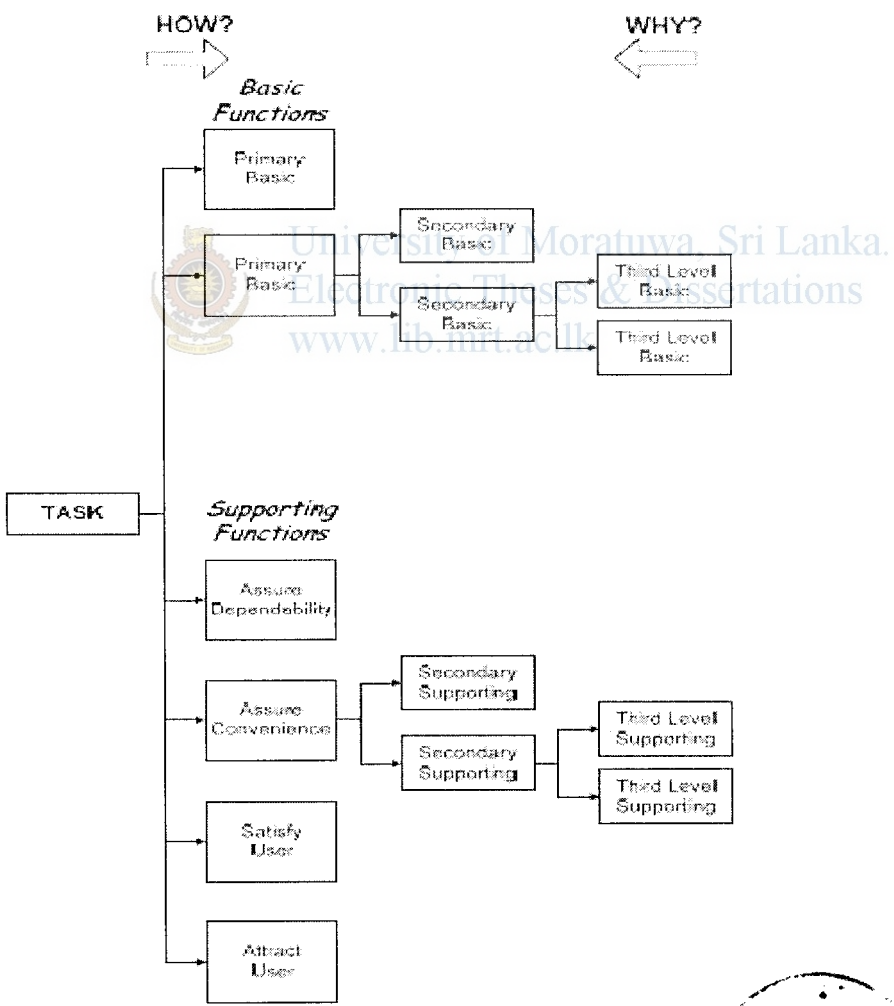



Figure - 1. Typical FAST diagram (Source: Value Engineering Handbook - IDA)



Function Analysis Phase - FAST Diagram		Date:	VE Team:
Form No:	VE - 03B	VE Study Number:	
Project Description			
Project Name:		Project No:	
FAST Diagram			
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(Author)

Completion of Form: VE – 04 [Creative Phase – Brainstorming]

Summarize original design and function in one line.

Complete a separate form for each function

BRAINSTORM on each of the functions to make as many ideas as possible.

Remember the number one rule of brainstorming, DO NOT JUDGE!

General Instructions:

Ground rules - the main objective of this phase is to collect as much as ideas that may lead to alternative solutions to the problem identified. Following ground rules may ensure generation of creative ideas.

- No idea is criticized and all ideas are recorded.
- Judicial and negative thinking is not permitted.
- To ensure large number of ideas, focus on quantity not quality.
- Pick the opportunities to improve or expand ideas as they are generated.
- Look for variety of ideas or solutions that covers a broader spectrum.
- Note down all the ideas generated, do not discard any even feel impractical.

Discourage Creativity Inhibitors – In this phase, it is required to make sure that maximum numbers of ideas are generated; hence, factors that act as creativity inhibitors should be controlled, minimized or eliminated. Examples of such inhibitors are,

Habitual Blocks:

- Desire to use “tried and true” procedures even though new and better ones are available.
- Rejection of alternative solutions those are incompatible with habitual solutions.
- Lack of positive outlook, lack of effort, conformity to custom, and reliance on authority.

Perceptual Blocks:

- Failure to use all the senses for observation.
- Failure to investigate the obvious.
- Inability to define terms.
- Difficulty in visualizing remote relationships.
- Failure to distinguish between cause and effect.

- Inability to define the problem clearly in terms that will lead to the solution of the real problem.

Cultural Blocks:

- Desire to conform to proper patterns, customs, or methods.
- Overemphasis on competition or cooperation.
- The drive to be practical above all else, thus making decisions too quickly.
- Belief that all indulgence in fantasy is a waste of time.
- Faith only in reason and logic.

Emotional Blocks:

- Fear of making a mistake or of appearing foolish.
- Fear of supervisors and distrust of colleagues.
- Too much emphasis on succeeding quickly.
- Difficulty in rejecting a workable solution and searching for a better one.
- Difficulty in changing set ideas (no flexibility) depending entirely upon judicial (biased) opinion.
- Inability to relax and let incubation take place.

(IDA, 2006)

Generate as much as ideas – The team should be encouraged to generate as many as possible ideas that can produce alternative ways to perform the functions selected for study. For this purpose following technique can effectively be used.

Creative Thinking – The VE team leader should encourage the team to be open-minded, inquisitive and creative in generating of ideas. Also, ‘creative thinking’ exercises and examples should be used to encourage the team. The energetic and positive VE leader can create the atmosphere that stimulates imaginations to create great ideas.

Brainstorming - is a group creativity technique designed to generate a large number of ideas for the solution to a problem (Wikipedia.com). The brainstorming session should be taken as a problem solving conference where all the participants’ proposals are encouraged.

List Making – Here the team can be asked to write five to ten ideas on a piece of paper and then have the ideas read one at a time.

Evaluation Phase

General Notes:

The objective of the Evaluation Phase is to analyze the results of the Creative Phase, review of the various alternatives, and select the best ideas for further expansion.

The evaluation can be performed in two stages. An initial evaluation in the first stage and a detail evaluation in the second stage would be recommended.

Initial Evaluation:

- Check the feasibility of the creative ideas made from Brainstorming session and cross out those alternatives that the team believes are unrealistic and, therefore, unacceptable.
- In doing so, everyone in the team should agree with the idea that selected unrealistic ideas are dropped.

Following steps will facilitate this process,

- Identify and select ideas that appear to be of very feasible and relatively high probability of success.
- Select ideas that appear to be of potential but which need further refinement in terms of scope.
- Remove ideas that appear to be of not potential in this stage.

The remaining ideas that are potentially workable are cost analyzed.

Completing Form: VE – 05 [Evaluation Phase – Detail Evaluation]

Detail Evaluation:

Develop and Rank Criteria specific for the project:

These criteria can be both generic and unique to the project that was selected for the study. After the criteria are identified, they must be ranked or rated. Each criteria need to be rated against all other criteria to determine the relative importance of each criteria for the project.

Choose up to eight criteria that are the key to the project. According to the situation, criteria can be determined. Example of such criteria would be of cost saving, implementation time, reliability, maintenance cost, safety, quality, environmental impact, simple to construct and so on.

Complete the criteria matrix.

Compare each pair of criteria and record their relative importance.

Assign a preference level for each criterion against all other criteria. Each "major preference" is 4 points; each "medium preference" is 3 points; each "minor preference" is 2 points and "no preference" is a point.

Calculate the total points for each criterion.

Prepare the criteria weight list for the evaluation of ideas.

Record any notes about the criteria matrix values in the comments / discussion section.

Example for criteria weighting process.

CRITERIA	RAW SCORE (WEIGHT)
A Protect the property (the wastewater treatment plant)	27
B Keep buffalo from pushing through	9
C Maintenance free (rust free, withstand winter)	3
D Aesthetically pleasing	6
E Cost	0
F Limits access to visitors	15
G Keep bears from getting through (includes digging under)	21
H Ease of operations during routine operation	3

How important

- 4 - Major preference
- 3 - Medium preference
- 2 - Minor preference
- 1 - Letter/Letter - no preference each scored one point



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	B	C	D	E	F	G	H
A	A4	A4	A3	A4	A4	A4	A4
B		B2	B2	B3	F2	G3	B2
C			D2	C2	F3	G4	C1 H1
D				D2	F2	G3	D2
E					F4	G4	H2
F						G3	F4
G							G4

Note : Drop Criteria with a Raw Score of 1
 (Criteria which gets dropped may be considered
 in Advantages/Disadvantages Analysis)

(Source: Value Engineering Guidance Handbook: United States Department of the Interior)

Evaluation Phase - Idea Evaluation	Date:	VE Team:
---	-------	----------

Form No:	VE - 05	VE Study Number:
-----------------	----------------	------------------

Project Description

Project Name:	Project No:
---------------	-------------

Evaluation Criteria

Ref No	Criteria	Comments
A	Criteria - A	
B	Criteria - B	
C	Criteria - C	
D	Criteria - D	
E	Criteria - E	
F	Criteria - F	
G	Criteria - G	
H	Criteria - H	

Criteria Matrix

	B	C	D	E	F	G	H	
A								
	B							
		C						
			D					
				E				
					F			
						G		

Total Points	
a	Criteria - A
b	Criteria - B
c	Criteria - C
d	Criteria - D
e	Criteria - E
f	Criteria - F
g	Criteria - G
h	Criteria - H
	Total Points (weight)

4 - Major preference
3 - Medium preference
2 - Minor preference
1 - Letter/Letter - no preference (each scored one point)

Criteria with a total point of 1 (or less) can be dropped from the list.
[Criteria which get dropped may be considered in advantages/disadvantages analysis]

Adapted from Value Engineering for Small Transportation Projects - By Clark J.A. (1999) & Value Engineering Guidance Handbook: United States Department of the Interior

Completion of Form: VE – 05A [Evaluation Phase - Matrix Analysis]

The purpose of this form is to evaluate each idea against the established and weighted criteria for the project.

Complete one form for each function. Also indicate the function of the selected project.

List all the desired criteria selected in form VE – 05 [Criteria – A to Criteria – I].

Include the relative weight of each criterion as calculated in form VE – 05 (Items a, b, c to i)

List the 'ORIGINAL' item and all the alternative ideas from Form: VE – 05 that requires comparison.

Grade how each of the alternative ideas satisfies each objective or criteria, i.e. 1 = Poor and 5 = Excellent.

Enter the grading for each alternative idea in the top part of the box.


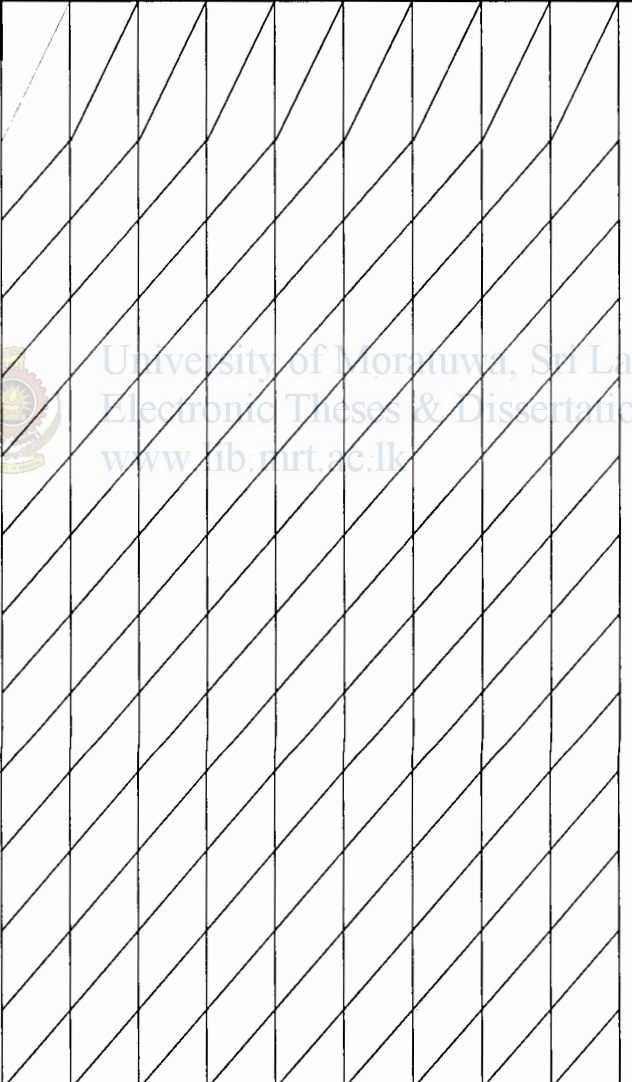
Multiply the rating by the weight for each combination. Enter the weighted rating in the lower part of the box.

Rank the alternatives according to the total score (1 = highest, 2 = second highest, etc.).
Select at least the top three ideas

FUNCTION FOR STUDY		DESIRED CRITERIA									TOTAL	FINAL RANKING
ALTERNATIVES	RELATIVE WEIGHTS	Protect the Property (the aesthetic "natural plan")	Keep bears from getting through	Limits access to visitors	Keep buffalo from pushing through	Aesthetically pleasing	Maintenance	Ease of operations	Cost			
	27		2	1	5	9	6	10	3	9		
1 Original design	135	9	5	5	5	3	3	4	2	4	396	2
2 Revise wastewater process smaller area needed	135	5	5	105	75	45	2	12	2	6	384	
3 Concrete fence high-tech "see-through" lasers, ultrasound	81	9	5	105	75	1	9	6	6	6	288	
4	54	2										
5 Pump to Gardiner, Montana	135	5	5	105	75	45	4	3	3	9	402	1
6 Fence: delete barbed wire	108	4	5	105	45	45	4	24	3	9	345	
7 Fence: 6-foot high, delete barbed wire, 10-foot post spacing	108	4	1	2	2	2	4	24	2	6	213	
8 Zoo moat	54	2										
9 Hedge with thorny brush	54	2										
10 Delete buried fence. Driven rods or posts	108	4	3	5	5	4	3	3	3	9	318	
11 Redesigned fence with horizontal base fence	135	5	5	105	75	45	3	18	3	9	396	2
12												
13												
EXCELLENT-5		VERY GOOD-4		GOOD-3		FAIR-2		POOR-1				

(Source: Value Engineering Guidance Handbook: United States Department of the Interior)

An example for Matrix Analysis

Evaluation Phase - Idea Evaluation					Date:		VE Team:			
Form No:			VE - 05A		VE Study Number:					
Project Description										
Project Name:						Project No:				
Function:		Desired Criteria							Total Points	Final Ranking
		Criteria - A	Criteria - B	Criteria - C	Criteria - D	Criteria - E	Criteria - F	Criteria - G		
Relative Weights		a	b	c	d	e	f	g	h	i
Idea Ref	Idea Description									
										

Grading of Ideas [Excellent-5, Very Good-4, Good-3, Fair-2, Poor-1]

Adapted from Value Engineering Guidance Handbook: United States Department of the Interior & Value Engineering Manual of instruction of Utah Department of Transportation.

Development Phase

In this phase, the best alternative ideas selected during the Evaluation Phase are thoroughly analyzed.

For this phase a set of six forms is provided. These forms will help VE team to develop each idea into preliminary design alternatives.



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Completion of Form: VE – 06 [Development Phase – Benefits]

After the alternative ideas are ranked and weighted against the criteria, a comparison of advantages and disadvantages need to be done. Advantages and disadvantages that are not addressed in the desired criteria are listed here.

Indicate the selected function.

List the selected creative ideas.

List advantages and disadvantages, also a rating can be assigned for these selected alternative ideas.



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Development Phase - Benefits				
Form No:	VE - 06	VE Study Number:	Date:	
Project Name:			VE team:	
Project Description				
Project No:				
Function Being Analysed:				
Item No	Selected Creative Idea	Advantages	Disadvantages	Rating



Adapted from Value Engineering Guidance Handbook: United States Department of the Interior

Completion of Form: VE – 06A [Development Phase – Sketches]

Having identified which functional areas can be changed, make a SIMPLE SKETCH (if applicable) of the project element as ‘ORIGINAL’ and as proposed.

Include enough information to clearly identify the proposed changes. It is important to remember that ‘a clear, easy to understand sketch is the best sales tool’.

Complete one form for each idea / alternative.



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Development Phase - Sketches		Date:	VE Team:
Form No:	VE - 06A	VE Study Number:	
Project Description			
Project Name:		Project No:	
Selected Creative Idea:			
Original Design (sketch attached Y/N)			
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Proposed Change (sketch attached Y/N)			

Adapted from Value Engineering Manual (2004) - West Virginia Department of Transport

Completion of Form: VE – 06B [Development Phase – Calculations]

It is necessary to provide sufficient calculations to enable all reviewers to analyze your proposed change and determine that it is a workable and realistic alternative.

Calculations should show technical data only.


Reserve cost calculations for the cost estimate forms.

Identify and explain all assumptions that were made if specific data is not available.

Include as many sheets as necessary.



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Development Phase - Calculation		Date:	VE Team:
Form No:	VE - 06B	VE Study Number:	
Project Description			
Project Name:		Project No:	
Selected Creative Idea:			
Calculations			
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Adapted from Value Engineering Manual (2004) - West Virginia Department of Transport

Completing Form: VE – 06C [Development Phase – Estimates]

The technical / engineering calculation can prove the viability or the build-ability of the selected alternative solution. In addition, it is necessary to show the resulted value improvement or cost savings.

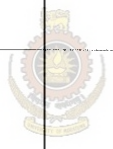
This sheet allows for a comparison of the costs for the various proposed alternatives to their original costs.

- Complete one form for each selected idea / alternative.
- Provide all the required cost details.
- Use the cost estimate (BOQs) of the ‘original design’ to calculate the total original cost.
- Provide the cost break-down for the ‘proposed design’ with as many as details required.
- List any assumptions made and indicate where your costs were obtained.



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Development Phase - Estimates			Date:		VE Team:			
Form No:		VE - 06C		VE Study Number:				
Project Description								
Project Name:				Project No:				
Selected Creative Idea:								
Construction Element	Original Design				Proposed Design			
	Unit	Qty	Rate	Amount	Unit	Qty	Rate	Amount



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Adapted from Value Engineering Manual (2004) - West Virginia Department of Transport

Completion of Form: VE – 06D [Development Phase - Life Cycle Cost]

The life cycle cost (LCC) is the economic measure of value. Therefore LCC method is used to compare and evaluate the total costs of the competing solutions.

The 'present worth method' of life cycle cost analysis is used to compare the competing design solutions. The present worth method requires the conversion of all present and future expenditures into 'today's cost'.

Estimate the Economic Life for the Item – projected effective useful life of the item (10, 15, 20, 25, years etc...)

Determine the Discount Rate to be used – this is the difference between the inflation rate assumed and the time value of money (interest rate)

Initial Costs:

Item Cost – these are the cost to produce or construct the item

Development Cost – these are the cost associated with design, testing, prototype and models.

Implementation Cost – they are the cost expected after the approval such as redesign, testing, contract administration and training.

Miscellaneous Cost – these costs depend on the item and it may include owner supplied equipments, financing, license and fees.

Single Expenditure (Non-recurring):

Repair and replacement costs – these are costs estimated on the basis of predicted failures and replacement of major system components. Each estimated cost is for a specific year in the future.

Salvage – this is referred to a residual value of an item. Salvage value is entered as a negative value in the LCC calculations.

Annual Costs:

Operation cost – these are for estimated annual expenditure for utilities, fuel, insurances, taxes and other fees.

General maintenance cost – for annual expenditures for scheduled upkeep and preventive maintenance.

Other annual costs – costs for annual use of equipment for items and annual support cost for management overheads.

PW Factor (present worth factor) from the chart in Appendix – C, it is the value of P/F factor where the interest rate is equal to the selected discount rate and number of year is equal to item (a) of single cost and so on.

PW Factor (present worth factor of annuity) from the chart in Appendix – C, it is the value of P/A factor where the interest rate is equal to the selected discount rate and number of year is equal to selected economic life.

For the initial cost, cost = PW (present worth)

To get the future single cost and future annual cost of each item, estimated cost are multiplied by the PW factor of each item.

This comparison is done for all the selected creative solution.

Development Phase - LCC Analysis		Date:	VE Team:	
Form No:	VE - 06D	VE Study Number:		
Project Description				
Project Name:			Project No:	
Discount Rate:		Economic Life:		
	Original Design		Alternative - 01/ Selected Idea	
	Cost	PW	Cost	PW
1. Total Initial costs				
i) Item Cost				
ii) Development Cost				
iii) Implementation Cost				
iv) Miscellaneous Cost				

Single cost				
[Single cost @% interest]				
a) Year ____ PW Factor ____				
b) Year ____ PW Factor ____				
c) Year ____ PW Factor ____				
d) Salvage / unused service life Year ____ PW Factor ____				
2. Future Single Cost				

Annual Costs (based on present worth of annuity)				
[Annual cost @% interest]				
a) Operation cost PW Factor ____				
a) General maintenance PW Factor ____				
b) Other annual costs PW Factor ____				
3. Future Annual Costs				

4. Total Future Costs (2+3)				
------------------------------------	--	--	--	--

5. Total life cycle costs (1+4)				
--	--	--	--	--

Adapted from Value Engineering Manual (2004) - West Virginia Department of Transport

Completion of Form: VE – 06E [Development Phase – Cost saving summary]

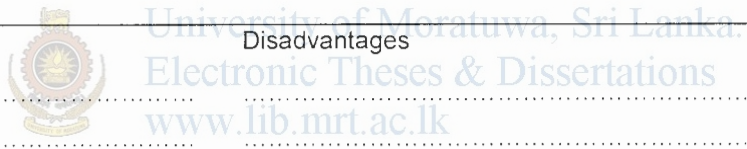
This sheet provides a summary of the recommended alternative and its cost savings.

- Complete one form for each alternative solution.
- Briefly describe the original and proposed concepts.
- Briefly discuss important advantages and disadvantages.
- Summarize the total cost saving.
- Discuss and justify the proposed alternative with regards to the advantages, value improvements and cost savings.



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Development Phase - Summary		Date:	VE Team:
Form No:	VE - 06E	VE Study Number:	
Project Description			
Project Name:		Project No:	
Function:			
Original Concept			
VE Concept			
Advantages		Disadvantages	
.....		
.....		
.....		
.....		
.....		
Discuss / Justification			



<i>Life Cycle Cost Summary (Present Worth Method)</i>			
	<i>Initial Cost</i>	<i>Life Cycle Cost</i>	<i>Total Cost</i>
Original Design			(a)
Proposed Change			(b)
Savings			(a-b)

Adapted from Value Engineering Manual (2004) - West Virginia Department of Transport & Value Engineering for Small Transportation Projects - By Clark J.A. (1999)

Completion of Form: VE – 07 [Presentation Phase - Executive Summary]

The purpose is to present a summary of the study and its results to the decision-makers.

The executive summary should include a concise, abstract of the VE study. It is the *executive action document from the team to the decision makers, highlighting the study and recommendations*

It should be confined to one page if possible.

As a minimum it should include:

General:

Project description including the total estimated construction cost

Date of the VE study

Results Obtained:

Number of recommendations



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- Total projected savings
- Savings as a percent of the project cost

Highlights:

Summarize significant recommendations

Constraints:

Identify any conditions (political, social, or project) that influenced the team's recommendations.

Presentation Phase - Executive Summary		Date:	VE Team:
Form No:	VE - 07	VE Study Number:	
Project Description			
Project Name:		Project No:	
Executive Summary			
General:			
Results Obtained:			
Highlights:			
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Constraints:			

Adapted from Value Engineering Manual (2004) - West Virginia Department of Transport

Presentation Phase – Preparation of Presentation

A good recommendation will require a good written and oral presentation.

The VE team should be ready with both written and oral (discussion) presentation to convince the stakeholders.



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Completion of Form: VE – 08 [Implementation Phase – Recommendation]

Once the VE study has been completed, the VE study recommendations need to be accepted and approved for implementation by the project stakeholders.

VE study team's recommendations are distributed along with this form to all the stakeholders for their review and comments.

Also meetings / discussions can be arranged with the stakeholders to discuss their responses and come to an agreement on the status of the recommendation.



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Implementation Phase - Recommendation		Date:	VE Team:
Form No:	VE - 08	VE Study Number:	
Project Description			
Project Name:		Project No:	
Recommendation:			
Prepared by:			
Review Status:	Accept	Conditionally Accept	Reject
Stakeholder Responses			
Technical Feasibility			
Implementable Portion			
Validated Cost Savings			
Scheduled Impact	 <p>University of Moratuwa, Sri Lanka. Electronic Theses & Dissertations www.lib.mrt.ac.lk</p>		
Safety Impact			
Issue Resolution			
Stakeholder Consensus			
Other Comments			

Adapted from Value Engineering for Small Transportation Projects - By Clark J.A. (1999)

Completion of Form: VE – 09 [Audit Phase – Summary]

The objective of the Audit Phase of the Value Engineering Job Plan is to check that desired results have been attained, documented, and reported.

List all the VE recommendations with brief description.

Record the actual implemented savings realized as against the initial anticipated savings.

Include any comments on savings or suggestions for improvements.



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Audit Phase - Summary

Form No:	VE - 09	VE Study Number:	Date:	VE team:
Project Description				
Project Name:				
Project No:				
VE Recommendation	Description	Anticipated Initial Saving	Implemented Saving	Comments



Adapted from Value Engineering for Small Transportation Projects - By Clark J.A. (1999)

Completion of Form: VE – 09A [Audit Phase – Data Recording]

The purpose of this form is to record data about the project and value engineering studies carried out for future reference. Also, these data can be included into a database for effective utilization.

Fill all the information as complete as possible.

It is required to fill out a form for each VE study carried out.



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Audit Phase - Data Recording		Date:
Form No:	VE - 09A	
Project Description		
Project Name:		
Project No:		
Type of Project:		
Project Location:		
Start Date:		
Completion Date:		
Project Manager:		
Major Project Elements		
VE Study Details		
VE Study Number:		
Study Date:		
VE Team Leader:		
VE Team Members:		
Summary Data		
Initial Estimated Project Cost:		
Final Project Cost:		
Number of Recommendations:		
Number of Approved Recommendations:		
Estimated value of all recommendations:		
Estimated value of approved recommendations:		
Implemented Savings:		
Details of VE Recommendations		
Recommendation - 1		
Brief Description:		
Estimated Saving:		
Implemented Savings:		
Comments:		
Recommendation - 2		
Brief Description:		
Estimated Saving:		
Implemented Savings:		
Comments:		
Recommendation - 3		
Brief Description:		
Estimated Saving:		
Implemented Savings:		
Comments:		



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Adapted from Value Engineering for Small Transportation Projects - By Clark J.A. (1999)

Appendix – B

Analysis of Survey Results

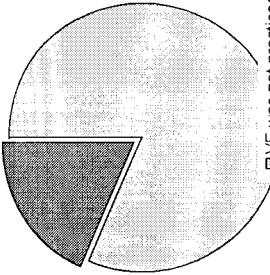


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Table - 1A Question - 1a, Contractors previous VE experience

Response	Number of responses				Responding %			
	M1	M2	M3	Total	M1	M2	M3	Total
VE was not practiced in the past	4	4	5	13	57%	100%	100%	81%
VE was practiced few times in the past (at least once)	3	0	0	3	43%	0%	0%	19%
Total	7	4	5	16	100%	100%	100%	100%

Question - 1a, Contractors previous VE experience



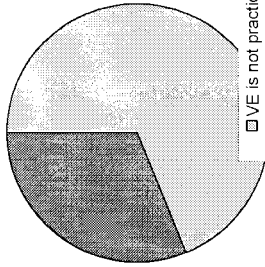
- VE was not practiced in the past
- VE was practiced few times in the past (at least once)



Table - 1B Question - 1b, Contractors current VE experience

Response	Number of responses				Responding %			
	M1	M2	M3	Total	M1	M2	M3	Total
VE is not practicing currently	3	3	5	11	43%	75%	100%	69%
VE is practicing currently - at least randomly	4	1	0	5	57%	25%	0%	31%
Total	7	4	5	16	100%	100%	100%	100%

Question - 1b, Contractors current VE experience

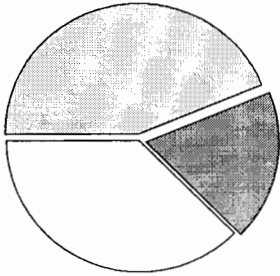


- VE is not practicing currently
- VE is practicing currently - at least randomly

Question (Narrow down version)	Respondent	Category	Summarized Answers	Special Comments
Question - 2 Do the people and management of the company know / knowledgeable about VE ?	Contractor - 1	M2	Not sure about the people Professionals might know Not sure about the management	
	Contractor - 2	M2	Supporting staff might not know it Management have some knowledge, have discuss few times to make alternative methods. Engineers might be knowing it	
	Contractor - 3	M1	Professional know about it, have used few times Management also know as a cost cutting tool	
	Contractor - 4	M1	Engineers / QSs know about it to a certain extent Through professional, management came to know about it	
	Contractor - 5	M1	Mid level management, engineers, QSs has a basic knowledge of it.	
	Contractor - 6	M1	Management also have heard of it (not in detail) Engineers & QSs have heard but not in detail Management know it to a certain extent	
	Contractor - 7	M1	QSs might be knowing it, how far is not clear Management - propose to use as a cost cutting tool	
	Contractor - 8	M1	QSs know about it, alternatives were compared Even management have a good knowledge of it Even construction people have made few proposals	
	Contractor - 9	M3	People & management knowledge - not very sure	
	Contractor - 10	M1	People and management are knowing it But the extent of it is not very clear Tender dept has used it for making alternative proposal in a tender	
	Contractor - 11	M3	People - not very sure Management know it to a certain extent	
	Contractor - 12	M3	Probably not	
	Contractor - 13	M2	No	
	Contractor - 14	M2	No	
	Contractor - 15	M3	No	
	Contractor - 16	M3	No	



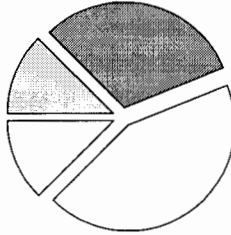
Question - 2a. Professionals's awareness / knowledge on VE



- Professionals know it to a certain extent
- Professionals have a better knowledge
- Professionals are not familiar with



Question - 2b. Management's awareness / knowledge on VE



- Management have a better knowledge
- Management know it to a certain level
- Management's knowledge not quite clear
- Management know it as a cost cutting tool

Table - 2A. Professionals's awareness / knowledge on VE

Response	Number of				Responding %			
	M1	M2	M3	Total	M1	M2	M3	Total
Professionals know it to a certain extent	4	2	1	7	57%	50%	20%	44%
Professionals have a better knowledge	3	0	0	3	43%	0%	0%	19%
Professionals are not familiar with	0	2	4	6	0%	50%	80%	38%
Total	7	4	5	16	100%	100%	100%	100%

Table - 2B. Management's awareness / knowledge on VE

Response	Number of				Responding %			
	M1	M2	M3	Total	M1	M2	M3	Total
Management have a better knowledge	2	0	0	2	29%	0%	0%	13%
Management know it to a certain level	3	1	1	5	43%	25%	20%	31%
Management's knowledge not quite clear	0	3	4	7	0%	75%	80%	44%
Management know it as a cost cutting tool	2	0	0	2	29%	0%	0%	13%
Total	7	4	5	16	100%	100%	100%	100%

Question (Narrow down version)	Respondent	Category	Summarized Answers	Special Comments
Question - 3 What is the general attitude of people & management of your company about VE?	Contractor - 1	M2	People does not know about it, even to make a comment Management - could not reached	
	Contractor - 2	M2	VE was not discussed before, therefore general attitude is not known	
	Contractor - 3	M1	Accept as a cost cutting tool Ready to take as a management tool as well	
	Contractor - 4	M1	People will not be interested, will see as a burden Professionals know it to a certain extent, and ready to learn if useful in business, see as a good tool	
	Contractor - 5	M1	People will resist, but can change Management have previous experience, therefore would be positive	
	Contractor - 6	M1	People will be not aware of it Management if not convinced will take as a weast Professionals ready to see as a positive management tool for construction works	
	Contractor - 7	M1	Not sure about the people Management is not interested, but can convinced with facts. Professional see as a dysfunctional good tool	It is a dis-functiong good tool
	Contractor - 8	M1	Ordinary people may be not aware of it Management proposes it for alternative bids, very positive Professionals know it to a certain extent, and ready to improve if prospects are available	
	Contractor - 9	M3	Professionals refer this as a cost cutting tool Management does not have good faith on VE	
	Contractor - 10	M1	Professionals see this as a option available for cost reduction Management has a positive attitude about it	
	Contractor - 11	M3	No positive attitude about it	
	Contractor - 12	M3	Not well aware of it so that no good attitude	
	Contractor - 13	M2	No	
	Contractor - 14	M2	No	
	Contractor - 15	M3	No	
	Contractor - 16	M3	No	



Table - 3A Question - 3a, Professional's attitude about VE

Response	Number of responses				Responding %			
	M1	M2	M3	Total	M1	M2	M3	Total
Professionals have a positive attitude about VE	4	0	1	5	57%	0%	20%	36%
Professionals do not have a positive attitude about VE	3	0	2	5	43%	0%	40%	36%
Professionals's attitude is not clear	0	2	2	4	0%	100%	40%	29%
Total	7	2	5	14	100%	100%	100%	100%

Table - 3B Question - 3b, Management's attitude about VE

Response	Number of responses				Responding %			
	M1	M2	M3	Total	M1	M2	M3	Total
Management have a positive attitude about VE	4	0	0	4	57%	0%	0%	25%
Management do not have a positive attitude about VE	2	0	2	4	29%	0%	40%	25%
Management's attitude is not clear	1	4	3	8	14%	100%	60%	50%
Total	7	4	5	16	100%	100%	100%	100%



Question (Narrow down version)	Respondent	Category	Summarized Answers	Special Comments
<p>Question - 4</p> <p>Are the people & management of your company aware of improvements / benefits that can gain by adapting VE in business?</p>	Contractor - 1	M2	<p>Not very sure about management awareness of the benefits of VE applications</p> <p>Professionals previous experience is less on this area. Advantages of VE may not be full aware</p> <p>Advantages other than in construction areas not known to many</p>	
	Contractor - 2	M2	<p>People's knowledge of benefits of VE not very sure of Qs's & Engineers may be knowing it, not sure</p>	
	Contractor - 3	M1	<p>People's knowledge of benefits of VE not very sure of</p> <p>Benefits of VE are known to professionals and management - mainly with regards to construction materials, methods</p> <p>Advantages other than in construction areas not readily known to them</p>	<p>We are lacking people with innovative skills at the moment. it is very difficult to find and keep people with such caliber for long time.</p>
	Contractor - 4	M1	<p>People's knowledge of benefits not very sure of Qs's and tendering department know VE as cost saving tool</p> <p>Management can easily be convinced about VE benefits by professionals</p> <p>Advantages other than in construction areas not readily known to them.</p>	<p>In our company, professionals can convince the management easily about innovative ways of doing things</p>
	Contractor - 5	M1	<p>People's awareness not quite sure</p> <p>Professionals know as cost saving benefits</p> <p>Management know cost saving benefits</p>	
	Contractor - 6	M1	<p>People's knowledge of benefits not very sure of</p> <p>Managements knowledge of VE benefits are very minimum</p> <p>Professionals know benefits with regards to the construction works, but not about the other areas</p> <p>Management can easily be convinced about VE benefits by professionals</p>	
	Contractor - 7	M1	<p>Professionals know benefits with regards to the construction works, not about the other areas</p> <p>Other VE benefits are not known to many</p>	<p>People with good VE skills should play the leading role</p>
	Contractor - 8	M1	<p>People's knowledge of benefits not very sure of</p> <p>Professionals know it to a certain extent, lot of other benefits were also discussed</p> <p>Even management have a good knowledge of it</p> <p>Benefits in other areas in business not very well known</p>	
	Contractor - 9	M3	<p>People & management know about the cost advantages</p> <p>Other VE benefits are not known to them</p>	
	Contractor - 10	M1	<p>Professionals know the value improvement it can deliver</p> <p>Management expect innovative ideas to reduce cost</p>	
	Contractor - 11	M3	<p>Clearly not, due to lack of professional involvement</p>	
	Contractor - 12	M3	No	
	Contractor - 13	M2	No	
	Contractor - 14	M2	No	
	Contractor - 15	M3	No	
	Contractor - 16	M3	No	

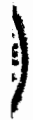


Table - 4A Question - 4a, Professional's knowledge on VE benefits

Response	Number of			Responding %				
	M1	M2	M3	Total	M1	M2	M3	Total
VE benefits are not known	0	2	4	6	0%	50%	80%	38%
VE benefits with regards to cost aspect, value improvement are known	3	1	1	5	43%	25%	20%	31%
Other VE benefits are not known (other than value improvement)	3	1	0	4	43%	25%	0%	25%
Most of the benefits are known	1	0	0	1	14%	0%	0%	6%
Total	7	4	5	16	100%	100%	100%	100%

Table - 4B Question - 4b, Management's knowledge on VE benefits

Response	Number of			Responding %				
	M1	M2	M3	Total	M1	M2	M3	Total
VE benefits are not known	2	4	4	10	29%	100%	80%	63%
VE benefits with regards to cost aspect, value improvement are known	3	0	1	4	43%	0%	20%	25%
Other VE benefits are not known	2	0	0	2	29%	0%	0%	13%
Total	7	4	5	16	100%	100%	100%	100%

Question (Narrow down version)	Respondent	Category	Summarized Answers	Special Comments
Question - 5 Are the people & management of your organization aware of correct VE methodologies (Job Plan, FAST, etc...) in adapting it in business?	Contractor - 1	M2	Have not done, also the understanding of the correct methodology is very doubtful Seems that, Job plan, brainstorming, FAST etc... not very familiar words to them. Cost benefit analysis, LCC analysis in VE context not very familiar with	NO' was the answer to second question raised
	Contractor - 2	M2	Not for sure	NO' was the answer to second question raised
	Contractor - 3	M1	Know only to compare cost of original with the alternative option Seems that, Job plan, brainstorming, FAST etc... not very familiar to them, but have heard of them. Not clearly know about the correct methodology	NOT always but people sometime discuss about possible solution (second question)
	Contractor - 4	M1	They know bit and pieces of it, but not the complete methodology Have heard of, Job plan, brainstorming, FAST etc... not never gone to many details in application	Not in that sense, but do talk (second question)
	Contractor - 5	M1	For sure not about the complete procedure or methodology Know only to compare cost of original design with alternative option	NO' was the answer to second question raised
	Contractor - 6	M1	Professionals know some aspects such as alternatives, functional analysis but not fully But the knowledge / experience of complete methodology is not very sure	NOT as in the books, we refer to professionals for advice when needed (second question)
	Contractor - 7	M1	Comparison of cost and savings for various design and materials options are known to them Not very sure about the knowledge on complete methodology.	Not in that sense, but do talk (second question)
	Contractor - 8	M1	Comparison of cost, savings, functions, are done to convince the consultants / clients Brainstorming is also done to a certain extent, only among manager level Not following the correct methodical VE approach	We do talk with people in other departments when resolution is required (second question)
	Contractor - 9	M3	Both people and management does not know about it	NO' was the answer to second question raised
	Contractor - 10	M1	To a certain extent, functional analysis and costs are compared for alternatives no proper brainstorming sessions.	Not in that sense, but do talk (second question)
	Contractor - 11	M3	No	NO' was the answer to second question raised
	Contractor - 12	M3	No for sure	NO' was the answer to second question raised
	Contractor - 13	M2	No	NO' was the answer to second question raised
	Contractor - 14	M2	No	NO' was the answer to second question raised
	Contractor - 15	M3	No	NO' was the answer to second question raised
	Contractor - 16	M3	No	NO' was the answer to second question raised

Table - 5 Question - 5, Awareness of correct VE methodologies

Response	Number of responses				Responding %			
	M1	M2	M3	Total	M1	M2	M3	Total
Fully aware of the VE methodology	0	0	0	0	0%	0%	0%	0%
VE methodology is known to a certain extent	4	1	0	5	57%	25%	0%	31%
Comparison of cost & function analysis are done	2	0	0	2	29%	0%	0%	13%
VE methodology is not known	1	3	5	9	14%	75%	100%	56%
Total	7	4	5	16	100%	100%	100%	100%



Question (Narrow downed version):	Respondent	Category	Summarized Answers	Special Comments
Question - 6 Does your company has a proper guideline / methodology for VE studies and submissions for client's approval? How do you do this?	Contractor - 1	M2	Not available	
	Contractor - 2	M2	Not available	
	Contractor - 3	M1	Not as a document, but professionals knowledge According to the situation, details will be looked into	At the moment we have a good set of people who can think & do differently, but when they left practice will stop
	Contractor - 4	M1	No such policy or methodology available Situational requirements are met	Do compare adavantages and disadvantages of both the original and alternative proposal, after cost saving
	Contractor - 5	M1	Not at all, cost comparisons are made to support idea	
	Contractor - 6	M1	No standard way of doing it	
	Contractor - 7	M1	Not as a document	
	Contractor - 8	M1	No such standard methodology available Situational requirements are met	
	Contractor - 9	M3	No	
	Contractor - 10	M1	Not as a documents Professionals do required paper work for submission	
	Contractor - 11	M3	No	
	Contractor - 12	M3	No	
	Contractor - 13	M2	No	
	Contractor - 14	M2	No	
	Contractor - 15	M3	No	
	Contractor - 16	M3	No	

Table - 6 Question - 6, Availability of a proper VE methodology / guideline in the company

Response	Number of responses				Responding %			
	M1	M2	M3	Total	M1	M2	M3	Total
	Proper methodology / guideline is available	0	0	0	0	0%	0%	0%
Proper methodology / guideline is not available	7	4	5	16	100%	100%	100%	100%
Total	7	4	5	16	100%	100%	100%	100%

Question (Narrow downed version);	Respondent	Category	Summarized Answers	Special Comments
Question - 7 Will the availability of proper VE methodology / guidebook promote application in construction business?	Contractor - 1	M2	Not very sure about the abilities of the VE	
	Contractor - 2	M2	Will be helpful, but will need lot of time to study	
	Contractor - 3	M1	Availability of a document is always good Practice can be improved	
	Contractor - 4	M1	Yes it will be a helpful if it a comprehensive document for that purpose	
	Contractor - 5	M1	Yes Also need educated people Training may be required	
	Contractor - 6	M1	Availability of a document is always good But it will not guarantee the use of it, unless management support, people's attitude are lacking	
	Contractor - 7	M1	If available, people can refer to it when required	
	Contractor - 8	M1	Availability of a document is always good It can make things easier for the people who do VE	
	Contractor - 9	M3	Will be useful in the future Trained people would be required	
	Contractor - 10	M1	It can standardized the practice Always better to have a guidance document	
	Contractor - 11	M3	Not sure in this context, also training required	
	Contractor - 12	M3	Will require lot of training	
	Contractor - 13	M2	No	
	Contractor - 14	M2	No	
	Contractor - 15	M3	No	
	Contractor - 16	M3	No	

Table - 7 Question - 7, Availability of proper VE methodology / guideline for good VE practice

Response	Number of			Responding %				
	M1	M2	M3	Total	M1	M2	M3	Total
Not very sure about	0	3	3	6	0%	75%	60%	37.5%
Will be very useful for a good VE practice	7	1	2	10	100%	25%	40%	62.5%
Total	7	4	5	16	100%	100%	100%	100%

Question (Narrow down version)	Respondent	Category	Summarized Answers	Special Comments
Question - 8	Contractor - 1	M2	Will be hard, but if management involved, it can be done	
	Contractor - 2	M2	Proper VE guide line is needed to follow initially Methodology need to be established with proper steps	incentives for VE team is a must
	Contractor - 3	M1	Yes, people need to be trained Proper VE guide line is needed to follow	
	Contractor - 4	M1	Management push and commitment is a must It will take long time to get used to the principles	
	Contractor - 5	M1	People with VE knowledge, time and opportunities will decide the successfulness Will be able, but very hard with the people	
	Contractor - 6	M1	If only supported by the top management Correct approach would be the problem, if only backed by the management	
	Contractor - 7	M1	May require lot of training There is a possibility, but people will resist due to additional work load	ability of technical staff to do things, and capabilities of professionals for designing and implementation of change would not be a problem as long as it gets the commitment and attention of the top people of the company
	Contractor - 8	M1	Management commitment is very much needed Success will depend on the interest of the people.	
	Contractor - 9	M3	Correct approach would be a problem with people's work load Selected set of people can be trained	
	Contractor - 10	M1	Also, good procedure need to be available, incentives need to be given With the blessings of the management yes	
	Contractor - 11	M3	People need to be motivated If the people are motivated and management support is available this can be done	
	Contractor - 12	M3	With proper guidance - yes If management is convinced about it, yes	
	Contractor - 13	M2	No	
	Contractor - 14	M2	No	
	Contractor - 15	M3	No	
	Contractor - 16	M3	No	

With a correct approach, do you believe that you can establish a proper VE practice in your company?
 .(How to intergrate VE into existing practice?)

Table - 8 Question - 8, Ability to establish good VE practice, with a correct approach

Response	Number of responses				Responding %			
	M1	M2	M3	Total	M1	M2	M3	Total
Will be difficult, but possible with top management involvement	4	1	3	8	57%	25%	60%	50%
Possible, but will take some time to people to get familiar	1	0	0	1	14%	0%	0%	6%
Not very clear	0	2	2	4	0%	50%	40%	25%
Incentives for people would attract people	2	1	0	3	29%	25%	0%	19%
Total	7	4	5	16	100%	100%	100%	100%



Question (Narrow down version)	Respondent	Category	Summarized Answers	Special Comments
Question - 9 How do you see the initiative taken by ICTAD to include VE into contract documents?	Contractor - 1	M2	Not very sure about	
	Contractor - 2	M2	Can establish if required people are available Also management involvement is required External consultations may required	
	Contractor - 3	M1	It would be a good thing, because the contractual rights can be established	
	Contractor - 4	M1	Contract clause will encourage the management and professionals to use it	
	Contractor - 5	M1	Need to study it Will be a good opportunity in the future	
	Contractor - 6	M1	ICTAD involvement will encourage this in the future	
	Contractor - 7	M1	Contractual provisions are very much needed	
	Contractor - 8	M1	This was the lacking part, contractual provision will guarantee the rights	
	Contractor - 9	M3	Good move	
	Contractor - 10	M1	This was the lacking part, contractual provision will guarantee the rights	
	Contractor - 11	M3	Will be good	
	Contractor - 12	M3	Will be good, consultant will not be able to reject them easily	
	Contractor - 13	M2	No	
	Contractor - 14	M2	No	
	Contractor - 15	M3	No	
	Contractor - 16	M3	No	

Table - 9 Question - 9, How do you see ICTAD latest movement on VE

Response	Number of responses				Responding %			
	M1	M2	M3	Total	M1	M2	M3	Total
Not very sure of	0	3	2	5	0%	75%	40%	31%
VE practice would be attractive with new contractual provisions	5	0	0	5	71%	0%	0%	31%
Will encourage the practice	2	1	3	6	29%	25%	60%	38%
Total	7	4	5	16	100%	100%	100%	100%

Question (Narrow down version)	Respondent	Category	Summarized Answers	Special Comments
<p>Question - 10</p> <p>Other than the people with required VE skills, do you have the other resources that requires for VE program, such as critical data / information about various materials, components, methods etc., technology, financial capabilities?</p>	Contractor - 1	M2	No database as such, also not familiar to new technologies	
	Contractor - 2	M2	Data not in a IT format, but archived files are available for get previous data	
	Contractor - 3	M1	Tender dept has stored data on construction materials and other important equipments	
	Contractor - 4	M1	Not in a database	
	Contractor - 5	M1	Estimation dept, has all the cost data that might be useful in the future.	
	Contractor - 6	M1	All the projects files are archived for future use	
	Contractor - 7	M1	All the projects files are archived for future use	
	Contractor - 8	M1	Database is available to record important data on projects, cost data, and other important informations are recorded for future use.	
	Contractor - 9	M3	No	
	Contractor - 10	M1	Not in a database	
	Contractor - 11	M3	Not in a IT format	
	Contractor - 12	M3	Not in a IT format	
	Contractor - 13	M2	No	
	Contractor - 14	M2	No	
	Contractor - 15	M3	No	
	Contractor - 16	M3	No	

Table - 10 Question - 10, Does the company has required resources such as database, technology, finance

Response	Number of				Responding %			
	M1	M2	M3	Total	M1	M2	M3	Total
No database available	2	3	5	10	29%	75%	100%	62.5%
Database is available to retrieve critical data required for VE study	3	0	0	3	43%	0%	0%	18.8%
No database available, but details of previous projects are available to refer	2	1	0	3	29%	25%	0%	18.8%
Total	7	4	5	16	100%	100%	100%	100%

Appendix – C

Engineering Economics Tables

Source: Value Engineering Manual (2004) - West Virginia
 University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
Department of Transport.lk

INTEREST RATE = 2.00%

N	(P/F)	(P/A)	(P/G)	(F/P)	(F/A)	(A/P)	(A/F)	N
1	0.9804	0.9804	0.0000	1.0200	1.0000	1.0200	1.0000	1
2	0.9612	1.9416	0.9612	1.0404	2.0200	0.5150	0.4950	2
3	0.9423	2.8839	2.8458	1.0612	3.0604	0.3468	0.3268	3
4	0.9238	3.8077	5.6173	1.0824	4.1216	0.2626	0.2426	4
5	0.9057	4.7135	9.2403	1.1041	5.2040	0.2122	0.1922	5
6	0.8880	5.6014	13.6801	1.1262	6.3081	0.1785	0.1585	6
7	0.8706	6.4720	18.9035	1.1487	7.4343	0.1545	0.1345	7
8	0.8535	7.3255	24.8779	1.1717	8.5830	0.1365	0.1165	8
9	0.8368	8.1622	31.5720	1.1951	9.7546	0.1225	0.1025	9
10	0.8203	8.9826	38.9551	1.2190	10.9497	0.1113	0.0913	10
11	0.8043	9.7868	46.9977	1.2434	12.1687	0.1022	0.0822	11
12	0.7885	10.5753	55.6712	1.2682	13.4121	0.0946	0.0746	12
13	0.7730	11.3484	64.9475	1.2936	14.6803	0.0881	0.0681	13
14	0.7579	12.1062	74.7999	1.3195	15.9739	0.0826	0.0626	14
15	0.7430	12.8493	85.2021	1.3459	17.2934	0.0778	0.0578	15
16	0.7284	13.5777	96.1288	1.3728	18.6393	0.0737	0.0537	16
17	0.7142	14.2919	107.5554	1.4002	20.0121	0.0700	0.0500	17
18	0.7002	14.9920	119.4581	1.4282	21.4123	0.0667	0.0467	18
19	0.6864	15.6785	131.8139	1.4568	22.8406	0.0638	0.0438	19
20	0.6730	16.3514	144.6003	1.4859	24.2974	0.0612	0.0412	20
21	0.6598	17.0112	157.7959	1.5157	25.7833	0.0588	0.0388	21
22	0.6468	17.6580	171.3795	1.5460	27.2990	0.0566	0.0366	22
23	0.6342	18.2922	185.3309	1.5769	28.8450	0.0547	0.0347	23
24	0.6217	18.9139	199.6305	1.6084	30.4219	0.0529	0.0329	24
25	0.6095	19.5235	214.2592	1.6406	32.0303	0.0512	0.0312	25
26	0.5976	20.1210	229.1987	1.6734	33.6709	0.0497	0.0297	26
27	0.5859	20.7069	244.4311	1.7069	35.3443	0.0483	0.0283	27
28	0.5744	21.2813	259.9392	1.7410	37.0512	0.0470	0.0270	28
29	0.5631	21.8444	275.7064	1.7758	38.7922	0.0458	0.0258	29
30	0.5521	22.3965	291.7164	1.8114	40.5681	0.0446	0.0246	30
31	0.5412	22.9377	307.9538	1.8476	42.3794	0.0436	0.0236	31
32	0.5306	23.4683	324.4035	1.8845	44.2270	0.0426	0.0226	32
33	0.5202	23.9886	341.0508	1.9222	46.1116	0.0417	0.0217	33
34	0.5100	24.4986	357.8917	1.9607	48.0338	0.0408	0.0208	34
35	0.5000	24.9986	374.8826	1.9999	49.9945	0.0400	0.0200	35
36	0.4902	25.4888	392.0405	2.0399	51.9944	0.0392	0.0192	36
37	0.4806	25.9695	409.3424	2.0807	54.0343	0.0385	0.0185	37
38	0.4712	26.4406	426.7764	2.1223	56.1149	0.0378	0.0178	38
39	0.4619	26.9026	444.3304	2.1647	58.2372	0.0372	0.0172	39
40	0.4529	27.3555	461.9931	2.2080	60.4020	0.0366	0.0166	40
41	0.4440	27.7995	479.7535	2.2522	62.6100	0.0360	0.0160	41
42	0.4353	28.2348	497.6010	2.2972	64.8622	0.0354	0.0154	42
43	0.4268	28.6616	515.5253	2.3432	67.1595	0.0349	0.0149	43
44	0.4184	29.0800	533.5165	2.3901	69.5027	0.0344	0.0144	44
45	0.4102	29.4902	551.5652	2.4379	71.8927	0.0339	0.0139	45
46	0.4022	29.8923	569.6621	2.4866	74.3306	0.0335	0.0135	46
47	0.3943	30.2866	587.7985	2.5363	76.8172	0.0330	0.0130	47
48	0.3865	30.6731	605.9657	2.5871	79.3535	0.0326	0.0126	48
49	0.3790	31.0521	624.1557	2.6388	81.9406	0.0322	0.0122	49
50	0.3715	31.4236	642.3606	2.6916	84.5794	0.0318	0.0118	50
51	0.3642	31.7878	660.5727	2.7454	87.2710	0.0315	0.0115	51
52	0.3571	32.1449	678.7849	2.8003	90.0164	0.0311	0.0111	52
53	0.3501	32.4950	696.9900	2.8563	92.8167	0.0308	0.0108	53
54	0.3432	32.8383	715.1815	2.9135	95.6731	0.0305	0.0105	54
55	0.3365	33.1748	733.3527	2.9717	98.5865	0.0301	0.0101	55
56	0.3299	33.5047	751.4975	3.0312	101.5583	0.0298	0.0098	56
57	0.3234	33.8281	769.6100	3.0918	104.5894	0.0296	0.0096	57
58	0.3171	34.1452	787.6845	3.1536	107.6812	0.0293	0.0093	58
59	0.3109	34.4561	805.7154	3.2167	110.8348	0.0290	0.0090	59
60	0.3048	34.7609	823.6975	3.2810	114.0515	0.0288	0.0088	60
65	0.2761	36.1975	912.7085	3.6225	131.1262	0.0276	0.0076	65
70	0.2500	37.4986	999.8343	3.9996	149.9779	0.0267	0.0067	70
75	0.2265	38.6771	1084.6393	4.4158	170.7918	0.0259	0.0059	75
80	0.2051	39.7445	1166.7868	4.8754	193.7720	0.0252	0.0052	80
85	0.1858	40.7113	1246.0241	5.3829	219.1439	0.0246	0.0046	85
90	0.1683	41.5869	1322.1701	5.9491	247.1567	0.0240	0.0040	90
95	0.1524	42.3800	1395.1033	6.5617	278.0650	0.0236	0.0036	95
100	0.1380	43.0984	1464.7527	7.2446	312.2323	0.0232	0.0032	100

INTEREST RATE = 3.00%

N	(P/F)	(P/A)	(P/G)	(F/P)	(F/A)	(A/P)	(A/F)	N
1	0.9709	0.9709	0.0000	1.0300	1.0000	1.0300	1.0000	1
2	0.9426	1.9135	0.9426	1.0609	2.0300	0.5226	0.4926	2
3	0.9151	2.8286	2.7729	1.0927	3.0909	0.3536	0.3235	3
4	0.8885	3.7171	5.4383	1.1255	4.1836	0.2690	0.2390	4
5	0.8626	4.5797	8.8888	1.1593	5.3091	0.2184	0.1884	5
6	0.8375	5.4172	13.0762	1.1941	6.4684	0.1846	0.1546	6
7	0.8131	6.2303	17.9547	1.2299	7.6625	0.1605	0.1305	7
8	0.7894	7.0197	23.4806	1.2668	8.8923	0.1425	0.1125	8
9	0.7664	7.7861	29.6119	1.3048	10.1591	0.1284	0.0984	9
10	0.7441	8.5302	36.3088	1.3439	11.4639	0.1172	0.0872	10
11	0.7224	9.2526	43.5330	1.3842	12.8078	0.1081	0.0781	11
12	0.7014	9.9540	51.2482	1.4258	14.1920	0.1005	0.0705	12
13	0.6810	10.6350	59.4196	1.4685	15.6178	0.0940	0.0640	13
14	0.6611	11.2961	68.0141	1.5126	17.0863	0.0885	0.0585	14
15	0.6419	11.9373	77.0002	1.5580	18.5989	0.0838	0.0538	15
16	0.6232	12.5611	86.3477	1.6047	20.1569	0.0796	0.0496	16
17	0.6050	13.1661	96.0280	1.6528	21.7616	0.0760	0.0460	17
18	0.5874	13.7535	106.0137	1.7024	23.4144	0.0727	0.0427	18
19	0.5703	14.3238	116.2788	1.7535	25.1169	0.0698	0.0398	19
20	0.5537	14.8775	126.7987	1.8061	26.8704	0.0672	0.0372	20
21	0.5375	15.4150	137.5496	1.8603	28.6765	0.0649	0.0349	21
22	0.5219	15.9369	148.5094	1.9161	30.5368	0.0627	0.0327	22
23	0.5067	16.4436	159.6566	1.9736	32.4529	0.0608	0.0308	23
24	0.4919	16.9355	170.9711	2.0328	34.4265	0.0590	0.0290	24
25	0.4776	17.4131	182.4336	2.0938	36.4593	0.0574	0.0274	25
26	0.4637	17.8768	194.0260	2.1566	38.5530	0.0559	0.0259	26
27	0.4502	18.3270	205.7309	2.2213	40.7096	0.0546	0.0246	27
28	0.4371	18.7641	217.5320	2.2879	42.9309	0.0533	0.0233	28
29	0.4243	19.1885	229.4137	2.3566	45.2189	0.0521	0.0221	29
30	0.4120	19.6004	241.3613	2.4273	47.5754	0.0510	0.0210	30
31	0.4000	20.0004	253.3609	2.5001	50.0027	0.0500	0.0200	31
32	0.3883	20.3883	265.3993	2.5751	52.5028	0.0490	0.0190	32
33	0.3770	20.7658	277.4642	2.6523	55.0778	0.0482	0.0182	33
34	0.3660	21.1318	289.5437	2.7319	57.7302	0.0473	0.0173	34
35	0.3554	21.4872	301.6267	2.8139	60.4621	0.0465	0.0165	35
36	0.3450	21.8323	313.7028	2.8983	63.2759	0.0458	0.0158	36
37	0.3350	22.1672	325.7622	2.9852	66.1742	0.0451	0.0151	37
38	0.3252	22.4925	337.7956	3.0748	69.1594	0.0445	0.0145	38
39	0.3158	22.8082	349.7942	3.1670	72.2342	0.0438	0.0138	39
40	0.3066	23.1148	361.7499	3.2620	75.4019	0.0433	0.0133	40
41	0.2976	23.4124	373.6551	3.3599	78.6633	0.0427	0.0127	41
42	0.2890	23.7014	385.5024	3.4607	82.0232	0.0422	0.0122	42
43	0.2805	23.9819	397.2852	3.5645	85.4839	0.0417	0.0117	43
44	0.2724	24.2543	408.9972	3.6715	89.0484	0.0412	0.0112	44
45	0.2644	24.5187	420.6325	3.7816	92.7199	0.0408	0.0108	45
46	0.2567	24.7754	432.1856	3.8950	96.5015	0.0404	0.0104	46
47	0.2493	25.0247	443.6515	4.0119	100.3965	0.0400	0.0100	47
48	0.2420	25.2667	455.0255	4.1323	104.4084	0.0396	0.0096	48
49	0.2350	25.5017	466.3031	4.2562	108.5406	0.0392	0.0092	49
50	0.2281	25.7298	477.4803	4.3839	112.7969	0.0389	0.0089	50
51	0.2215	25.9512	488.5535	4.5154	117.1808	0.0386	0.0086	51
52	0.2150	26.1662	499.5191	4.6509	121.6962	0.0382	0.0082	52
53	0.2088	26.3750	510.3742	4.7904	126.3471	0.0379	0.0079	53
54	0.2027	26.5777	521.1157	4.9341	131.1375	0.0376	0.0076	54
55	0.1968	26.7744	531.7411	5.0821	136.0716	0.0373	0.0073	55
56	0.1910	26.9655	542.2481	5.2346	141.1538	0.0371	0.0071	56
57	0.1855	27.1509	552.6345	5.3917	146.3884	0.0368	0.0068	57
58	0.1801	27.3310	562.8985	5.5534	151.7800	0.0366	0.0066	58
59	0.1748	27.5058	573.0384	5.7200	157.3334	0.0364	0.0064	59
60	0.1697	27.6756	583.0526	5.8916	163.0534	0.0361	0.0061	60
65	0.1464	28.4529	631.2010	6.8300	194.3328	0.0351	0.0051	65
70	0.1263	29.1234	676.0869	7.9178	230.5941	0.0343	0.0043	70
75	0.1089	29.7018	717.6978	9.1789	272.6309	0.0337	0.0037	75
80	0.0940	30.2008	756.0865	10.6409	321.3630	0.0331	0.0031	80
85	0.0811	30.6312	791.3529	12.3357	377.8570	0.0326	0.0026	85
90	0.0699	31.0024	823.6302	14.3005	443.3489	0.0323	0.0023	90
95	0.0603	31.3227	853.0742	16.5782	519.2720	0.0319	0.0019	95
100	0.0520	31.5989	879.8540	19.2186	607.2877	0.0316	0.0016	100

INTEREST RATE = 4.00%

N	(P/F)	(P/A)	(P/G)	(F/P)	(F/A)	(A/P)	(A/F)	N
1	0.9615	0.9615	0.0000	1.0400	1.0000	1.0400	1.0000	1
2	0.9246	1.8861	0.9246	1.0816	2.0400	0.5302	0.4902	2
3	0.8890	2.7751	2.7025	1.1249	3.1216	0.3603	0.3203	3
4	0.8548	3.6299	5.2670	1.1699	4.2465	0.2755	0.2355	4
5	0.8219	4.4518	8.5547	1.2167	5.4163	0.2246	0.1846	5
6	0.7903	5.2421	12.5062	1.2653	6.6330	0.1908	0.1508	6
7	0.7599	6.0021	17.0657	1.3159	7.8983	0.1666	0.1266	7
8	0.7307	6.7327	22.1806	1.3686	9.2142	0.1485	0.1085	8
9	0.7026	7.4353	27.8013	1.4233	10.5828	0.1345	0.0945	9
10	0.6756	8.1109	33.8814	1.4802	12.0061	0.1233	0.0833	10
11	0.6496	8.7605	40.3772	1.5395	13.4864	0.1141	0.0741	11
12	0.6246	9.3851	47.2477	1.6010	15.0258	0.1066	0.0666	12
13	0.6006	9.9856	54.4546	1.6651	16.6268	0.1001	0.0601	13
14	0.5775	10.5631	61.9618	1.7317	18.2919	0.0947	0.0547	14
15	0.5553	11.1184	69.7355	1.8009	20.0236	0.0899	0.0499	15
16	0.5339	11.6523	77.7441	1.8730	21.8245	0.0858	0.0458	16
17	0.5134	12.1657	85.9581	1.9479	23.6975	0.0822	0.0422	17
18	0.4936	12.6593	94.3498	2.0258	25.6454	0.0790	0.0390	18
19	0.4746	13.1339	102.8933	2.1068	27.6712	0.0761	0.0361	19
20	0.4564	13.5903	111.5647	2.1911	29.7781	0.0736	0.0336	20
21	0.4388	14.0292	120.3414	2.2788	31.9692	0.0713	0.0313	21
22	0.4220	14.4511	129.2024	2.3699	34.2480	0.0692	0.0292	22
23	0.4057	14.8568	138.1284	2.4647	36.6179	0.0673	0.0273	23
24	0.3901	15.2470	147.1012	2.5633	39.0826	0.0656	0.0256	24
25	0.3751	15.6221	156.1040	2.6658	41.6459	0.0640	0.0240	25
26	0.3607	15.9828	165.1212	2.7725	44.3117	0.0626	0.0226	26
27	0.3468	16.3296	174.1385	2.8834	47.0842	0.0612	0.0212	27
28	0.3335	16.6631	183.1424	2.9987	49.9676	0.0600	0.0200	28
29	0.3207	16.9837	192.1206	3.1187	52.9663	0.0589	0.0189	29
30	0.3083	17.2920	201.0618	3.2434	56.0849	0.0578	0.0178	30
31	0.2965	17.5885	209.9556	3.3731	59.3283	0.0569	0.0169	31
32	0.2851	17.8736	218.7924	3.5081	62.7015	0.0559	0.0159	32
33	0.2741	18.1476	227.5634	3.6484	66.2095	0.0551	0.0151	33
34	0.2636	18.4112	236.2607	3.7943	69.8579	0.0543	0.0143	34
35	0.2534	18.6646	244.8768	3.9461	73.6522	0.0536	0.0136	35
36	0.2437	18.9083	253.4052	4.1039	77.5983	0.0529	0.0129	36
37	0.2343	19.1426	261.8399	4.2681	81.7022	0.0522	0.0122	37
38	0.2253	19.3679	270.1754	4.4388	85.9703	0.0516	0.0116	38
39	0.2166	19.5845	278.4070	4.6164	90.4091	0.0511	0.0111	39
40	0.2083	19.7928	286.5303	4.8010	95.0255	0.0505	0.0105	40
41	0.2003	19.9931	294.5414	4.9931	99.8265	0.0500	0.0100	41
42	0.1926	20.1856	302.4370	5.1928	104.8196	0.0495	0.0095	42
43	0.1852	20.3708	310.2141	5.4005	110.0124	0.0491	0.0091	43
44	0.1780	20.5488	317.8700	5.6165	115.4129	0.0487	0.0087	44
45	0.1712	20.7200	325.4028	5.8412	121.0294	0.0483	0.0083	45
46	0.1646	20.8847	332.8104	6.0748	126.8706	0.0479	0.0079	46
47	0.1583	21.0429	340.0914	6.3178	132.9454	0.0475	0.0075	47
48	0.1522	21.1951	347.2446	6.5705	139.2632	0.0472	0.0072	48
49	0.1463	21.3415	354.2689	6.8333	145.8337	0.0469	0.0069	49
50	0.1407	21.4822	361.1638	7.1067	152.6671	0.0466	0.0066	50
51	0.1353	21.6175	367.9289	7.3910	159.7738	0.0463	0.0063	51
52	0.1301	21.7476	374.5638	7.6866	167.1647	0.0460	0.0060	52
53	0.1251	21.8727	381.0686	7.9941	174.8513	0.0457	0.0057	53
54	0.1203	21.9930	387.4436	8.3138	182.8454	0.0455	0.0055	54
55	0.1157	22.1086	393.6890	8.6464	191.1592	0.0452	0.0052	55
56	0.1112	22.2198	399.8054	8.9922	199.8055	0.0450	0.0050	56
57	0.1069	22.3267	405.7935	9.3519	208.7978	0.0448	0.0048	57
58	0.1028	22.4296	411.6540	9.7260	218.1497	0.0446	0.0046	58
59	0.0989	22.5284	417.3881	10.1150	227.8757	0.0444	0.0044	59
60	0.0951	22.6235	422.9966	10.5196	237.9907	0.0442	0.0042	60
65	0.0781	23.0467	449.2014	12.7987	294.9684	0.0434	0.0034	65
70	0.0642	23.3945	472.4789	15.5716	364.2905	0.0427	0.0027	70
75	0.0528	23.6804	493.0408	18.9453	448.6314	0.0422	0.0022	75
80	0.0434	23.9154	511.1161	23.0498	551.2450	0.0418	0.0018	80
85	0.0357	24.1085	526.9384	28.0436	676.0901	0.0415	0.0015	85
90	0.0293	24.2673	540.7369	34.1193	827.9833	0.0412	0.0012	90
95	0.0241	24.3978	552.7307	41.5114	1012.7846	0.0410	0.0010	95
100	0.0198	24.5050	563.1249	50.5049	1237.6237	0.0408	0.0008	100

INTEREST RATE = 5.00%

N	(P/F)	(P/A)	(P/G)	(F/P)	(F/A)	(A/P)	(A/F)	N
1	0.9524	0.9524	0.0000	1.0500	1.0000	1.0500	1.0000	1
2	0.9070	1.8594	0.9070	1.1025	2.0500	0.5378	0.4878	2
3	0.8638	2.7232	2.6347	1.1576	3.1525	0.3672	0.3172	3
4	0.8227	3.5460	5.1028	1.2155	4.3101	0.2820	0.2320	4
5	0.7835	4.3295	8.2369	1.2763	5.5256	0.2310	0.1810	5
6	0.7462	5.0757	11.9680	1.3401	6.8019	0.1970	0.1470	6
7	0.7107	5.7864	16.2921	1.4071	8.1420	0.1728	0.1228	7
8	0.6768	6.4632	20.9700	1.4775	9.5491	0.1547	0.1047	8
9	0.6446	7.1078	26.1268	1.5513	11.0266	0.1407	0.0907	9
10	0.6139	7.7217	31.6520	1.6289	12.5779	0.1295	0.0795	10
11	0.5847	8.3064	37.4988	1.7103	14.2068	0.1204	0.0704	11
12	0.5568	8.8633	43.6241	1.7959	15.9171	0.1128	0.0628	12
13	0.5303	9.3936	49.9879	1.8856	17.7130	0.1065	0.0565	13
14	0.5051	9.8986	56.5538	1.9799	19.5986	0.1010	0.0510	14
15	0.4810	10.3797	63.2880	2.0789	21.5786	0.0963	0.0463	15
16	0.4581	10.8378	70.1597	2.1829	23.6575	0.0923	0.0423	16
17	0.4363	11.2741	77.1405	2.2920	25.8404	0.0887	0.0387	17
18	0.4155	11.6896	84.2043	2.4066	28.1324	0.0855	0.0355	18
19	0.3957	12.0853	91.3275	2.5270	30.5390	0.0827	0.0327	19
20	0.3769	12.4622	98.4884	2.6533	33.0660	0.0802	0.0302	20
21	0.3589	12.8212	105.6673	2.7860	35.7193	0.0780	0.0280	21
22	0.3418	13.1630	112.8461	2.9253	38.5052	0.0760	0.0260	22
23	0.3256	13.4886	120.0087	3.0715	41.4305	0.0741	0.0241	23
24	0.3101	13.7986	127.1402	3.2251	44.5020	0.0725	0.0225	24
25	0.2953	14.0939	134.2275	3.3864	47.7271	0.0710	0.0210	25
26	0.2812	14.3752	141.2585	3.5557	51.1135	0.0696	0.0196	26
27	0.2678	14.6430	148.2226	3.7335	54.6691	0.0683	0.0183	27
28	0.2551	14.8981	155.1101	3.9201	58.4026	0.0671	0.0171	28
29	0.2429	15.1411	161.9126	4.1161	62.3227	0.0660	0.0160	29
30	0.2314	15.3725	168.6226	4.3219	66.4388	0.0651	0.0151	30
31	0.2204	15.5926	175.2333	4.5380	70.7608	0.0641	0.0141	31
32	0.2099	15.8027	181.7392	4.7649	75.2988	0.0633	0.0133	32
33	0.1999	16.0025	188.1351	5.0032	80.0638	0.0625	0.0125	33
34	0.1904	16.1929	194.4168	5.2533	85.0670	0.0618	0.0118	34
35	0.1813	16.3742	200.5807	5.5160	90.3203	0.0611	0.0111	35
36	0.1727	16.5469	206.6237	5.7918	95.8363	0.0604	0.0104	36
37	0.1644	16.7113	212.5434	6.0814	101.6281	0.0598	0.0098	37
38	0.1566	16.8679	218.3378	6.3855	107.7095	0.0593	0.0093	38
39	0.1491	17.0170	224.0054	6.7048	114.0950	0.0588	0.0088	39
40	0.1420	17.1591	229.5452	7.0400	120.7998	0.0583	0.0083	40
41	0.1353	17.2944	234.9564	7.3920	127.8398	0.0578	0.0078	41
42	0.1288	17.4232	240.2389	7.7616	135.2318	0.0574	0.0074	42
43	0.1227	17.5459	245.3925	8.1497	142.9933	0.0570	0.0070	43
44	0.1169	17.6628	250.4175	8.5572	151.1430	0.0566	0.0066	44
45	0.1113	17.7741	255.3145	8.9850	159.7002	0.0563	0.0063	45
46	0.1060	17.8801	260.0844	9.4343	168.6852	0.0559	0.0059	46
47	0.1009	17.9810	264.7281	9.9060	178.1194	0.0556	0.0056	47
48	0.0961	18.0772	269.2467	10.4013	188.0254	0.0553	0.0053	48
49	0.0916	18.1687	273.6418	10.9213	198.4267	0.0550	0.0050	49
50	0.0872	18.2559	277.9148	11.4674	209.3480	0.0548	0.0048	50
51	0.0831	18.3390	282.0673	12.0408	220.8154	0.0545	0.0045	51
52	0.0791	18.4181	286.1013	12.6428	232.8562	0.0543	0.0043	52
53	0.0753	18.4934	290.0184	13.2749	245.4990	0.0541	0.0041	53
54	0.0717	18.5651	293.8208	13.9387	258.7739	0.0539	0.0039	54
55	0.0683	18.6335	297.5104	14.6356	272.7126	0.0537	0.0037	55
56	0.0651	18.6985	301.0894	15.3674	287.3482	0.0535	0.0035	56
57	0.0620	18.7605	304.5599	16.1358	302.7157	0.0533	0.0033	57
58	0.0590	18.8195	307.9243	16.9426	318.8514	0.0531	0.0031	58
59	0.0562	18.8758	311.1846	17.7897	335.7940	0.0530	0.0030	59
60	0.0535	18.9293	314.3432	18.6792	353.5837	0.0528	0.0028	60
65	0.0419	19.1611	328.6910	23.8399	456.7980	0.0522	0.0022	65
70	0.0329	19.3427	340.8409	30.4264	588.5285	0.0517	0.0017	70
75	0.0258	19.4850	351.0721	38.8327	756.6537	0.0513	0.0013	75
80	0.0202	19.5965	359.6460	49.5614	971.2288	0.0510	0.0010	80
85	0.0158	19.6838	366.8007	63.2544	1245.0871	0.0508	0.0008	85
90	0.0124	19.7523	372.7488	80.7304	1594.6073	0.0506	0.0006	90
95	0.0097	19.8059	377.6774	103.0347	2040.6935	0.0505	0.0005	95
100	0.0076	19.8479	381.7492	131.5013	2610.0252	0.0504	0.0004	100

INTEREST RATE = 6.00%

N	(P/F)	(P/A)	(P/G)	(F/P)	(F/A)	(A/P)	(A/F)	N
1	0.9434	0.9434	0.0000	1.0600	1.0000	1.0600	1.0000	1
2	0.8900	1.8334	0.8900	1.1236	2.0600	0.5454	0.4854	2
3	0.8396	2.6730	2.5692	1.1910	3.1836	0.3741	0.3141	3
4	0.7921	3.4651	4.9455	1.2625	4.3746	0.2886	0.2286	4
5	0.7473	4.2124	7.9345	1.3382	5.6371	0.2374	0.1774	5
6	0.7050	4.9173	11.4594	1.4185	6.9753	0.2034	0.1434	6
7	0.6651	5.5824	15.4497	1.5036	8.3936	0.1791	0.1191	7
8	0.6274	6.2098	19.8416	1.5938	9.8975	0.1610	0.1010	8
9	0.5919	6.8017	24.5768	1.6895	11.4913	0.1470	0.0870	9
10	0.5584	7.3601	29.6023	1.7908	13.1808	0.1359	0.0759	10
11	0.5268	7.8869	34.8702	1.8983	14.9716	0.1268	0.0668	11
12	0.4970	8.3838	40.3369	2.0122	16.8699	0.1193	0.0593	12
13	0.4688	8.8527	45.9629	2.1329	18.8821	0.1130	0.0530	13
14	0.4423	9.2950	51.7128	2.2609	21.0151	0.1076	0.0476	14
15	0.4173	9.7122	57.5546	2.3966	23.2760	0.1030	0.0430	15
16	0.3936	10.1059	63.4592	2.5404	25.6725	0.0990	0.0390	16
17	0.3714	10.4773	69.4011	2.6928	28.2129	0.0954	0.0354	17
18	0.3503	10.8276	75.3569	2.8543	30.9057	0.0924	0.0324	18
19	0.3305	11.1581	81.3062	3.0256	33.7600	0.0896	0.0296	19
20	0.3118	11.4699	87.2304	3.2071	36.7856	0.0872	0.0272	20
21	0.2942	11.7641	93.1136	3.3996	39.9927	0.0850	0.0250	21
22	0.2775	12.0416	98.9412	3.6035	43.3923	0.0830	0.0230	22
23	0.2618	12.3034	104.7007	3.8197	46.9958	0.0813	0.0213	23
24	0.2470	12.5504	110.3812	4.0489	50.8156	0.0797	0.0197	24
25	0.2330	12.7834	115.9732	4.2919	54.8645	0.0782	0.0182	25
26	0.2198	13.0032	121.4684	4.5494	59.1564	0.0769	0.0169	26
27	0.2074	13.2105	126.8600	4.8223	63.7058	0.0757	0.0157	27
28	0.1956	13.4062	132.1420	5.1117	68.5281	0.0746	0.0146	28
29	0.1846	13.5907	137.3096	5.4184	73.6398	0.0736	0.0136	29
30	0.1741	13.7648	142.3588	5.7435	79.0582	0.0726	0.0126	30
31	0.1643	13.9291	147.2864	6.0881	84.8017	0.0718	0.0118	31
32	0.1550	14.0840	152.0901	6.4534	90.8898	0.0710	0.0110	32
33	0.1462	14.2302	156.7681	6.8406	97.3432	0.0703	0.0103	33
34	0.1379	14.3681	161.3192	7.2510	104.1838	0.0696	0.0096	34
35	0.1301	14.4982	165.7427	7.6861	111.4348	0.0690	0.0090	35
36	0.1227	14.6210	170.0387	8.1473	119.1209	0.0684	0.0084	36
37	0.1158	14.7368	174.2072	8.6361	127.2681	0.0679	0.0079	37
38	0.1092	14.8460	178.2490	9.1543	135.9042	0.0674	0.0074	38
39	0.1031	14.9491	182.1652	9.7035	145.0385	0.0669	0.0069	39
40	0.0972	15.0463	185.9568	10.2857	154.7620	0.0665	0.0065	40
41	0.0917	15.1380	189.6256	10.9029	165.0477	0.0661	0.0061	41
42	0.0865	15.2245	193.1732	11.5570	175.9505	0.0657	0.0057	42
43	0.0816	15.3062	196.6017	12.2505	187.5076	0.0653	0.0053	43
44	0.0770	15.3832	199.9130	12.9855	199.7580	0.0650	0.0050	44
45	0.0727	15.4558	203.1096	13.7646	212.7435	0.0647	0.0047	45
46	0.0685	15.5244	206.1938	14.5905	226.5081	0.0644	0.0044	46
47	0.0647	15.5890	209.1681	15.4659	241.0986	0.0641	0.0041	47
48	0.0610	15.6500	212.0351	16.3939	256.5645	0.0639	0.0039	48
49	0.0575	15.7076	214.7972	17.3775	272.9584	0.0637	0.0037	49
50	0.0543	15.7619	217.4574	18.4202	290.3359	0.0634	0.0034	50
51	0.0512	15.8131	220.0181	19.5254	308.7561	0.0632	0.0032	51
52	0.0483	15.8614	222.4823	20.6969	328.2814	0.0630	0.0030	52
53	0.0456	15.9070	224.8525	21.9387	348.9783	0.0629	0.0029	53
54	0.0430	15.9500	227.1316	23.2550	370.9170	0.0627	0.0027	54
55	0.0406	15.9905	229.3222	24.6503	394.1720	0.0625	0.0025	55
56	0.0383	16.0288	231.4272	26.1293	418.8223	0.0624	0.0024	56
57	0.0361	16.0649	233.4490	27.6971	444.9517	0.0622	0.0022	57
58	0.0341	16.0990	235.3905	29.3589	472.6488	0.0621	0.0021	58
59	0.0321	16.1311	237.2542	31.1205	502.0077	0.0620	0.0020	59
60	0.0303	16.1614	239.0428	32.9877	533.1282	0.0619	0.0019	60
65	0.0227	16.2891	246.9450	44.1450	719.0829	0.0614	0.0014	65
70	0.0169	16.3845	253.3271	59.0759	967.9322	0.0610	0.0010	70
75	0.0126	16.4558	258.4527	79.0569	1300.9487	0.0608	0.0008	75
80	0.0095	16.5091	262.5493	105.7960	1746.5999	0.0606	0.0006	80
85	0.0071	16.5489	265.8096	141.5789	2342.9817	0.0604	0.0004	85
90	0.0053	16.5787	268.3946	189.4645	3141.0752	0.0603	0.0003	90
95	0.0039	16.6009	270.4375	253.5463	4209.1042	0.0602	0.0002	95
100	0.0029	16.6175	272.0471	339.3021	5638.3681	0.0602	0.0002	100

INTEREST RATE = 7.00%

N	(P/F)	(P/A)	(P/G)	(F/P)	(F/A)	(A/P)	(A/F)	N
1	0.9346	0.9346	0.0000	1.0700	1.0000	1.0700	1.0000	1
2	0.8734	1.8080	0.8734	1.1449	2.0700	0.5531	0.4831	2
3	0.8163	2.6243	2.5060	1.2250	3.2149	0.3811	0.3111	3
4	0.7629	3.3872	4.7947	1.3108	4.4399	0.2952	0.2252	4
5	0.7130	4.1002	7.6467	1.4026	5.7507	0.2439	0.1739	5
6	0.6663	4.7665	10.9784	1.5007	7.1533	0.2098	0.1396	6
7	0.6227	5.3893	14.7149	1.6058	8.6540	0.1856	0.1156	7
8	0.5820	5.9713	18.7889	1.7182	10.2598	0.1675	0.0975	8
9	0.5439	6.5152	23.1404	1.8385	11.9780	0.1535	0.0835	9
10	0.5083	7.0236	27.7156	1.9672	13.8164	0.1424	0.0724	10
11	0.4751	7.4987	32.4665	2.1049	15.7836	0.1334	0.0634	11
12	0.4440	7.9427	37.3506	2.2522	17.8885	0.1259	0.0559	12
13	0.4150	8.3577	42.3302	2.4098	20.1406	0.1197	0.0497	13
14	0.3878	8.7455	47.3718	2.5785	22.5505	0.1143	0.0443	14
15	0.3624	9.1079	52.4461	2.7590	25.1290	0.1098	0.0398	15
16	0.3387	9.4466	57.5271	2.9522	27.8881	0.1059	0.0359	16
17	0.3166	9.7632	62.5923	3.1588	30.8402	0.1024	0.0324	17
18	0.2959	10.0591	67.6219	3.3799	33.9990	0.0994	0.0294	18
19	0.2765	10.3356	72.5991	3.6165	37.3790	0.0968	0.0268	19
20	0.2584	10.5940	77.5091	3.8697	40.9955	0.0944	0.0244	20
21	0.2415	10.8355	82.3393	4.1406	44.8652	0.0923	0.0223	21
22	0.2257	11.0612	87.0793	4.4304	49.0057	0.0904	0.0204	22
23	0.2109	11.2722	91.7201	4.7405	53.4361	0.0887	0.0187	23
24	0.1971	11.4693	96.2545	5.0724	58.1767	0.0872	0.0172	24
25	0.1842	11.6536	100.6765	5.4274	63.2490	0.0858	0.0158	25
26	0.1722	11.8258	104.9814	5.8074	68.6765	0.0846	0.0146	26
27	0.1609	11.9867	109.1655	6.2139	74.4838	0.0834	0.0134	27
28	0.1504	12.1371	113.2264	6.6488	80.6977	0.0824	0.0124	28
29	0.1406	12.2777	117.1622	7.1143	87.3465	0.0814	0.0114	29
30	0.1314	12.4090	120.9713	7.6123	94.4608	0.0806	0.0106	30
31	0.1228	12.5318	124.6553	8.1451	102.0730	0.0798	0.0098	31
32	0.1147	12.6466	128.2123	8.7153	110.2182	0.0791	0.0091	32
33	0.1072	12.7538	131.6435	9.3253	118.9334	0.0784	0.0084	33
34	0.1002	12.8540	134.9507	9.9781	128.2588	0.0778	0.0078	34
35	0.0937	12.9477	138.1353	10.6766	138.2369	0.0772	0.0072	35
36	0.0875	13.0352	141.1993	11.4239	148.9135	0.0767	0.0067	36
37	0.0818	13.1170	144.1441	12.2236	160.3374	0.0762	0.0062	37
38	0.0765	13.1935	146.9733	13.0793	172.5610	0.0758	0.0058	38
39	0.0715	13.2649	149.6883	13.9948	185.6403	0.0754	0.0054	39
40	0.0668	13.3317	152.2923	14.9745	199.6351	0.0750	0.0050	40
41	0.0624	13.3941	154.7892	16.0227	214.6096	0.0747	0.0047	41
42	0.0583	13.4524	157.1807	17.1443	230.6322	0.0743	0.0043	42
43	0.0545	13.5070	159.4702	18.3444	247.7765	0.0740	0.0040	43
44	0.0509	13.5579	161.6609	19.6285	266.1209	0.0738	0.0038	44
45	0.0476	13.6055	163.7553	21.0025	285.7493	0.0735	0.0035	45
46	0.0445	13.6500	165.7584	22.4726	306.7518	0.0733	0.0033	46
47	0.0416	13.6916	167.6714	24.0457	329.2244	0.0730	0.0030	47
48	0.0389	13.7305	169.4981	25.7289	353.2701	0.0728	0.0028	48
49	0.0363	13.7668	171.2417	27.5299	378.9990	0.0726	0.0026	49
50	0.0339	13.8007	172.9051	29.4570	406.5289	0.0725	0.0025	50
51	0.0317	13.8325	174.4915	31.5190	435.9860	0.0723	0.0023	51
52	0.0297	13.8621	176.0037	33.7253	467.5050	0.0721	0.0021	52
53	0.0277	13.8898	177.4447	36.0861	501.2303	0.0720	0.0020	53
54	0.0259	13.9157	178.8173	38.6122	537.3164	0.0719	0.0019	54
55	0.0242	13.9399	180.1243	41.3150	575.9286	0.0717	0.0017	55
56	0.0226	13.9626	181.3665	44.2071	617.2436	0.0716	0.0016	56
57	0.0211	13.9837	182.5524	47.3015	661.4506	0.0715	0.0015	57
58	0.0198	14.0035	183.6785	50.6127	708.7522	0.0714	0.0014	58
59	0.0185	14.0219	184.7495	54.1555	759.3648	0.0713	0.0013	59
60	0.0173	14.0392	185.7677	57.9464	813.5204	0.0712	0.0012	60
65	0.0123	14.1099	190.1452	81.2729	1146.7552	0.0709	0.0009	65
70	0.0088	14.1604	193.5185	113.9894	1614.1342	0.0706	0.0006	70
75	0.0063	14.1964	196.1035	159.8760	2269.6574	0.0704	0.0004	75
80	0.0045	14.2220	198.0743	224.2344	3189.0627	0.0703	0.0003	80
85	0.0032	14.2403	199.5717	314.5003	4478.5761	0.0702	0.0002	85
90	0.0023	14.2533	200.7042	441.1030	6287.1854	0.0702	0.0002	90
95	0.0016	14.2626	201.5581	618.6697	8823.8535	0.0701	0.0001	95
100	0.0012	14.2693	202.2001	867.7163	12381.6618	0.0701	0.0001	100

INTEREST RATE = 8.00%

N	(P/F)	(P/A)	(P/G)	(F/P)	(F/A)	(A/P)	(A/F)	N
1	0.9259	0.9259	0.0000	1.0500	1.0000	1.0800	1.0000	1
2	0.8573	1.7833	0.8573	1.1664	2.0800	0.5608	0.4808	2
3	0.7938	2.5771	2.4450	1.2597	3.2464	0.3880	0.3080	3
4	0.7350	3.3121	4.6501	1.3605	4.5061	0.3019	0.2219	4
5	0.6806	3.9927	7.3724	1.4693	5.8666	0.2505	0.1705	5
6	0.6302	4.6229	10.5233	1.5869	7.3359	0.2163	0.1363	6
7	0.5835	5.2064	14.0242	1.7138	8.9228	0.1921	0.1121	7
8	0.5403	5.7466	17.8061	1.8509	10.6366	0.1740	0.0940	8
9	0.5002	6.2469	21.8081	1.9990	12.4876	0.1601	0.0801	9
10	0.4632	6.7101	25.9766	2.1589	14.4866	0.1490	0.0690	10
11	0.4289	7.1390	30.2657	2.3316	16.6455	0.1401	0.0601	11
12	0.3971	7.5361	34.6339	2.5182	18.9771	0.1327	0.0527	12
13	0.3677	7.9038	39.0463	2.7196	21.4953	0.1265	0.0465	13
14	0.3405	8.2442	43.4723	2.9372	24.2149	0.1213	0.0413	14
15	0.3152	8.5595	47.8857	3.1722	27.1521	0.1168	0.0368	15
16	0.2919	8.8514	52.2640	3.4259	30.3243	0.1130	0.0330	16
17	0.2703	9.1216	56.5863	3.7000	33.7502	0.1096	0.0296	17
18	0.2502	9.3719	60.8426	3.9960	37.4502	0.1067	0.0267	18
19	0.2317	9.6036	65.0134	4.3157	41.4463	0.1041	0.0241	19
20	0.2145	9.8181	69.0898	4.6610	45.7620	0.1019	0.0219	20
21	0.1987	10.0168	73.0629	5.0338	50.4229	0.0998	0.0198	21
22	0.1839	10.2007	76.9257	5.4365	55.4568	0.0980	0.0180	22
23	0.1703	10.3711	80.6726	5.8715	60.8933	0.0964	0.0164	23
24	0.1577	10.5288	84.2997	6.3412	66.7648	0.0950	0.0150	24
25	0.1460	10.6748	87.8041	6.8485	73.1059	0.0937	0.0137	25
26	0.1352	10.8100	91.1842	7.3964	79.9544	0.0925	0.0125	26
27	0.1252	10.9352	94.4390	7.9891	87.3508	0.0914	0.0114	27
28	0.1159	11.0511	97.5687	8.6271	95.3388	0.0905	0.0105	28
29	0.1073	11.1584	100.5733	9.3173	103.9659	0.0896	0.0096	29
30	0.0994	11.2578	103.4553	10.0627	113.2832	0.0888	0.0088	30
31	0.0920	11.3498	106.2163	10.8677	123.3459	0.0881	0.0081	31
32	0.0852	11.4350	108.8575	11.7371	134.2135	0.0875	0.0075	32
33	0.0789	11.5139	111.3819	12.6760	145.9506	0.0869	0.0069	33
34	0.0730	11.5869	113.7924	13.6901	158.6267	0.0863	0.0063	34
35	0.0676	11.6546	116.0920	14.7853	172.3169	0.0858	0.0058	35
36	0.0626	11.7172	118.2839	15.9682	187.1021	0.0853	0.0053	36
37	0.0580	11.7752	120.3713	17.2456	203.0703	0.0849	0.0049	37
38	0.0537	11.8289	122.3573	18.6253	220.3159	0.0845	0.0045	38
39	0.0497	11.8786	124.2470	20.1153	238.9412	0.0842	0.0042	39
40	0.0460	11.9246	126.0422	21.7245	259.0565	0.0839	0.0039	40
41	0.0426	11.9672	127.7470	23.4625	280.7810	0.0836	0.0036	41
42	0.0395	12.0067	129.3651	25.3395	304.2435	0.0833	0.0033	42
43	0.0365	12.0432	130.8993	27.3666	329.5830	0.0830	0.0030	43
44	0.0338	12.0771	132.3547	29.5560	356.9496	0.0828	0.0028	44
45	0.0313	12.1084	133.7331	31.9204	386.5056	0.0826	0.0026	45
46	0.0290	12.1374	135.0384	34.4741	418.4261	0.0824	0.0024	46
47	0.0269	12.1643	136.2739	37.2320	452.9002	0.0822	0.0022	47
48	0.0249	12.1891	137.4423	40.2106	490.1322	0.0820	0.0020	48
49	0.0230	12.2122	138.5483	43.4274	530.3427	0.0819	0.0019	49
50	0.0213	12.2335	139.5923	46.9016	573.7702	0.0817	0.0017	50
51	0.0197	12.2532	140.5799	50.6537	620.6718	0.0816	0.0016	51
52	0.0183	12.2715	141.5121	54.7060	671.3255	0.0815	0.0015	52
53	0.0169	12.2884	142.3923	59.0825	726.0316	0.0814	0.0014	53
54	0.0157	12.3041	143.2223	63.8091	785.1141	0.0813	0.0013	54
55	0.0145	12.3186	144.0065	68.9139	848.9232	0.0812	0.0012	55
56	0.0134	12.3321	144.7454	74.4270	917.8371	0.0811	0.0011	56
57	0.0124	12.3445	145.4421	80.3811	992.2640	0.0810	0.0010	57
58	0.0115	12.3560	146.0987	86.8116	1072.6451	0.0809	0.0009	58
59	0.0107	12.3667	146.7173	93.7565	1159.4568	0.0809	0.0009	59
60	0.0099	12.3766	147.3000	101.2571	1253.2133	0.0808	0.0008	60
65	0.0067	12.4160	149.7387	148.7798	1847.2481	0.0805	0.0005	65
70	0.0046	12.4428	151.5325	218.6064	2720.0801	0.0804	0.0004	70
75	0.0031	12.4611	152.8443	321.2045	4002.5566	0.0802	0.0002	75
80	0.0021	12.4735	153.8001	471.9548	5886.9354	0.0802	0.0002	80
85	0.0014	12.4820	154.4925	693.4565	8655.7061	0.0801	0.0001	85
90	0.0010	12.4877	154.9925	1018.9151	12723.9386	0.0801	0.0001	90
95	0.0007	12.4917	155.3524	1497.1205	18701.5069	0.0801	0.0001	95
100	0.0005	12.4943	155.6107	2199.7613	27484.5157	0.0800	0.0000	100

INTEREST RATE = 9.00%

N	(F/F)	(P/A)	(P/G)	(F/P)	(F/A)	(A/P)	(A/F)	N
1	0.9174	0.9174	0.0000	1.0900	1.0000	1.0900	1.0000	1
2	0.8417	1.7591	0.8417	1.1881	2.0900	0.5685	0.4785	2
3	0.7722	2.5313	2.3860	1.2950	3.2781	0.3951	0.3051	3
4	0.7084	3.2397	4.5113	1.4116	4.5731	0.3087	0.2187	4
5	0.6499	3.8897	7.1110	1.5386	5.9847	0.2571	0.1671	5
6	0.5963	4.4859	10.0924	1.6771	7.5233	0.2229	0.1329	6
7	0.5470	5.0330	13.3746	1.8280	9.2004	0.1987	0.1087	7
8	0.5019	5.5348	16.8877	1.9926	11.0285	0.1807	0.0907	8
9	0.4604	5.9952	20.5711	2.1719	13.0210	0.1668	0.0768	9
10	0.4224	6.4177	24.3728	2.3674	15.1929	0.1558	0.0658	10
11	0.3875	6.8052	28.2481	2.5804	17.5603	0.1469	0.0569	11
12	0.3555	7.1607	32.1590	2.8127	20.1407	0.1397	0.0497	12
13	0.3262	7.4869	36.0731	3.0658	22.9534	0.1336	0.0436	13
14	0.2992	7.7862	39.9633	3.3417	26.0192	0.1284	0.0384	14
15	0.2745	8.0607	43.8069	3.6425	29.3609	0.1241	0.0341	15
16	0.2519	8.3126	47.5849	3.9703	33.0034	0.1203	0.0303	16
17	0.2311	8.5436	51.2821	4.3276	36.9737	0.1170	0.0270	17
18	0.2120	8.7556	54.8960	4.7171	41.3013	0.1142	0.0242	18
19	0.1945	8.9501	58.3868	5.1417	46.0185	0.1117	0.0217	19
20	0.1784	9.1285	61.7770	5.6044	51.1601	0.1095	0.0195	20
21	0.1637	9.2922	65.0509	6.1088	56.7645	0.1076	0.0176	21
22	0.1602	9.4424	68.2048	6.6586	62.8733	0.1059	0.0159	22
23	0.1378	9.5802	71.2359	7.2579	69.5319	0.1044	0.0144	23
24	0.1264	9.7066	74.1433	7.9111	76.7898	0.1030	0.0130	24
25	0.1160	9.8226	76.9265	8.6231	84.7009	0.1018	0.0118	25
26	0.1064	9.9290	79.5863	9.3992	93.3240	0.1007	0.0107	26
27	0.0976	10.0266	82.1241	10.2451	102.7231	0.0997	0.0097	27
28	0.0895	10.1161	84.5419	11.1671	112.9682	0.0989	0.0089	28
29	0.0822	10.1983	86.8422	12.1722	124.1354	0.0981	0.0081	29
30	0.0754	10.2737	89.0280	13.2677	136.3075	0.0973	0.0073	30
31	0.0691	10.3428	91.1024	14.4618	149.5752	0.0967	0.0067	31
32	0.0634	10.4062	93.0690	15.7633	164.0370	0.0961	0.0061	32
33	0.0582	10.4644	94.9314	17.1820	179.8003	0.0956	0.0056	33
34	0.0534	10.5178	96.6935	18.7284	196.9823	0.0951	0.0051	34
35	0.0490	10.5668	98.3590	20.4140	215.7108	0.0946	0.0046	35
36	0.0449	10.6118	99.9319	22.2512	236.1247	0.0942	0.0042	36
37	0.0412	10.6530	101.4162	24.2538	258.3759	0.0939	0.0039	37
38	0.0378	10.6908	102.8158	26.4367	282.6298	0.0935	0.0035	38
39	0.0347	10.7255	104.1345	28.8160	309.0665	0.0932	0.0032	39
40	0.0318	10.7574	105.3762	31.4094	337.8824	0.0930	0.0030	40
41	0.0292	10.7866	106.5445	34.2363	369.2919	0.0927	0.0027	41
42	0.0268	10.8134	107.6432	37.3175	403.5281	0.0925	0.0025	42
43	0.0246	10.8380	108.6758	40.6761	440.8457	0.0923	0.0023	43
44	0.0226	10.8605	109.6456	44.3370	481.5218	0.0921	0.0021	44
45	0.0207	10.8812	110.5561	48.3273	525.8587	0.0919	0.0019	45
46	0.0190	10.9002	111.4103	52.6767	574.1860	0.0917	0.0017	46
47	0.0174	10.9176	112.2115	57.4176	626.8628	0.0916	0.0016	47
48	0.0160	10.9336	112.9625	62.5852	684.2804	0.0915	0.0015	48
49	0.0147	10.9482	113.6661	68.2179	746.8656	0.0913	0.0013	49
50	0.0134	10.9617	114.3251	74.3575	815.0836	0.0912	0.0012	50
51	0.0123	10.9740	114.9420	81.0497	889.4411	0.0911	0.0011	51
52	0.0113	10.9853	115.5193	88.3442	970.4908	0.0910	0.0010	52
53	0.0104	10.9957	116.0593	96.2951	1058.8349	0.0909	0.0009	53
54	0.0095	11.0053	116.5642	104.9617	1155.1301	0.0909	0.0009	54
55	0.0087	11.0140	117.0362	114.4083	1260.0918	0.0908	0.0008	55
56	0.0080	11.0220	117.4772	124.7050	1374.5001	0.0907	0.0007	56
57	0.0074	11.0294	117.8892	135.9285	1499.2051	0.0907	0.0007	57
58	0.0067	11.0361	118.2739	148.1620	1635.1385	0.0906	0.0006	58
59	0.0062	11.0423	118.6331	161.4966	1783.2955	0.0906	0.0006	59
60	0.0057	11.0480	118.9683	176.0313	1944.7921	0.0905	0.0005	60
65	0.0037	11.0701	120.3344	270.8460	2998.2885	0.0903	0.0003	65
70	0.0024	11.0844	121.2942	416.7301	4619.2232	0.0902	0.0002	70
75	0.0016	11.0938	121.9646	641.1909	7113.2321	0.0901	0.0001	75
80	0.0010	11.0998	122.4306	986.5517	10950.5741	0.0901	0.0001	80
85	0.0007	11.1038	122.7533	1517.9320	16854.8003	0.0901	0.0001	85
90	0.0004	11.1064	122.9758	2335.5266	25939.1842	0.0900	0.0000	90
95	0.0003	11.1080	123.1287	3593.4971	39916.6350	0.0900	0.0000	95
100	0.0002	11.1091	123.2335	5529.0408	61422.6755	0.0900	0.0000	100

INTEREST RATE = 10.00%

N	(P/F)	(P/A)	(P/G)	(F/P)	(F/A)	(A/P)	(A/F)	N
1	0.9091	0.9091	0.0000	1.1000	1.0000	1.1000	1.0000	1
2	0.8264	1.7355	0.8264	1.2100	2.1000	0.5762	0.4762	2
3	0.7513	2.4869	2.3291	1.3310	3.3100	0.4021	0.3021	3
4	0.6830	3.1699	4.3781	1.4641	4.6410	0.3155	0.2155	4
5	0.6209	3.7908	6.8618	1.6105	6.1051	0.2638	0.1638	5
6	0.5645	4.3553	9.6842	1.7716	7.7156	0.2296	0.1296	6
7	0.5132	4.8684	12.7631	1.9487	9.4872	0.2054	0.1054	7
8	0.4665	5.3349	16.0287	2.1436	11.4359	0.1874	0.0874	8
9	0.4241	5.7590	19.4215	2.3579	13.5795	0.1736	0.0736	9
10	0.3855	6.1446	22.8913	2.5937	15.9374	0.1627	0.0627	10
11	0.3505	6.4951	26.3963	2.8531	18.5312	0.1540	0.0540	11
12	0.3186	6.8137	29.9012	3.1384	21.3843	0.1468	0.0468	12
13	0.2897	7.1034	33.3772	3.4523	24.5227	0.1408	0.0408	13
14	0.2633	7.3667	36.8005	3.7975	27.9750	0.1357	0.0357	14
15	0.2394	7.6061	40.1520	4.1772	31.7725	0.1315	0.0315	15
16	0.2176	7.8237	43.4164	4.5950	35.9497	0.1278	0.0278	16
17	0.1978	8.0216	46.5819	5.0545	40.5447	0.1247	0.0247	17
18	0.1799	8.2014	49.6395	5.5599	45.5992	0.1219	0.0219	18
19	0.1635	8.3649	52.5827	6.1159	51.1591	0.1195	0.0195	19
20	0.1486	8.5136	55.4069	6.7275	57.2750	0.1175	0.0175	20
21	0.1351	8.6487	58.1095	7.4002	64.0025	0.1156	0.0156	21
22	0.1228	8.7715	60.6893	8.1403	71.4027	0.1140	0.0140	22
23	0.1117	8.8832	63.1462	8.9543	79.5430	0.1126	0.0126	23
24	0.1015	8.9847	65.4813	9.8497	88.4973	0.1113	0.0113	24
25	0.0923	9.0770	67.6964	10.8347	98.3471	0.1102	0.0102	25
26	0.0839	9.1609	69.7940	11.9182	109.1818	0.1092	0.0092	26
27	0.0763	9.2372	71.7773	13.1100	121.0999	0.1083	0.0083	27
28	0.0693	9.3066	73.6495	14.4210	134.2099	0.1075	0.0075	28
29	0.0630	9.3696	75.4146	15.8631	148.6309	0.1067	0.0067	29
30	0.0573	9.4269	77.0766	17.4494	164.4940	0.1061	0.0061	30
31	0.0521	9.4790	78.6395	19.1943	181.9434	0.1055	0.0055	31
32	0.0474	9.5264	80.1078	21.1138	201.1378	0.1050	0.0050	32
33	0.0431	9.5694	81.4856	23.2252	222.2515	0.1045	0.0045	33
34	0.0391	9.6086	82.7773	25.5477	245.4767	0.1041	0.0041	34
35	0.0356	9.6442	83.9872	28.1024	271.0244	0.1037	0.0037	35
36	0.0323	9.6765	85.1194	30.9127	299.1268	0.1033	0.0033	36
37	0.0294	9.7059	86.1781	34.0039	330.0395	0.1030	0.0030	37
38	0.0267	9.7327	87.1673	37.4043	364.0434	0.1027	0.0027	38
39	0.0243	9.7570	88.0908	41.1448	401.4478	0.1025	0.0025	39
40	0.0221	9.7791	88.9525	45.2593	442.5926	0.1023	0.0023	40
41	0.0201	9.7991	89.7560	49.7852	487.8518	0.1020	0.0020	41
42	0.0183	9.8174	90.5047	54.7637	537.6370	0.1019	0.0019	42
43	0.0166	9.8340	91.2019	60.2401	592.4007	0.1017	0.0017	43
44	0.0151	9.8491	91.8508	66.2641	652.6408	0.1015	0.0015	44
45	0.0137	9.8628	92.4544	72.8905	718.9048	0.1014	0.0014	45
46	0.0125	9.8753	93.0157	80.1795	791.7953	0.1013	0.0013	46
47	0.0113	9.8866	93.5372	88.1975	871.9749	0.1011	0.0011	47
48	0.0103	9.8969	94.0217	97.0172	960.1723	0.1010	0.0010	48
49	0.0094	9.9063	94.4715	106.7190	1057.1896	0.1009	0.0009	49
50	0.0085	9.9148	94.8889	117.3909	1163.9085	0.1009	0.0009	50
51	0.0077	9.9226	95.2761	129.1299	1281.2994	0.1008	0.0008	51
52	0.0070	9.9296	95.6351	142.0429	1410.4293	0.1007	0.0007	52
53	0.0064	9.9360	95.9679	156.2472	1552.4723	0.1006	0.0006	53
54	0.0058	9.9418	96.2763	171.8719	1708.7195	0.1006	0.0006	54
55	0.0053	9.9471	96.5619	189.0591	1880.5914	0.1005	0.0005	55
56	0.0048	9.9519	96.8264	207.9651	2069.6506	0.1005	0.0005	56
57	0.0044	9.9563	97.0712	228.7616	2277.6156	0.1004	0.0004	57
58	0.0040	9.9603	97.2977	251.6377	2506.3772	0.1004	0.0004	58
59	0.0036	9.9639	97.5072	276.8015	2758.0149	0.1004	0.0004	59
60	0.0033	9.9672	97.7010	304.4816	3034.8164	0.1003	0.0003	60
65	0.0020	9.9796	98.4705	490.3707	4893.7073	0.1002	0.0002	65
70	0.0013	9.9873	98.9870	789.7470	7887.4696	0.1001	0.0001	70
75	0.0008	9.9921	99.3317	1271.8954	12708.9537	0.1001	0.0001	75
80	0.0005	9.9951	99.5606	2048.4002	20474.0021	0.1000	0.0000	80
85	0.0003	9.9970	99.7120	3298.9690	32979.6903	0.1000	0.0000	85
90	0.0002	9.9981	99.8118	5313.0226	53120.2261	0.1000	0.0000	90
95	0.0001	9.9988	99.8773	8556.6760	85556.7605	0.1000	0.0000	95
100	0.0001	9.9993	99.9202	13780.6123	137796.1234	0.1000	0.0000	100

INTEREST RATE = 12.00%

N	(P/F)	(F/A)	(P/G)	(F/P)	(F/A)	(A/P)	(A/F)	N
1	0.8929	0.8929	0.0000	1.1200	1.0000	1.1200	1.0000	1
2	0.7972	1.6901	0.7972	1.2544	2.1200	0.5917	0.4717	2
3	0.7118	2.4018	2.2208	1.4049	3.3744	0.4163	0.2963	3
4	0.6355	3.0373	4.1273	1.5735	4.7793	0.3292	0.2092	4
5	0.5674	3.6048	6.3970	1.7623	6.3528	0.2774	0.1574	5
6	0.5066	4.1114	8.9302	1.9738	8.1152	0.2432	0.1232	6
7	0.4523	4.5638	11.6443	2.2107	10.0890	0.2191	0.0991	7
8	0.4039	4.9676	14.4714	2.4760	12.2997	0.2013	0.0813	8
9	0.3606	5.3282	17.3563	2.7731	14.7757	0.1877	0.0677	9
10	0.3220	5.6502	20.2541	3.1058	17.5487	0.1770	0.0570	10
11	0.2875	5.9377	23.1288	3.4783	20.6546	0.1684	0.0484	11
12	0.2567	6.1944	25.9523	3.8960	24.1331	0.1614	0.0414	12
13	0.2292	6.4235	28.7024	4.3635	28.0291	0.1557	0.0357	13
14	0.2046	6.6282	31.3624	4.8871	32.3926	0.1509	0.0309	14
15	0.1827	6.8109	33.9202	5.4736	37.2797	0.1468	0.0268	15
16	0.1631	6.9740	36.3670	6.1304	42.7533	0.1434	0.0234	16
17	0.1456	7.1196	38.6973	6.8660	48.8337	0.1405	0.0205	17
18	0.1300	7.2497	40.9080	7.6800	55.7497	0.1379	0.0179	18
19	0.1161	7.3658	42.9979	8.5128	63.4997	0.1358	0.0158	19
20	0.1037	7.4694	44.9676	9.3463	72.0524	0.1339	0.0139	20
21	0.0926	7.5620	46.8188	10.8038	81.6987	0.1322	0.0122	21
22	0.0826	7.6446	48.5543	12.1003	92.5026	0.1308	0.0108	22
23	0.0738	7.7184	50.1776	13.5523	104.6029	0.1296	0.0096	23
24	0.0659	7.7843	51.6929	15.1788	118.1552	0.1285	0.0085	24
25	0.0588	7.8431	53.1046	17.0001	133.3339	0.1275	0.0075	25
26	0.0525	7.8957	54.4177	19.0401	150.3339	0.1267	0.0067	26
27	0.0469	7.9425	55.6369	21.3249	169.3740	0.1259	0.0059	27
28	0.0419	7.9844	56.7674	23.8839	190.6989	0.1252	0.0052	28
29	0.0374	8.0218	57.8141	26.7499	214.5828	0.1247	0.0047	29
30	0.0334	8.0552	58.7821	29.9899	241.3327	0.1241	0.0041	30
31	0.0298	8.0850	59.6761	33.5551	271.2926	0.1237	0.0037	31
32	0.0266	8.1116	60.5010	37.5817	304.8477	0.1233	0.0033	32
33	0.0238	8.1354	61.2612	42.0915	342.4294	0.1229	0.0029	33
34	0.0212	8.1566	61.9612	47.1425	384.5210	0.1226	0.0026	34
35	0.0189	8.1755	62.6052	52.7996	431.6636	0.1223	0.0023	35
36	0.0169	8.1924	63.1970	59.1356	484.4631	0.1221	0.0021	36
37	0.0151	8.2075	63.7406	66.2318	543.5967	0.1218	0.0018	37
38	0.0135	8.2210	64.2394	74.1797	609.8305	0.1216	0.0016	38
39	0.0120	8.2330	64.6967	83.0812	684.0102	0.1215	0.0015	39
40	0.0107	8.2438	65.1159	93.0510	767.0914	0.1213	0.0013	40
41	0.0096	8.2534	65.4997	104.2171	860.1424	0.1212	0.0012	41
42	0.0086	8.2619	65.8509	116.7231	964.3595	0.1210	0.0010	42
43	0.0078	8.2696	66.1722	130.7299	1081.0826	0.1209	0.0009	43
44	0.0068	8.2764	66.4659	146.4175	1211.8125	0.1208	0.0008	44
45	0.0061	8.2825	66.7342	163.9876	1358.2300	0.1207	0.0007	45
46	0.0054	8.2880	66.9792	183.6661	1522.2176	0.1207	0.0007	46
47	0.0049	8.2928	67.2028	205.7061	1705.8838	0.1206	0.0006	47
48	0.0043	8.2972	67.4068	230.3908	1911.5898	0.1205	0.0005	48
49	0.0039	8.3010	67.5929	258.0377	2141.9906	0.1205	0.0005	49
50	0.0035	8.3045	67.7624	289.0022	2400.0182	0.1204	0.0004	50
51	0.0031	8.3076	67.9169	323.6825	2689.0204	0.1204	0.0004	51
52	0.0028	8.3103	68.0576	362.5243	3012.7029	0.1203	0.0003	52
53	0.0025	8.3128	68.1856	406.0273	3375.2272	0.1203	0.0003	53
54	0.0022	8.3150	68.3022	454.7505	3781.2545	0.1203	0.0003	54
55	0.0020	8.3170	68.4082	509.3206	4236.0050	0.1202	0.0002	55
56	0.0018	8.3187	68.5046	570.4391	4745.3257	0.1202	0.0002	56
57	0.0016	8.3203	68.5923	638.8918	5315.7647	0.1202	0.0002	57
58	0.0014	8.3217	68.6719	715.5688	5954.6565	0.1202	0.0002	58
59	0.0012	8.3229	68.7443	801.4258	6670.2153	0.1201	0.0001	59
60	0.0011	8.3240	68.8100	897.5969	7471.6411	0.1201	0.0001	60
65	0.0006	8.3281	69.0581	1581.8725	13173.9374	0.1201	0.0001	65
70	0.0004	8.3303	69.2103	2787.7998	23223.3319	0.1200	0.0000	70
75	0.0002	8.3316	69.3031	4913.0558	40933.7987	0.1200	0.0000	75
80	0.0001	8.3324	69.3594	8658.4831	72145.6925	0.1200	0.0000	80
85	0.0001	8.3328	69.3935	15259.2057	127151.7140	0.1200	0.0000	85
90	0.0000	8.3330	69.4140	26991.9342	224091.1185	0.1200	0.0000	90
95	0.0000	8.3332	69.4263	47392.7766	394931.4719	0.1200	0.0000	95
100	0.0000	8.3332	69.4336	83522.2657	696010.5477	0.1200	0.0000	100

INTEREST RATE = 15.00%

N	(P/F)	(P/A)	(P/G)	(F/P)	(F/A)	(A/P)	(A/F)	N
1	0.8696	0.8696	0.0000	1.1500	1.0000	1.1500	1.0000	1
2	0.7561	1.6257	0.7561	1.3225	2.1500	0.6151	0.4651	2
3	0.6575	2.2832	2.0712	1.5209	3.4725	0.4380	0.2880	3
4	0.5718	2.8550	3.7864	1.7490	4.9934	0.3503	0.2003	4
5	0.4972	3.3522	5.7751	2.0114	6.7424	0.2983	0.1483	5
6	0.4323	3.7845	7.9368	2.3131	8.7537	0.2642	0.1142	6
7	0.3759	4.1604	10.1924	2.6600	11.0668	0.2404	0.0904	7
8	0.3269	4.4873	12.4807	3.0590	13.7268	0.2229	0.0729	8
9	0.2843	4.7716	14.7546	3.5179	16.7858	0.2096	0.0596	9
10	0.2472	5.0188	16.9795	4.0456	20.3037	0.1993	0.0493	10
11	0.2149	5.2337	19.1289	4.6524	24.3493	0.1911	0.0411	11
12	0.1869	5.4206	21.1849	5.3503	29.0017	0.1845	0.0345	12
13	0.1625	5.5831	23.1352	6.1528	34.3519	0.1791	0.0291	13
14	0.1413	5.7245	24.9725	7.0757	40.5047	0.1747	0.0247	14
15	0.1229	5.8474	26.6930	8.1371	47.5804	0.1710	0.0210	15
16	0.1069	5.9542	28.2960	9.3576	55.7175	0.1679	0.0179	16
17	0.0929	6.0472	29.7828	10.7613	65.0751	0.1654	0.0154	17
18	0.0808	6.1280	31.1565	12.3755	75.8364	0.1632	0.0132	18
19	0.0703	6.1982	32.4213	14.2318	88.2118	0.1613	0.0113	19
20	0.0611	6.2593	33.5822	16.3665	102.4436	0.1598	0.0098	20
21	0.0531	6.3125	34.6448	18.8215	118.8101	0.1584	0.0084	21
22	0.0462	6.3587	35.6150	21.6447	137.6316	0.1573	0.0073	22
23	0.0402	6.3988	36.4988	24.8915	159.2764	0.1563	0.0063	23
24	0.0349	6.4338	37.3023	28.6252	184.1678	0.1554	0.0054	24
25	0.0304	6.4641	38.0314	32.9190	212.7930	0.1547	0.0047	25
26	0.0264	6.4906	38.6918	37.8568	245.7120	0.1541	0.0041	26
27	0.0230	6.5135	39.2890	43.5353	283.5688	0.1535	0.0035	27
28	0.0200	6.5335	39.8283	50.0656	327.1041	0.1531	0.0031	28
29	0.0174	6.5509	40.3146	57.5755	377.1697	0.1527	0.0027	29
30	0.0151	6.5660	40.7526	66.2118	434.7451	0.1523	0.0023	30
31	0.0131	6.5791	41.1466	76.1435	500.9569	0.1520	0.0020	31
32	0.0114	6.5905	41.5006	87.5651	577.1005	0.1517	0.0017	32
33	0.0099	6.6005	41.8184	100.6998	664.6655	0.1515	0.0015	33
34	0.0086	6.6091	42.1033	115.8048	765.3654	0.1513	0.0013	34
35	0.0075	6.6166	42.3586	133.1755	881.1702	0.1511	0.0011	35
36	0.0065	6.6231	42.5872	153.1519	1014.3457	0.1510	0.0010	36
37	0.0057	6.6288	42.7916	176.1246	1167.4975	0.1509	0.0009	37
38	0.0049	6.6338	42.9743	202.5433	1343.6222	0.1507	0.0007	38
39	0.0043	6.6380	43.1374	232.9248	1546.1655	0.1506	0.0006	39
40	0.0037	6.6418	43.2830	267.8635	1779.0903	0.1506	0.0006	40
41	0.0032	6.6450	43.4128	308.0431	2046.9539	0.1505	0.0005	41
42	0.0028	6.6478	43.5286	354.2495	2354.9969	0.1504	0.0004	42
43	0.0025	6.6503	43.6317	407.3870	2709.2465	0.1504	0.0004	43
44	0.0021	6.6524	43.7235	468.4950	3116.6334	0.1503	0.0003	44
45	0.0019	6.6543	43.8051	538.7693	3585.1285	0.1503	0.0003	45
46	0.0016	6.6559	43.8778	619.5847	4123.8977	0.1502	0.0002	46
47	0.0014	6.6573	43.9423	712.5224	4743.4824	0.1502	0.0002	47
48	0.0012	6.6585	43.9997	819.4007	5456.0047	0.1502	0.0002	48
49	0.0011	6.6596	44.0506	942.3108	6275.4055	0.1502	0.0002	49
50	0.0009	6.6605	44.0958	1083.6574	7217.7163	0.1501	0.0001	50
51	0.0008	6.6613	44.1360	1246.2061	8301.3737	0.1501	0.0001	51
52	0.0007	6.6620	44.1715	1433.1370	9547.5798	0.1501	0.0001	52
53	0.0006	6.6626	44.2031	1648.1075	10980.7167	0.1501	0.0001	53
54	0.0005	6.6631	44.2311	1895.3236	12628.8243	0.1501	0.0001	54
55	0.0005	6.6636	44.2558	2179.6222	14524.1479	0.1501	0.0001	55
56	0.0004	6.6640	44.2778	2506.5655	16703.7701	0.1501	0.0001	56
57	0.0003	6.6644	44.2972	2882.5503	19210.3356	0.1501	0.0001	57
58	0.0003	6.6647	44.3144	3314.9329	22092.8859	0.1500	0.0000	58
59	0.0003	6.6649	44.3296	3812.1728	25407.8188	0.1500	0.0000	59
60	0.0002	6.6651	44.3431	4383.9987	29219.9916	0.1500	0.0000	60
65	0.0001	6.6659	44.3903	8817.7874	58778.5826	0.1500	0.0000	65
70	0.0001	6.6663	44.4156	17735.7200	118231.4669	0.1500	0.0000	70
75	0.0000	6.6665	44.4292	35672.8680	237812.4532	0.1500	0.0000	75
80	0.0000	6.6666	44.4364	71750.8794	478332.5293	0.1500	0.0000	80
85	0.0000	6.6666	44.4402	144316.6470	962104.3133	0.1500	0.0000	85
90	0.0000	6.6666	44.4422	290272.3252	1935142.1680	0.1500	0.0000	90
95	0.0000	6.6667	44.4433	583841.3276	3892268.8509	0.1500	0.0000	95
100	0.0000	6.6667	44.4438	1174313.4507	7828749.6713	0.1500	0.0000	100

