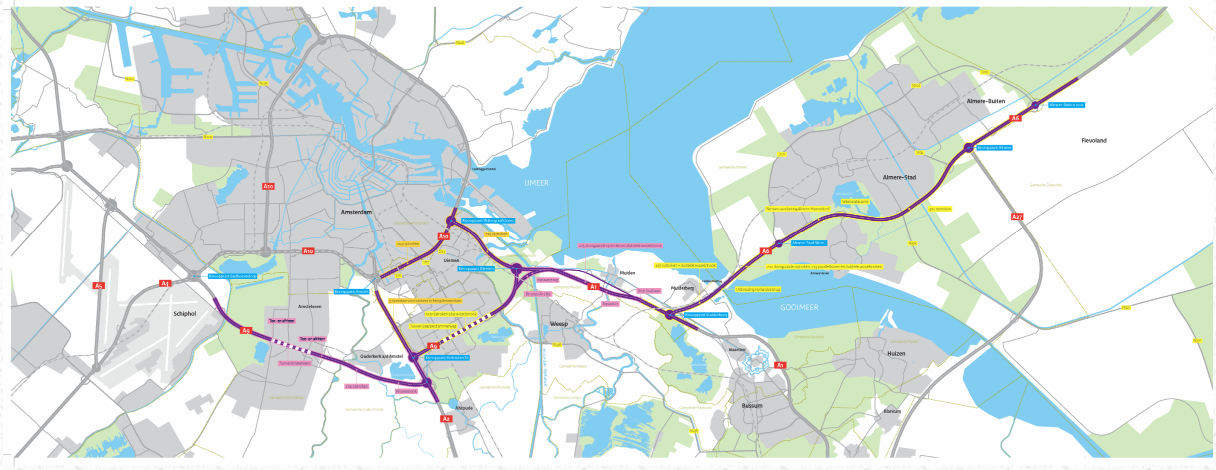

Construction Management and Engineering Master Thesis

Value Engineering: An Optimization Tool for Public Works Organizations

Improving the Value for Money at Rijkswaterstaat

Author: Felipe Castro Arenas

Value Engineering: An Optimization Tool for Public Works Organizations

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1) Overview SAA project - http://www.rijksoverheid.nl/ministeries/ienm/documenten-en-publicaties/rapporten/2011/03/18/overzichtskaart-saa-feb-2011.html
2) Aerial photograph Knoopunt Muiderberg - https://beeldbank.rws.nl, Rijkswaterstaat / Joop van Houdt.

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Abstract

Public infrastructure is an essential ingredient for the economic development of society. Historically, public infrastructure projects have been an exclusive task of governments. However, pressure on capacity and the environment exerted by competitive economic development has forced many governments to adopt "regulatory capitalism"[1] measures. Among others, this has forced them to attempt delegation strategies by creating parallel independent regulatory agencies and to strive for closer collaboration with the private sector. Such a demanding context is the basic rationale behind this research project. What can make public works organizations more effective? How can they optimize their internal processes in order to keep up the pace with more challenging end users' requirements and taxpayers' demands?

Value Engineering, an optimization tool that emerged in the manufacturing sector is not a new invention. It has a long and successful history that spans more than 50 years, back until the days of World War II. Progressively, it has spread throughout all economic sectors after decades of development and practice among pioneers. Both public and private sectors have benefited from its implementation. The construction industry has not been exempted from VE's proliferation. In fact, several public works organizations around the world currently utilize VE for the inception and development of infrastructure projects and the benefits drawn from it have been so significant that governments have even enacted laws to make it mandatory among their executive agencies. VE has proven effective for improving the value of infrastructure projects, among others, through the optimization of life cycle costs.

Nonetheless, ambiguity remains as to which are the most beneficial moments in a project lifecycle to perform a VE study. That is the main research question in this thesis and the answer obtained is particularly meant to fit into RWS's forthcoming main project delivery process – Sneller & Beter. So, the last part of this report includes recommendations for both RWS and one of its current flagship projects – the SAA.

VE's global use among practitioners with different backgrounds and working cultures has led to an array of definitions and terminologies that sometimes collide and generate confusion. However the basic concepts remain identical. Value Analysis, Value Engineering, Value Methodology and Value Management are common terms used when referring to VE but, as many authors argue, the choice of names is trivial, as long as its original systematic process is carefully followed. For the sake of clarity and consistency, this document will attach to the term Value Engineering (VE).

This document refers to VE as a management technique that uses recognized tools in a systematic manner – the Job Plan – and that is always executed by a multidisciplinary team – the VE Team. Such tools are used to identifying the function of a product, service or process and establishing a value system for that function. Ultimately, they are deployed so to provide the necessary function reliability at the lowest overall cost. This definition embraces two levels of deployment of VE:

[1] See (Levi-Faur, 2005)

1) strategic, which is referred to as the Learning Paradigm in section 3.2.2 and 2) tactical, which relates to the Optimizing Paradigm explained in section 3.2.1.

The former focuses on creating a common language by which stakeholders can define and agree upon a value system for particular functions. This is essential during the early phases of projects where problems arise as fuzzy and ill-structured situations. The latter is more suitable during later stages of a project life cycle where problems have already been clearly defined and hence value enhancement is sought through optimization of designs and preservation of functionality.

Two public works organizations that share similarities in terms of institutional setup and business configuration with RWS are presented herein as benchmark organizations regarding the use of VE. One belongs to the USA government and has adopted this methodology to deploy in certain public projects not only because legislation demands it to do so but also because it has improved, since its adoption, the value of its processes and assets. The other belongs to the UK government and though it does not follow legislative rules in this regard, it does integrate VE in its standard project delivery framework and adheres to European standards, which establish best practices for the use of VE. The former is the Federal Highway Administration (FHWA) and the latter is the Highways Agency (HA).

Two distinct styles in the application of VE can be identified in this benchmark study, although they share basic principles in terms of VE study timing. The Americans commonly perform one single but exhaustive VE study during the early stages of a project lifecycle, before it is procured to the construction industry market. Conversely, the English prefer executing several shorter VE studies spread throughout the project lifecycle, including construction and handover stages. Furthermore, these two distinct styles are found to be characterized by each of the two levels of deployment identified previously in the theoretical framework. The American style displays more traits of the optimizing paradigm whereas the English style is closely related to the learning paradigm of VE.

This benchmark study also revealed VE studies' effectiveness is closely affected by the timing of the study within the project lifecycle. Accordingly, it was found that the earlier the timing of the VE study, the higher its potential for improving the value of the project. Particularly, the middle stage, after conceptualization and before detailed design has surfaced as the favored stage for achieving better results from a value study.

Since the Americans maintain a comprehensive record of the savings achieved by VE in every project, unlike the English; which enabled the presentation of clear and detailed proof on the optimizing benefits VE has provided the FHWA for the last 13 years; the validation of this research's theoretical framework required a twofold approach. The optimizing paradigm was validated using the benchmark study, while the learning paradigm was validated through several interviews and a survey to carefully selected members of the VE community. These were utilized to obtain experiences, from certified Value Engineers, concerning the adequacy of VE in the domain of Soft Systems Thinking.

The validation of the learning paradigm relies here on the assumption that VE may help process managers realize better decision-making processes. With this in mind, the traits of a good decision-making process were defined. These correspond to four main elements identified by (Bruijn, Heuvelhof, & Veld, 2002). Hence, this validation part evaluates the extent to which VE may contribute to the Openness, Substance, Speed and Protection of Core Values of decision-making processes. The survey and interviews revealed consistent recognition of VE's contribution to the former two elements but a more moderate one regarding the latter two.

Therefore, it may be concluded that VE should not be applied to every infrastructure project. In fact, project selection for VE studies must be done carefully, since a VE effort should be previously justified by potential value improvements. VE studies require resources and sufficient time allocation in the project plan, which cannot be overseen while designing a proper value improvement strategy. Yet, the interviews and survey have evidenced the soft benefits of VE, which can enhance the management of decision-making processes by public works organizations, in particular when utilized during early phases of a project life cycle. In fact, this practice arises as a strategic tool for public management in complex network environments.

Finally, this research highlights the various benefits RWS may draw from integrating VE into its newer project delivery framework. The recommended moments for this integration are two moments during the exploration phase – verkenning; one during the planning phase; and incentives for the use of Value Engineering Change Proposals (VECPs) from private contractors after they are awarded with the realization of the project. The first two moments would require studies facilitated with soft systems techniques – i.e. the learning paradigm of VE – while the third instance would require facilitation focused on hard systems thinking – i.e. the optimizing paradigm of VE.

The SAA is a project that, even though it currently stands at posterior phases of its lifecycle, it may still avail from the benefits of VE. The scale, complexity and future impacts of this project make the SAA a fine candidate for comprehensive VE studies. Although its final route decision has already been taken, three of its subprojects have not yet entered the contractual phase, which gives room to envisage the use of VECPs. Therefore, the recommendation for this important project is to include contractual clauses that encourage potential contractors to come up with VECPs during the tendering and posterior phases of subprojects 3, 4 and 5.

Preface

After working for seven months in my graduation project, this report concludes my MSc programme in Construction Management and Engineering. Since February 2011, I have had the opportunity to investigate about Value Engineering and its use in public works organizations while, at the same time, experience first-hand the professional environment and working style of a distinguished Dutch governmental agency.

Rijkswaterstaat, the executive agency of the Dutch Ministry of Transport and the Environment sponsored this thesis through its Schiphol-Amsterdam-Almere project. My first contact with Rijkswaterstaat took place as an intern for its LEF Future Center, where I collaborated in a multidisciplinary and cross-cultural team to explore new ways of financing public infrastructure projects. This experience accrued my interest on the challenges of managing public infrastructure projects and thus triggered my curiosity for Value Engineering.

Rijkswaterstaat has been striving to increase productivity and optimize its project delivery processes, which opened a window of opportunity for this thesis. Furthermore, its emerging Value Engineering program offered a platform to support my empirical research. With this in mind, the aim of this graduation project was aligned to identifying the benefits of Value Engineering and, particularly, determining the most effective timing to execute Value Engineering studies in public works organizations.

Besides the knowledge gained on this particular subject, I cherish having worked alongside professors and professionals whose support was invaluable to accomplish this project. My acknowledgements go to all members of my graduation committee for their academic guidance. Special gratitude goes to Anand Ramdien for his coaching on Value Engineering and constant support. I would also like to thank Maarten Oliedam for being my contact with the Schiphol-Amsterdam-Almere project team and certainly project director Jan Slager for allowing me to realize this thesis under this project's auspice. Last but not least, I thank Timme Hendriksen for his advice and for enabling me to reach renowned value engineers across the globe.

Felipe Castro Arenas
Delft, August 2011

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List of abbreviations

ABB	Description
CALTRANS	California State Department of Transportation
CEN	European Committee for Standardization
CVS	Certified Value Specialist
DfT	England's Department for Transport
DOT	US Department of Transportation
DTC	Design to Cost
EGB	European Governing Board for the European Value Management Training and Certification System
FAST	Function Analysis System Technique
FDOT	Florida Department of Transportation
FHWA	US Federal Highway Administration
GDOT	Georgia Department of Transportation
GE	General Electric Company
HA	England's Highways Agency
HM Treasury	UK's Economics and Finance Ministry
HST	Hard Systems Thinking
IRA	Independent Regulatory Agency
ITS	Information Technology Systems
IVM	Institute of Value Management
LCC	Life Cycle Costing
M4I	Movement for Innovation
MBO	Management by Objectives
NHS	US National Highway System
NYSDOT	New York State Department of Transportation
O&M	Operation & Maintenance
OGC	UK's Office of Government Commerce
OIG	US Department of Transportation's Office of Inspector General
OMB	US Office of Management and Budget
PA&ED	Caltrans's Project Approval and Environmental Document
PID	Caltrans's Project Initiation Document
PMP	Project Management Professional
ProRail	Dutch Rail Network Infrastructure Manager
PS&E	Caltrans's Plans, Specifications and Estimates
RICS	Royal Institution of Chartered Surveyors
ROI	Return on Investment
RWS	Rijkswaterstaat – Executive agency of the Dutch Ministry of Infrastructure and the Environment
SAA	Schiphol – Amsterdam – Almere
SAVE International	International Society of American Value Engineers
SE	Systems Engineering
SPRINT	European Strategic Program for Innovation and Technology Transfer
SST	Soft Systems Thinking
TRB	American Transportation Research Board
TRIZ	Theory of Inventive Problem Solving
URFs	User Related Functions
VA	Value Analysis
VE	Value Engineering
VECP	Value Engineering Change Proposal
VfM	Value for Money
VM	Value Management or Value Methodology
VMP	Value Methodology Practitioner

1. Introduction

It is a commonly held perception that it takes an average of 14 years to deliver a major highway project from planning through completion[2]. Moreover, the public expects more accountability in how governments spend their money and seeks best value from their tax-funded investments. This phenomenon has spawned a personal interest to explore more efficient ways of undertaking infrastructure projects, which in turn has given place to this particular research project. This kind of projects is characterized by large initial investments and seldom positive rates of return. Besides complex environments often surrounding these projects, they usually involve intricate networks of stakeholders. All these traits require not only unique managerial capabilities but also an intelligent use of the broad range of scientific approaches available.

The tendency to engage ever more complex and larger infrastructure projects has become a challenge for both the private and the public sectors of the building and construction industry. Adaptability in this matter can be identified more easily in the private sector. Therefore, public works organizations have the urgency to catch up in terms of productivity with their private counterparts. This has become a public concern, since taxpayers expect higher value for their money. This concern has escalated to a political level, to such an extent, that in the case of the Dutch Ministry of Infrastructure and Environment, a clear vision has been set for its executive branches to work more efficiently. Therefore, a window of opportunity is open for this research project, since Value Engineering (VE) is a proven tool for improving productivity.

Thus, Rijkswaterstaat (RWS), the Department of Transportation of the Dutch Ministry of Infrastructure and Environment, will sponsor this graduation project. In particular, it will take place within a current project of this organization, namely the Schiphol-Amsterdam-Almere (SAA) project.

1.1. Context

The construction industry plays a major role in the performance of any country's economy. Infrastructure projects are especially critical to the economic development of countries, due to the large direct and indirect effects they generate during their entire life cycle. Technological advancements are permitting the conception of ever larger and more complex infrastructure projects and global competition alongside urgency for sustainable development are driving the construction industry to the forefront of public scrutiny.

Nonetheless, there is a vast evidence of construction projects failing to fulfill primary objectives in regards to budget, schedule, quality and performance. Traditional approaches have many times shown successful at delivering technically challenging projects but have often failed at delivering projects were complexity is not only a trait of technical requirements but also a trait of problem definition and stakeholders management. Yet, these are common characteristics to the current type of infrastructure projects.

[2] Article by Boudewijn Warbroek published in Binnenlands Bestuur on 07-08-2009.

Collaboration between the public and private sector has been sought in order to embark this type of projects and several enhancements have been achieved. However, such relationships are often characterized by distrust and conflict among parties, which typically result in unworthy efforts and unsatisfactory performance of projects. There is usually an element of distrust in the relationships among clients, clients' representatives, contractors, designers, consultants and end users, that deteriorates collaboration – an essential ingredient for success in these endeavors.

This type of projects not only requires collaboration between the public and private sectors but also collaboration among numerous disciplines that find themselves involved in them due to their increasing complexity and larger scale effects. Again, such disciplines tend to work independently, in a compartmentalized manner. This makes it difficult to streamline work in large construction projects and the results of these drawbacks often translate into budget and time overruns and unsatisfied stakeholders.

According to the UK National Audit Office[3], a better performing construction industry requires, among other things:

- More consideration of end users in design and construction of buildings;
- Move away from adversarial approaches between the industry and clients;
- More consideration to the costs and value of a building over its whole life and the quality of the contractors;
- Partnering between clients and contractors to resolve problems collaboratively, to reduce project slippage and cost overruns and eliminate waste in labor and materials;
- Longer term relationships between clients and contractors to promote continuous improvements in time, cost and quality;
- Develop a learning culture on projects and within organizations, and;
- Better management of construction supply chains.

1.2. Purpose

Governments face serious difficulties in the delivery of major highway projects. More ambitious and complex projects are being conceived. They usually require vast amounts of scarce resources and are being perceived as unacceptably lengthy endeavors. Yet, a reliable and safe transportation system is a key factor to support their economy and sustain their environment. Therefore, there is a clear need to improve efficiency in the delivery of public works and VE has proven to be an effective technique for fulfilling such need.

VE has a long history of successful practices in the manufacturing industry, which has enabled it to spread to the construction industry with seemingly successful cases. It has been observed, however, that this methodology yields different results depending on the stage of the project when it is deployed. That is why this research project focuses on the preferred timing for VE to generate its greatest benefits. Thus, the main purpose of this dissertation is as follows:

[3] (Great Britain. National Audit Office., Great Britain. Parliament., & House of Commons., 2001)

The objective of this research project is to identify the potential benefits of Value Engineering for public works organizations, specifically in highway projects, and to make recommendations for an effective integration of this technique into RWS's main project delivery process by making a comparison with similar organizations that have already implemented and experienced the added value of this approach.

Hence, the following topics fall out of the scope of this project and therefore will not be included in this dissertation:

- Detailed functioning of the Value Engineering methodology.
- Comprehensive exposition of tools and techniques commonly used within the Value Engineering methodology.
- Application of the Value Engineering methodology.

1.3. Research Questions

The purpose of this project will be achieved by giving supported answers to the following questions:

<u>Main research question:</u>

1. How could Value Engineering be more effectively integrated in RWS's main process ("Sneller & Beter")?

The next sub-questions derive from the main research question and their answers will also contribute to achieving the main purpose of this project.

2. Does Value Engineering offer any added value at all?
3. What potential benefits does Value Engineering offer public works organizations?
4. During which phases of a project life cycle does Value Engineering offer the greatest benefits?
5. Where in RWS's main process could Value Engineering practices generate higher impact in line with the organization's strategic goals?

1.4. Expected Results

The realization of this research project is expected to yield robust arguments that convince decision makers of the potential benefits of a well-managed VE program within their organizations, particularly in public organizations involved with transportation projects.

Most importantly, this project will allow the identification of the stages of a project life cycle where VE offers the greatest benefits. Eventually, VE will show effective at achieving different goals at different stages. This research will explore how VE may adapt to the changing phases of a project so that it offers specific advantages at specific moments of a project life cycle.

Finally, this research project is expected to offer a guide to RWS on the potentially best moments for integrating VE within its "Sneller & Beter" project delivery model. Last but not least, the Schiphol-Amsterdam-Almere (SAA) project will receive recommendations on whether and when to perform VE studies.

1.5. *Report Structure*

This dissertation is structured as follows:

Chapter 1: Introduction

This chapter describes the current situation in the construction industry and thus highlights the rationale behind this research project. It also defines the intention of this work and the expected results of this research. It defines who may potentially benefit from the results of this project. It presents the research questions addressed in this dissertation and gives an overview of the expected results. Finally, it summarizes the main structure of the report.

Chapter 2: Research Methodology

This chapter explains the selected approach to arrive at the answers to the research questions and the reasons for using such approach. A benchmark study to demonstrate the hard systems thinking benefits offered by VE and validation through experts survey to demonstrate soft systems thinking benefits offered by VE. Both approaches will eventually justify the implementation of VE in RWS and similar organizations. Division of approaches made because there are plenty of data available to do a hard systems thinking benchmark of VE, while there are little available to do the same with the soft systems thinking.

Chapter 3: The enhancing attributes of Value Engineering

This chapter presents the history and available definitions of VE. It explains the distinction between its Hard and Soft systems thinking facets and then exposes VE's introduction to and performance on the construction industry. Finally, this chapter highlights the benefits and potentials of VE by showing that it has even been adopted in other countries through laws and standards.

Chapter 4: Value Engineering: optimizing contribution to public works organizations

This chapter forms the benchmark part of this dissertation. It demonstrates VE's benefits through qualitative and quantitative data presented by similar organizations mainly in USA and UK. It focuses mainly on the Hard paradigm, that is, the capacity of VE to reduce costs and improve functionality. Most importantly, it draws attention to the timing of the different VE studies presented in this benchmark.

Chapter 5: Value Engineering: collaborative contribution to public works organizations

This chapter demonstrates VE's benefits through qualitative data obtained from experts survey. It focuses mainly on the Soft paradigm, that is, the capacity of VE to facilitate networks management, team building and other soft issues common to ill-structured and poorly defined projects. Like chapter 4, it draws attention to the timing of VE studies so that to obtain these types of benefits.

Chapter 6: Rijkswaterstaat towards a progressive transformation

This chapter gives a broad characterization of RWS and its strategic goals. It presents RWS's forthcoming project delivery process ("Sneller & Beter") and its connection to those goals. It identifies possible gaps that could be bridged by using VE. Finally, this chapter provides an additional validation of VE's potential benefits by presenting the results of VE studies already performed on the Schiphol-Amsterdam-Almere (SAA) project.

Chapter 7: Conclusions and Recommendations

This chapter summarizes the findings presented in this dissertation and concludes why VE should be adopted by RWS and similar organizations. It points out the best moments to apply VE within “Sneller & Beter” and closes with recommendations for the remainder of the SAA project.

2. Research Methodology

This chapter presents the research methodology used to undertake this project. It explains the selected approach to arrive at the answers to the research questions and the reasons for using such an approach. First, the research framework is presented. Then an overview of the methodology used is described and the different methods utilized are explained and justified. Finally, some adjustments made to the original approach are presented and rationalized.

2.1. Research framework

In order to achieve the main objective of this research project, the following framework has been designed to support the progress of the investigation. (Verschuren & Doorewaard, 2005)

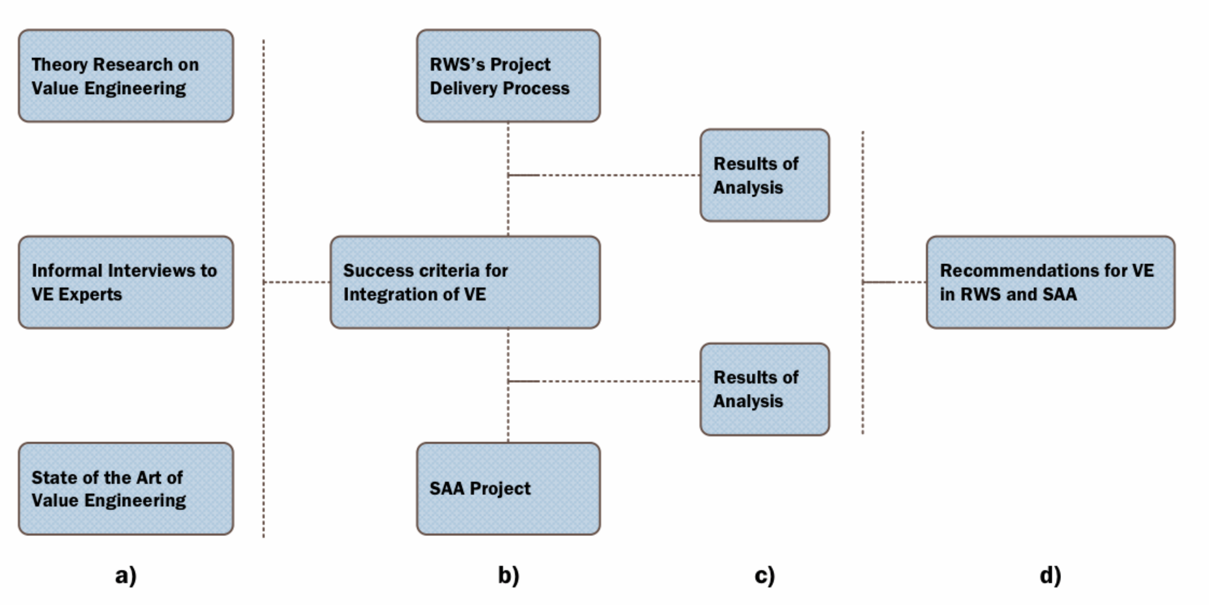


Figure 1: Research framework

This figure reflects both the need to pursue a thorough understanding of both the theory and practice behind VE and the current procedures adopted by RWS. Furthermore, the SAA (Schiphol-Amsterdam-Almere) project arises as a cornerstone of RWS's first attempts to using VE. Even though several VE studies have already been carried out on this project, they have only been done in a conjectural manner. They took place as corrective measures, since the organization still lacks a structured adoption of this technique. Therefore, the SAA project may serve both as a research object for validation of claims about VE and as a recipient of recommendations for potential implementation of this technique.

Additionally, Figure 1 reflects the need to clearly understand how RWS conceives and delivers its infrastructure projects – highway projects in particular. Once this is done, it is then possible to identify the more effective strategies for implementing VE in RWS's project delivery process.

2.2. Research approach

This project will be approached through an empirical research strategy. It will not be held entirely at the faculty of Civil Engineering of TU Delft, but instead it will entail the researcher to go out into the field in person, in this case by joining RWS as an intern at the SAA project. Both RWS as an organization and the SAA project as a product of this organization form the research objects for this research.

As it may be derived from Figure 1, the core of the research framework relies mainly on direct observation of the research objects and interpretation and comparison of qualitative data retrieved through literature review, interviews with Value Engineers and VE practitioners and analysis of corporate and project documentation.

This research strategy was selected in response to the level of depth required by the research objective and the constraints relative to time and language. It starts by filtering and converging research material from a broad range of available literature and third parties' expertise on VE, thus addressing the elements outlined in segment *a)* of the research framework. In order to speed up the learning process about theory and current practice of VE, the literature review is supplemented with interviews to Value Engineers, VE practitioners, project managers and consultants acquainted with this methodology.

After this initial deepening step, this strategy will steer the research project towards a comparative analysis among the criteria identified therein and the research objects, which in this case are RWS and especially the SAA project (refer to segments *b)* and *c)* of the research framework). This entails a closer observation to the institutional framework of RWS and its corporate processes besides those processes specific to the SAA project. Due to language constraints – i.e. most of the documentation relative to the organization and the project are in Dutch – this comparison phase will heavily rely on interviews to RWS staff and members of the SAA project team.

This will finally direct this research project towards the conclusive segment of the research framework (*d)* Recommendations for VE at RWS), which is the deepest level of the entire investigation work, as shown in the following figure:

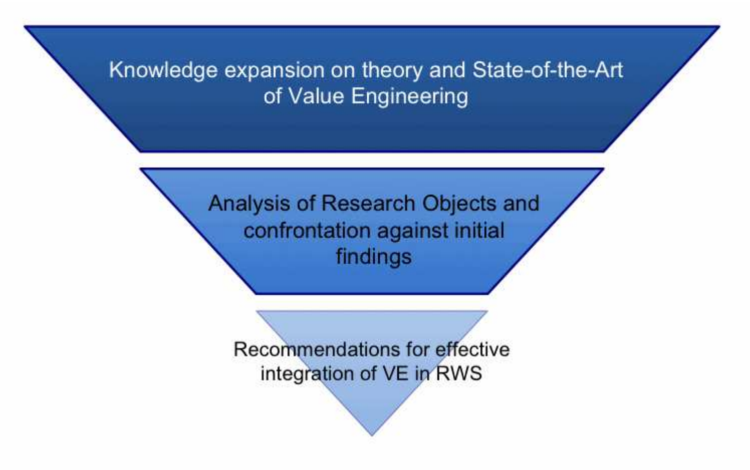


Figure 2: Research strategy

The previous representation of this research strategy implies how light will be progressively shed upon the deepest challenge of this project. The initial steps of this strategy will be conducted mainly through a comprehensive analysis of available literature on the subject of VE. This will focus on documentation regarding the use of VE in public works organizations. Here, the American case provides a good source of information, since it has been established by law that public organizations in the United States must implement VE practices into their processes. The British case also stands as a relevant benchmark, though its recognized standards and best practice guides. Nonetheless, personal interviews will be also conducted at this stage in order to support and enhance the literature study on the subject. Thus, approaching organizations like ProRail, that have already been using VE for several years, may contribute significantly to describe the State-of-the-Art of VE in The Netherlands.

The middle-way step of this research strategy will make use of personal interviews and content analysis of archives and documents pertaining to RWS and particularly the SAA project. The combination of these two methods seeks to gain a rapid and thorough understanding of both the general internal processes of this public organization and the particular procedures that have been and are being applied in this important infrastructure project.

The strategy will be concluded with a confrontation of the findings from the first topmost stage, namely the success criteria of VE application (see Figure 1 segment *b*), against the discoveries made during the analysis of the research objects (see Figure 2).

2.3. Adjustment to research approach

On the outset of the research, a distinction between two paradigms within VE was identified. This raised the need for an adjustment to the original research approach. The two paradigms affecting the study of VE – the Learning Paradigm and the Optimizing Paradigm – relate to the Soft and the Hard Systems Thinking and are addressed in the theoretical framework of this document – i.e. chapter 3.2. The literature review and the contact with VE experts originated the identification of this distinction, which would eventually affect directly the timing of VE studies, which is in turn the main issue addressed in research question number 4.

It was apparent that most of the literature spun around the Hard Systems Thinking of VE while little was available on the Soft paradigm. This evidence made it clear that the original research approach would not be totally appropriate and needed adjustment. A different strategy needed to be deployed, in order to reveal the "soft" and "hard" traits of VE and thus identify the criteria against which recommendations for a successful integration of VE could be drawn.

Therefore, the research approach was decided to be supplemented with a survey and a benchmark study, thus adding an extra step to the original research framework (see Figure 3 *b)*). The former would include respondents with expertise on facilitation of VE studies carried out in public works organizations. The latter would include this same type of organizations in which mature VE programs are already fully integrated into their processes. The adjusted research framework may then be visualized in the next figure.

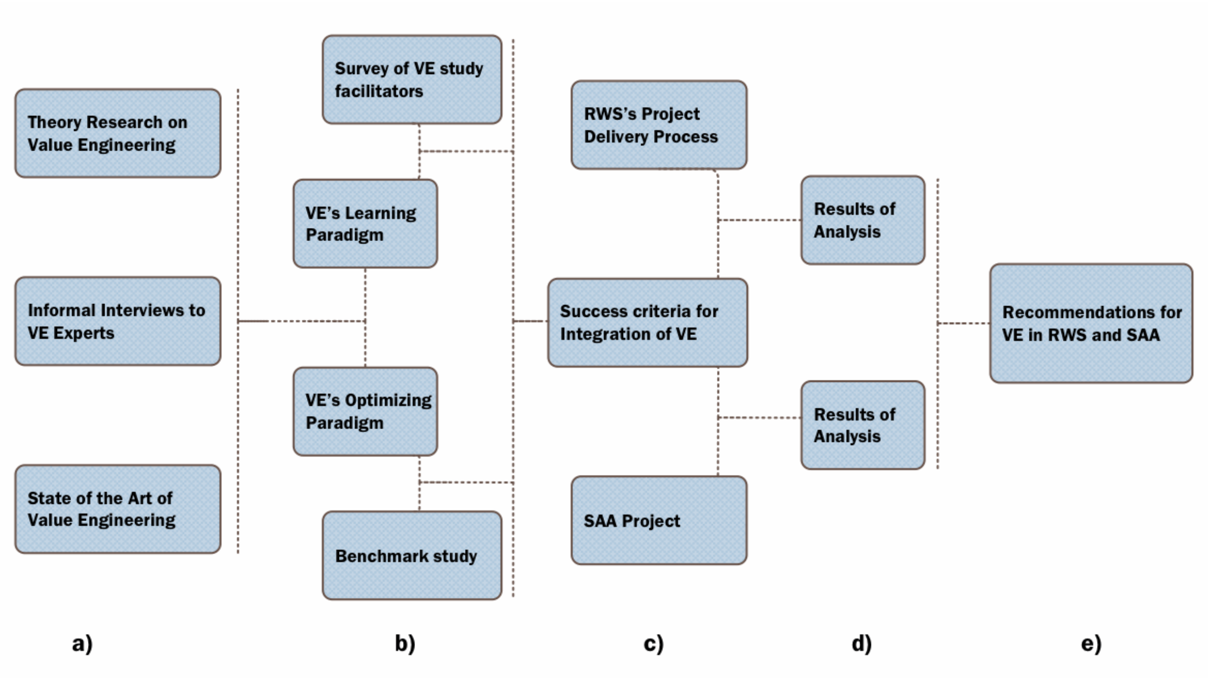


Figure 3: Adjusted research framework

3. The Enhancing Attributes of Value Engineering

This chapter constitutes the main theoretical framework of this document. It describes the essential traits of VE, so that the reader gets acquainted to the concept, its history and its attributes.

First, an overview of the different definitions and labels attached to the VE concept is presented, followed by a review on the history and developments of this methodology since its conception by Lawrence D. Miles. Next, this chapter offers a hint on the functioning mechanism of this technique and mentions some of the various instruments commonly used with it. This is a quick description of the principles of VE that merely seeks to familiarize the reader with this methodology. A wide array of literature is available on describing the VE methodology and its functionalities. However, this falls out of the scope of this document.

Thirdly, this chapter dives into the trace of VE within the construction industry, in order to start a closer connection between the theory and the practical objectives of this research project. Finally, this chapter concludes with the presentation of regulatory and standardizing documents, which direct and promote the use of VE worldwide.

3.1. Introduction and history of Value Engineering

All projects hide unnecessary costs in their designs. Studies invariably show that all designs have unnecessary costs regardless of the expertise of the design teams. Yet, saving money and, at the same time, providing better value, is a concept that everyone can support. The benefits of spreading investments, building more for less money, increasing efficiency and reducing dependency on energy-intensive systems are being constantly pursued. Everyone is looking for a sound investment with a high rate of return. (Zimmerman & Hart, 1982)

In today's economic environment, cost control, a focus on performance, responsiveness to change, and increasing operational efficiencies are critical attributes for long-term profitability in any organization. (Stewart, 2005)

3.1.1. Definitions

This constant quest calls for effective techniques that provide for higher value of projects. The long history of VE has proven this is an effective tool for achieving the aforementioned objectives. In fact, Zimmerman and Hart (1982) define VE as "a proven **management technique** using a **systematized approach** to seek out the best **functional balance between the cost, reliability, and performance** of a product or project. It seeks to improve the management capability of people and to promote progressive change by identifying and removing unnecessary costs." (Zimmerman & Hart, 1982) (emphasis added).

This is not the unique definition of VE. In fact, many definitions are found in recent literature, which even refer to it interchangeably as Value Management, Value Analysis or Value Methodology. All of them allude to the advantages of this technique to pursuing such objectives. However, it is important to notice a specific differentiation between two of these terms proclaimed by Kelly et. al (2004). They proclaim Value Management signifies a service in which more than just the basic function of an element, component, or system is to be considered. In fact, it refers to the structured management of the total value equation through all stages of a project and therefore subsumes VE as a component part of the whole service.

In other words, they limit VE to the optimization of designs through the enhancement of the value balance of design elements, thus keeping it an exclusive methodology to be deployed during posterior stages of project life cycles – i.e. design, construction and operation stages. Conversely, they relate Value Management either to the Value studies executed at the front end of projects, where optimization is not directed towards design issues but towards strategic decision-making; or to the overall management of several VE studies organized throughout and implemented into the entire lifecycle of projects.

Additional definitions follow, which provide a broader acknowledgment of this concept.

(Stewart, 2005) asserts that Value Methodology is an organized process based on a specific job plan executed by a multidisciplinary team. He affirms that it can be successfully applied to products, manufacturing processes, administrative procedures and construction projects. "Value Methodology (VM) is an organized process that has been effectively used within a wide range of industries to achieve their continuous improvement goals, and in government agencies to better manage their limited construction budgets. The success of the VM is due to its capacity to identify opportunities to remove unnecessary costs from facilities, products and services while assuring that performance, and other critical factors, meet or exceed the customer's expectations." (Stewart, 2005)

According to Kelly et. al (2004), Value Management refers to a process in which the functional benefits of a project are made **explicit** and confronted with a value system determined by the client. In this context, "'the client' refers to the person, persons or organizations responsible for the inception of the project and for its eventual adoption into the client's mainstream business" (Kelly, Male, & Graham, 2004). Similarly, the client's value system establishes the compromise between costs and the variables that determine the level of quality expected by the client from the finished project.

Finally, SAVE International, the premier international society devoted to the advancement and promotion of the Value Methodology, establishes in its Value Standard and Body of Knowledge, that function analysis is the foundation of the Value Methodology and the key activity that differentiates it from other problem-solving or improvement practices. Again, it defines the Value Methodology as a "**systematic** process used by a **multidisciplinary** team to improve the <u>value</u> of a project through the analysis of its **functions**. Value is defined as a fair return or equivalent in goods, services, or money for something exchanged [and] commonly represented by the relationship:

$$Value \approx {}^{Function}\!/_{Resources}$$

where function is measured by the performance requirements of the customer and resources are measured in materials, labor, price, time, etc. required to accomplish that function. A Value Methodology focuses on improving value by identifying alternate ways to reliably accomplish a function that meets the performance expectations of the customer.” (SAVE International, 2007) (emphasis added)

It has been clearly exposed how VE seeks to maintain the balance between costs and functionality of a project without sacrificing the performance requirements of the customer. However, VE is often confused with other cost reduction techniques. Nevertheless, it makes use of two distinctive elements, which make it unique:

- Function analysis and its relation to cost and performance.
- Organization of concepts and techniques into a specific job plan.

Cost reduction activities are part-oriented. This usually means altering construction techniques, substituting less expensive systems, relaxing tolerances, and/or thinning or changing of material. Normally, this will produce savings without an alteration of the design concept, usually at the expense of functionality. On the contrary, Value Engineering is function-driven, and generally leads to new or refined concepts that perform needed functions more simply with higher quality and more economical manufacturing processes or construction techniques. The basic, general question in Value Engineering studies is, “How can the process be modified to reliably accomplish the required functions more efficiently?” This line of thinking often leads to new concepts that improve the performance of the functions while reducing costs. (Stewart, 2005)

3.1.2. History

VE, a technique born of necessity in a single company, has become a widely used methodology for effective utilization of resources. (Stewart, 2005)

During the period of World War II, from 1938 to 1945, Lawrence Delos Miles conceived the VE methodology. Miles, regarded as the father of VE, was an engineer for General Electric Company in charge of purchasing programs. During these days, input resources were exceptionally scarce. Resources like steel, copper, bronze, electrical resistors and capacitors were totally scheduled and he was assigned the task of “finding, negotiating for and getting” a number of these vital materials for production of armament parts. Stopping production was not an option in this environment. Yet, Miles was frequently faced with refusing suppliers who were already over-extended in their increasing schedules. (Stewart, 2005)

Therefore, this desperate situation forced Miles to ask himself over and over again the same kind of question: “If I can’t get the product, I’ve got to get the function. How can you provide the function by using some machine or labor or material that you can get?”. This philosophy proved very successful to Miles, for engineering tests and approvals and schedules could still be met. Thus “function” grew in vitality and was to later mature into the development of Value Analysis techniques. (Stewart, 2005) Further experience with these techniques was to reveal reduction of development times, production costs and improvement of products. Miles learned first-hand both the productive and the destructive force of human attitudes and practices, and their effect on appropriate designs and appropriate costs. His way of thinking shifted from

“What material am I buying?” to “What FUNCTION am I buying?”.

In late 1947, Miles had researched and developed workable techniques that would secure more cost effective processes and designs in the company. This new functional approach was first described by Miles as follows:

“To an exceptional degree it focuses on what is important, develops knowledge about it, and then causes great creativity in that area. You select from the creative approaches, answers that may not have come in years with other thinking methods. When the system was put to work the first time, it resulted in replacing a bronze clip holding a cover on a refrigerator control (that could flex millions of times without breaking) with a lower cost brass clip (that would flex thousands of times). Quality was not sacrificed because the clip would be flexed only about six times in the lifetime of the refrigerator. The $7,000 per year savings may seem like nothing, but when the same technique was applied to everything in the control box, the yearly savings jumped to $1.25 million.” (Stewart, 2005)

This definition stresses the importance given by Value Analysis (VA) techniques to finding the proper quality of a product at a proper cost.

For the next three years, Miles trained GE personnel in this newly born methodology, and in the meantime, he learned that greatest benefits could come when customers and vendors also know and use the VA functional and methodical thinking approaches. Sooner than later, GE agreed to provide VA training to other industries as well and, between 1948 and 1952, $10 million in benefits were reported. (Stewart, 2005)

Since 1954, VA experienced a gradual spread among Federal agencies in USA. Miles and his staff assisted the implementation of the first Federal Government program for the US Navy Bureau of Ships, where the methodology was first introduced to the construction industry. In 1963, the Department of Defense established specific requirements for a formal VE program within the three military services, which affected their design and construction activities. Suppliers were also included in this program and incentive-sharing clauses were mandated in construction contracts. It also introduced full-time Value Engineers within agency staffs to promote and manage the program.

The high level of success achieved by the Department of Defense led to further recognition in civil agencies. Great expansion followed in the next fifteen years. Today every Federal agency in USA with a significant construction or purchasing program employs VE in some form. In addition to Defense, such agencies include the General Services Administration, the Environmental Protection Agency, the U.S. Forest Service, the Veteran’s Administration, the Federal Highway Administration, and the Department of the Interior. This was further expanded during the 1980’s by the Executive Branch, with the support of the USA Congress, to include requirements for the application of VE to all agencies within the Federal Government. In addition, a few states and city governments have directed, through legislative action, that value methodology be applied to all capital expenditures.

The global development of VE began in the 1960’s through North American companies whose subsidiaries were located mainly in Europe and Australia. In the 1970's, manufacturing industries of primarily Japan adopted and extensively began applying the principles of VE. During the 1990's, there has been a shift from the application of VE solely to the design and production of components to its introduction to the business strategy as a whole. This approach was first referred to, in the manufacturing industry, as Value Management and can be clearly exemplified with the lever of quality diagram developed by Winston Davies at Jaguar Cars. (See Figure 4) (Kelly, et al., 2004)

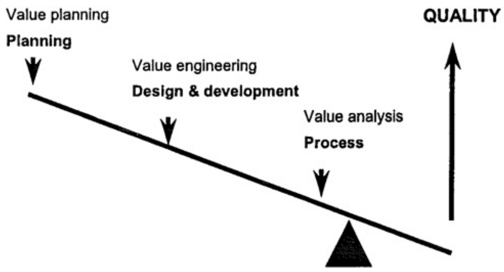


Figure 4: Winston Davies's lever of quality[4]

This lever of quality diagram demonstrates that a given quality enhancement can be achieved by applying either minimal effort at the Value Planning stage or great effort at the Value Analysis stage. Thus, Value Management still remains as a technique for competitive advantage within the manufacturing industry, like the total value management methodology outlined by the Ford Motor Company. (Kelly, et al., 2004)

3.2. Value Engineering: Hard and Soft Systems Thinking

The aim of this section is to present two paradigms embedded in the VE methodology, namely the optimizing paradigm of classical systems engineering and the learning paradigm of soft systems thinking[5]. This two-fold presentation offers a comprehensive exposition of the attributes of VE.

3.2.1. The optimizing paradigm of hard systems thinking

SAVE International's Value Standard and Body of Knowledge defines the steps and components that constitute a valid VE Study. Even though it has not been prepared as a legal document, it constitutes the main guide for practitioners and offers common terminology and a generic methodology for the effective application of VE to improve the value of projects.

This guide asserts that VE may be applied several times during the life cycle of a project, although it affirms that later applications may often entail higher implementation costs. It argues that early application of VE helps to steer a project in the right direction, while posterior applications help to refine the project's direction based on new or changing information.

[4] Taken from (Kelly, et al., 2004)
[5] This distinction in systems thinking can be clearly seen in (Checkland, 2000)

In addition, the generic methodology provided by this Value Standard and Body of Knowledge may be applied as a quick response study to address a particular problem or as an integral part of an overall organizational effort to stimulate innovation and improve performance characteristics. In other words, it may be used both in a proactive and a reactive manner to improve either specific projects' or organizations' performance. (SAVE International, 2007)

As previously mentioned in the "Definitions" section, VE relies on a systematic process. This systematic methodology, always executed by a multidisciplinary team and facilitated/lead by a Value Engineer, follows a structured and disciplined procedure called the Job Plan. (SAVE International, 2007)

The Job Plan is executed in the mid-stage of every VE study, which generally comprises three different stages. These three stages are:

Stage 1. Pre-Workshop (Preparation)

Stage 2. Workshop (Execution of the Job Plan)

Stage 3. Post-Workshop (Documentation and Implementation)

Firstly, the Pre-Workshop (Preparation) stage addresses the planning and organization of the value study. This usually entails activities like:

- Obtaining senior management support;
- Obtaining key documents such as scope of project, drawings, specifications, and project estimate;
- Identifying and prioritizing strategic issues of concern;
- Developing the study schedule;
- Identifying VE Team members;
- If appropriate, inviting suppliers, customers, or stakeholders to participate in the value study, and;
- Distribute information to team members for review.

Ultimately, Stage 1 will create a clear understanding of what senior management needs to have addressed. VE Team members will be knowledgeable of and committed to achieve the project's objectives. Additionally, this is the appropriate moment to decide whether to increase or decrease certain study parameters for the next stages.

Secondly, the Workshop stage addresses the actual execution of the Job Plan. It typically requires five days, excluding the other two stages; although it may vary according to the size, complexity and stage of development of the project under study. This typical 5-day workshop duration is common in North American VE studies. European consultants, however, tend to condense the Workshop stage to 1,5 – 2 days due to client imposed constraints, in spite of some VE experts' disagreement[6].

Generally, every Job Plan follows six sequential phases (see Figure 5) revolving always around analysis of functions. Invariably, a multidisciplinary team of

[6] (Hunter & Kelly, 2004)

experienced professionals and project stakeholders executes every Job Plan. Additionally, it must be facilitated by a VE Team Leader, who shall hold a certification recognized by SAVE International.

The following figure illustrates the process flow of a typical value study and also reveals the six sequential phases of the Job Plan.

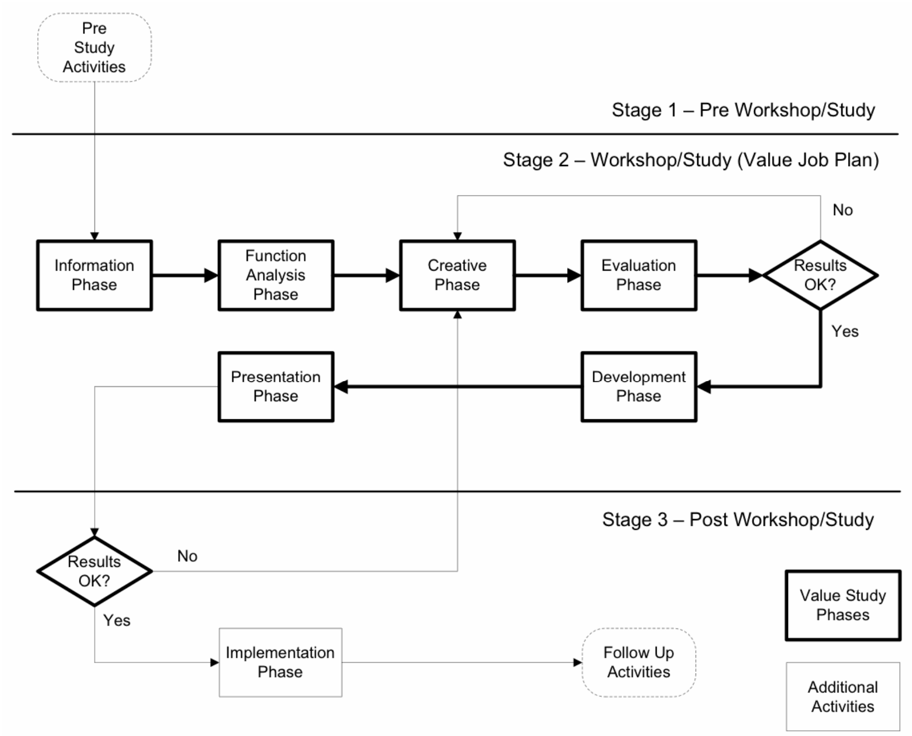


Figure 5: Value Study flow chart after SAVE International's Value Standard

SAVE International's Value Standard and Body of Knowledge defines the six sequential phases of the Job Plan as follows:

1. **Information Phase:** during this first phase of the Job Plan, the team reviews and defines the current situation of the project and identifies the objectives of the value study. Constraints, needs and desires of users, owners and stakeholders are identified during this phase. This phase provides a common, basic level of understanding of the project for all members of the team. It usually includes a site visit, identification of high-level project functions and confirmation of success parameters of the project.
2. **Function Analysis Phase:** this phase is devoted to defining the project's functions using a two-word active verb/measurable noun context. The information gathered during the Information phase is translated into functions of the project. This ultimately yields a thorough understanding of the project from a functional perspective – i.e. what the project must do, rather than how the project is currently conceived. Through the use of tools like FAST (Function Analysis System Technique), the team identifies functions relationships and value-mismatched functions on which to focus in order to improve the project. High cost functions will be tested for their worth. This will be the basis for the speculation of ideas.

3. **Creative Phase:** here the team makes use of creative techniques like brainstorming, the Gordon technique, the Nominal Group technique, TRIZ, and Synetics, to generate various ideas related to alternative ways of performing the functions identified in the previous stages. The objective is to find alternative ways of performing functions that enhance or at least maintain performance or acceptance at a reasonable cost.
4. **Evaluation Phase:** this phase should provide a screening of the various alternatives previously generated in order to identify those which are worth spending quality time to further develop, for they present the greatest potential to improve the project's value. Finally, the team produces a focused list of alternatives that may be further developed into value-based solutions for the project.
5. **Development Phase:** during this phase, the team further analyzes the highest ranked alternatives, selects those with merit and develops them into Value Alternatives. This includes assessment of low, medium and high-risk scenarios, besides a clear demonstration of the rationale behind every change a Value Alternative entails for the project development. It also generally includes a verification of the selected alternatives against the success parameters established during the information phase; cost benefit analyses; and development of action plans that define implementation steps, dates and responsibilities for each Value Alternative.
6. **Presentation Phase:** this phase concludes the Job Plan stage – 2nd stage – of every typical Value study. Here, generally the team leader elaborates the report and/or presentation whereby the results obtained during the previous phase are given to the Value study client and decision makers. It is paramount during this phase to be able to convey the right information so that management and other key stakeholders understand the rationale of the Value Alternatives. Seeking to provide the best elements for a comprehensive decision making, this stage commonly produces a briefing document, risk analyses, cost vs. worth comparisons, present worth analyses, and confrontation of pros and cons of each Value Alternative.

Figure 6, adapted from (Kasi, 2009) summarizes the previous six-phase definition of a Job Plan. The terminology he uses varies slightly from that used by SAVE International, but the principles remain the same. He refers to the Creative Phase previously defined as the Speculation Phase. He merges the Information and Function Analysis Phases into one broader Information Phase where the same aforementioned activities are executed. Thus, this figure depicts the general workflow of the Job Plan and illustrates which aspects are commonly addressed during each phase.

Finally, Stage 3 (Post-Workshop stage) addresses the implementation and follow-up of the Value Alternatives developed during the workshop and accepted and embraced by senior management or decision makers of the project. During this stage, the project stakeholders determine what will be changed in the project as a result of the Value Study. Common activities regarding the implementation of alternatives, include:

- Establishing action plans for those alternatives accepted and document the rationale for the rejected alternatives;

- Obtaining commitments for implementation;
- Track value achievement resulting from implemented alternatives, and;
- Validating benefits of implemented changes;

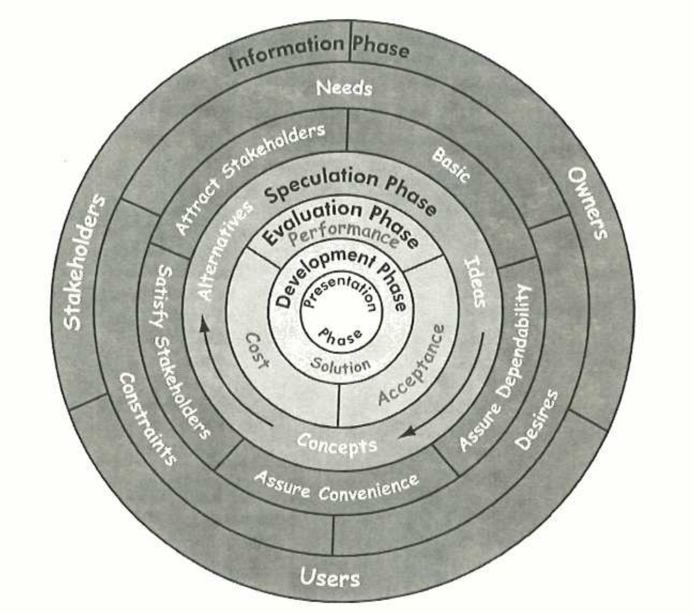


Figure 6: The VE Job Plan

Common activities regarding the follow-up of the value study, include:

- Preparing a report of lessons learned, and other items to be recorded or tracked through implementation;
- Identifying where opportunities were missed;
- Identifying roadblocks to innovation and understanding why they existed, and;
- Integrating the Value Study results into the organization's lessons learned or program reporting.

Ultimately, this last stage of a Value Study serves as a reflection stage. Individuals will become better value creators by reflecting on theories they held before the Value Study and comparing the way things turned out. This is a key step in learning what will help the organization become better at managing innovation.

That is the common 3-Stage procedure every Value study normally follows. Besides the Function Analysis Phase, which forms the basis of VE, a crucial element of every Job Plan is the Creative Phase and much importance is given to this particular phase during the Workshop stage. In fact, the United Kingdom's economics and finance ministry (commonly known as HM Treasury) asserts, in its *CUP Guidance No.54 – Value Management*, that the worth of using VE is only really as good as the quality of ideas generated during this phase. That is why all VE techniques emphasize the importance of creativity and imagination by brainstorming a range of possible solutions to a clearly defined problem.

The objectives of VE related to its optimizing paradigm of systems engineering are dominated by cost reduction. (Green, 1994) However, the optimization of Value can be achieved by several means besides the reduction of costs. Value can be optimized by balancing the amount to which needs are satisfied against the resources utilized in so doing.

Needs, as defined by the international standard on Value Management EN 1325-1, relate to what is necessary for or desired by the user. Total need may comprise, among others, use needs and esteem needs. The former refer to tangible measurable activities, while the latter refer to subjective, attractive or moral wants which are usually difficult to measure. Regardless of the type of needs in consideration, VE seeks to satisfy them, in whole or in part, through a comprehensive analysis of functions. The functions to be performed by the subject product or service must satisfy such needs.

This requires an approach different from that of the optimizing paradigm offered by Systems Engineering. VE, therefore, also offers a soft systems thinking approach the enables practitioners to address these highly more subjective requirements of stakeholders.

3.2.2. The learning paradigm of soft systems thinking

As previously mentioned, Value may be improved not only by a simple cost cutting maneuver but also by deciphering the right balance between satisfaction of stakeholders' needs and use of resources. Figure 7 depicts the various possibilities addressed by VE for improvement of Value.

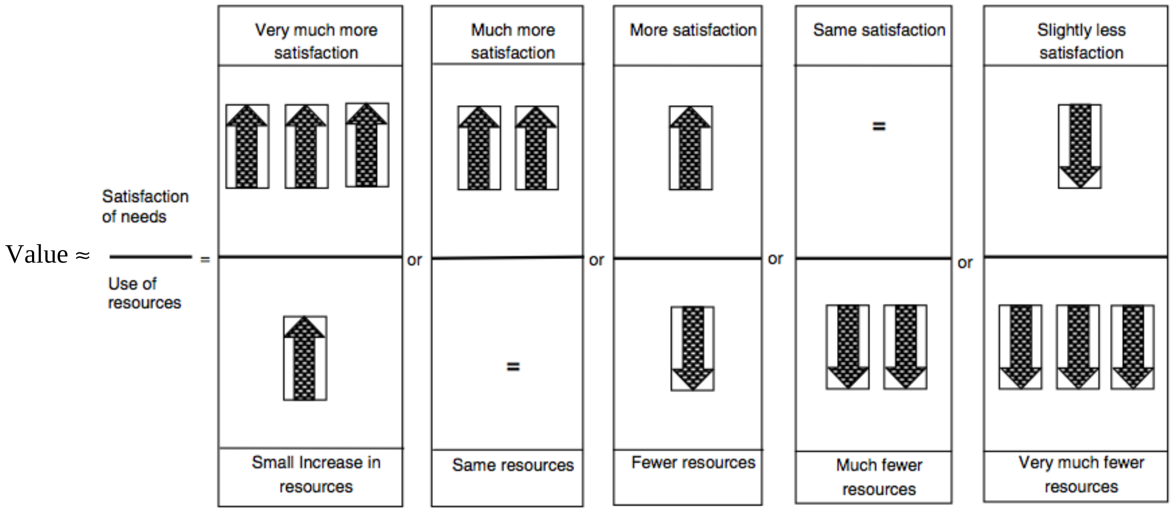


Figure 7: Different ways of improving Value (European Committee for Standardization, 2000)

In this respect, the purpose of VE is to develop a common understanding of the design problem and to explicitly identify an agreed statement of needs by the project stakeholders. (Green, 1994) defines this soft systems approach of VE as "a structured process of dialogue and debate among a team of designers and decision makers" whereby a common decision framework is agreed upon. This decision framework should provide room for participants of the value study to think about and communicate the comparative merits of alternative courses of action.

In other words, the soft systems paradigm of VE is concerned with the achievement of a shared perceived reality among stakeholders. This is especially important when projects show highly dynamic and unstructured – i.e. during the early conceptual stages of complex projects. Such traits of projects are often present because different parties possess very different perceptions of what the problem they are trying to solve actually is. These differences in perception constitute part of the problem. Single-criterion cost models may well be adequate when addressing the optimizing paradigm of Systems Engineering, however, they fall short when addressing the learning paradigm of soft systems thinking.

When the Value Engineer enters the paradigm of soft systems thinking, his/her role is comparable to that of a therapist (Green, 1994). At this moment, the Value Engineer works with clients, designers and users to help them articulate their requirements in the most clear and explicit way possible, so that ambiguities and misconceptions that may dwarf the achievement of a shared perceived reality among them are avoided. That is why the "soft side" of VE provides for an environment where thought and communication is facilitated by the Value Engineer.

The learning paradigm of VE is mostly deployed during early stages of a project's life cycle. (Green, 1994) asserts there are two moments where VE studies avail the most from the soft systems thinking. One moment is at the end of the Concept stage and the next moment is at the end of the Feasibility stage. Adapted from (Green, 1994), the following figure illustrates this timing of studies where the learning paradigm of VE emerges as the central issue.

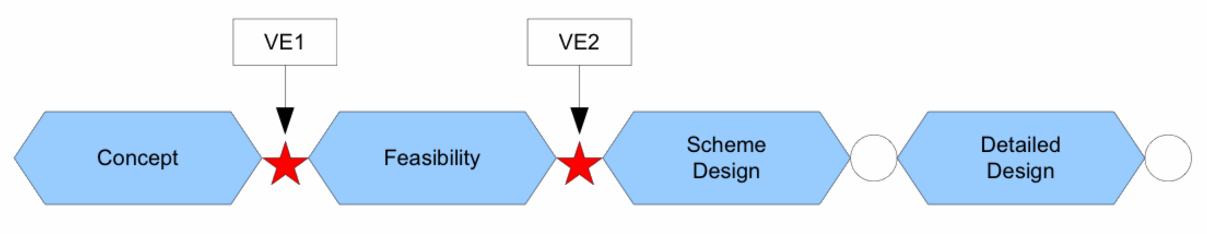


Figure 8: Timing of "Soft" VE studies

These two points in any project's life cycle coincide with moments where important client decision must be made. The first study is held at the end of the Concept stage when the product or service is first suggested as a possible solution to a perceived problem. This study, therefore, revolves around the decision as to whether the particular project should proceed or not. The primary objective here is to verify the need for the product or service before the client becomes committed to financial expenditure. Plus, this study must ensure there are clear project objectives and these are understood by all stakeholders. Thus, this study will not provide "optimal" solutions. Instead, it will enhance the stakeholders' understanding of the problem.

The second study is held at the end of the Feasibility stage, when generally the outline brief of the project has been completed and the design team has produced a number of costed outline proposals. Here the objectives are different from that of the first instance. This second study seeks to verify that the previously established design objectives are still valid. It also aims at ensuring that the choice of outline design proposal is made in accordance with the appropriate performance criteria. Finally, it attempts to secure marginal value improvements in the chosen design option.

In short, the learning paradigm of VE converts this methodology into a means of group decision support that is based on the techniques of decision analysis. Thus, VE provides a “common language for understanding, and a grammar for manipulating meaning in ways which are not easy with words alone.” (Green, 1994) Only after the understanding of the stakeholders has converged with the content of the decision model, as a result of the collaborative efforts made with VE, can one ensure their commitment to the decision outcome.

3.2.3. Implications of Value Engineering for project management

According to (Yeo, 1993), successful project management depends on the use of both hard and soft systems thinking. VE offers a bridge to link project management and its hard systems thinking foundation with the learning paradigm of soft systems thinking.

On the one hand, VE offers a set of techniques to optimize designs, performance and functionality of projects. Its collaborative and structured methodology and its transparent and unambiguous language enable decision makers to attain optimal solutions. The devotion to functional analysis and creative thinking achieve results that translate in cost savings without sacrificing quality.

On the other hand, VE constitutes a set of techniques that ensure sufficient initial attention to “exploring the problem”. This task is often underestimated. In fact, large-scale complex projects usually display unclear and ill formulated objectives. These cases generally suffer from low probabilities of success.

Project managers are often impatient to start building, since this bias for action is often an essential precondition for a successful project manager. However, the desire to achieve early measurable progress often acts to the detriment of the end product. Furthermore, managing a project within time, cost and quality will still result in a dissatisfied client when various stakeholders have not agreed on the performance objectives. VE plays an important role in resolving conflict within the client organization relating to objectives. Even if a total consensus cannot be achieved, there is benefit in simply making conflict explicit at an early stage. (Green, 1994)

Additionally, VE enables project managers to exert a greater degree of control over the early stages of the project life cycle and to generate a team-building atmosphere that will foster cooperation throughout the project. It also serves to provide clients with confidence that their money is being spent in a rational manner and seeking maximum utility.

Finally, VE avails from both the optimizing paradigm of systems engineering and the learning paradigm of soft systems thinking. The former makes this a management tool that is applicable to design problems, which are well structured and easily defined. In this case, it primarily focuses on the identification of alternative solutions to well structured problems. The latter surfaces when “functions” still remain as subjective characteristics of the project and refrain from being constant over time; when problems are dominated by conflicting objectives and value judgments. In this case, it adapts its competences to improving communication and establishing a common perception of what is required.

3.3. Value Engineering in the Construction Industry

This section reveals the proliferation of VE from its early beginnings in the manufacturing industry to the construction industry. It exemplifies the introduction of this methodology into the construction industry by drawing on the events that led to its adoption and continued use in the construction industries of the USA and the United Kingdom. It concludes with some considerations that must be regarded when VE enters the domains of the construction industry.

3.3.1. Prelude to a wide use of Value Engineering in the Construction Industry

As mentioned before, VE was first introduced to the construction industry in the mid 1950's through a Federal Government program for the US Navy Bureau of Ships. Then, in the early 1960's, it continued its wide spread onto this industry when the American Department of Defense established specific requirements for a formal VE program directed towards all their design and construction activities.

Alphonse Dell'Isola, fellow of the International Society of American Value Engineers (SAVE International), pioneered the introduction of VE in the construction industry. He focused on the same goals as Lawrence D. Miles in developing a value analysis process for construction. He asserts that improving project value is the main objective of VE. Additionally, he states that the project team should utilize VE to overcome poor project value and quality, including:

- Lack of shared project information, like insufficient data on the function of stakeholders' requirements, which may include building materials and processes.
- Lack of ideas or failure to develop alternate solutions and then making choices based on economics and performance.
- Temporary circumstances, like urgent delivery, design or schedule circumstances which may force decisions that, while quick, are often incomplete with regard to value.
- Honest but wrong beliefs. Often decisions are based on what is believed to be correct rather than facts.
- Habits and attitudes developed as a response to doing the same thing, the same way, under the same circumstances.
- Changes in stakeholders' requirements which may cause costs to increase without awareness.
- Lack of communication and coordination which become oftentimes reasons for unnecessary costs, and
- Outdated standards and specifications. In this regard, VE helps isolate and focus new technologies and standards in areas where high costs with poor value may incur based on wrong or legacy information. Thus VE can provide a framework for a rigorous review of project specifications. (Dell'Isola, 1997)

Respectively, the US Army Corps of Engineers benefits from one of the longest running programs within the construction industry and have been a leader in applying VE to construction projects since 1964. This particular program has returned US$ 20 for each dollar spent on the VE effort, and has documented over US$ 3,1 billion in savings and cost avoidance since its inception. (Stewart, 2005) Its raison d'être is to provide the required project at the lowest life cycle cost while maintaining or enhancing project performance. The US Army Corps of Engineers utilizes VE for several purposes, like:

- Solve technical problems
- Prepare project scopes
- Negotiate environmental contracts
- Optimize planning of projects
- Provide project review
- Ensure project coordination with sponsors, customers and users
- Ensure that projects meet their intended need and purpose

Similarly, the California Department of Transportation (Caltrans) – leader in the use of VE for transportation – has been improving the value of their projects through the use of VE since 1969. Only between 1996 and 2001 have they attained savings of nearly US$ 700 million. (Stewart, 2005)

Caltrans regularly conducts three different types of VE studies. Its flagship are the Value studies conducted on highway construction projects. With more than 50 Value studies per year on the design of highways, bridges and other supporting facilities, Caltrans averages over US$ 100 million per year in implemented cost savings resulting from this type of Value studies. Product studies, on the other hand, are Value studies that Caltrans undertakes in order to improve the quality of highway products. This second type of Value studies enables Caltrans to identify products that need to be updated due to changing technology, outdated application, or any other changes that affect their standard engineering products. Last but not least, Caltrans also utilizes VE to improve the quality of their processes, such as policy making, procedures and business practices.

The global development of VE began in the 1960's with the spread of VE techniques by North American subsidiary companies to principally Europe and Australia. In the UK, VE in construction evolved in the late 1980's. The spread to the UK was largely through organizations with North American head offices and the research activities of UK academics. As for the English construction industry, the climate of the 1990's fostered the development of innovative systems such as VE. In fact, various initiatives emerged, which sought to increase the efficiency and effectiveness of the industry. For example, the Latham Report[7], which spawned the Construction Industry Board, dedicated significant coverage to VE as a methodology conducive to good practice and modernization of the industry. Likewise, the Egan Report[8], which spawned the Movement for Innovation (M4I), was influential in shifting a substantial proportion of the construction industry towards more collaborative working; and this is an environment where VE thrives. Furthermore, the Office of Government Commerce places VE within its guides for good practice in construction procurement processes (the Achieving Excellence Procurement Guides). Newer procurement systems have initiated forward-thinking contracts, such as PPC 2000, that promote and formalize the use of VE.

Moreover, research activity earned support and funding from the Education Trust of the Royal Institution of Chartered Surveyors (RICS) and the Engineering and Physical Sciences Research Council. Aided by the European SPRINT program

[7] (Latham, 1994)
[8] (Great Britain. Construction Task Force. & Egan, 1998)

(Strategic Program for Innovation and Technology Transfer), VE activity in UK construction led the publication of a European standard for Value Management, authored by a consortium of the various Value associations throughout Europe. A training and qualification system entitled Value for Europe has been configured with its own European Governing Board (EGB). Within the UK, the Institute of Value Management (IVM) is currently developing systems and procedures, ethics and standards and a branch network for the advancement of this methodology. (Kelly, et al., 2004)

As a local pioneer on the use of VE, the Highways Agency has gained public recognition for following best practice in contract management, for securing value for money and for improving the level of certainty in delivering to budget and schedule. This Executive Agency of the Department for Transport (DfT), responsible for operating, maintaining and improving the strategic road network in England has long experienced the benefits of VE.

By the end of March 2009, the Highways Agency identified £66 million of savings through VE workshops. These savings are identified through sharing engineering best practice across Highways Agency, which ensures that more efficient ways of working are developed and shared effectively. For example, these workshops have delivered savings through encouraging the re-use of materials found at construction sites and through promoting the recycling of waste from local quarries, both of which can be alternatives to purchasing materials when constructing roads.

Likewise, continuous improvement and sharing cost reductions between the Highways Agency and its managing agents, in the delivery of routine and winter maintenance, has enabled several contract renewals for maintenance areas to deliver efficiency gains of £23 million. In addition, value for money gains on provider and managed works amounted to £16 million in fiscal year 2008-2009.

3.3.2. Particular considerations to Value Engineering in the Construction Industry

A number of key factors must be considered when applying the Value concept to the construction industry. First, it is essential to identify the parties who affect the costs of construction projects. Figure 9 graphically depicts impact on costs of various groups who are usually related to decision making in these projects.

From this figure, the groups having the greatest cost impact are the owner/agencies through their requirements, standards and criteria, and the designers through their decisions. The block sizes indicated are variable and depend on the agency and type of project among others. Normally the designer has the greatest impact on costs. Thus, (Dell'Isola, 1982) asserts that the greatest effort should be directed to these two areas if significant cost savings are to be realized.

Secondly, experience shows that the determination of points during the life cycle of a construction project where VE is used is closely related with the kind of payoff it may proffer. Figure 10 represents a graph of cost reduction potential versus cost to change. The curves indicate that savings potential decreases drastically the later VE is applied during planning, design, and construction, the breakeven point varying with the project and item being reviewed. For example, a foundation study would have an earlier breakeven point than a study involving finishes or facades. Owners and designer, (Dell'Isola, 1982) argues, should realize this and thus initiate VE studies early enough to realize maximum savings with minimum redesign efforts.

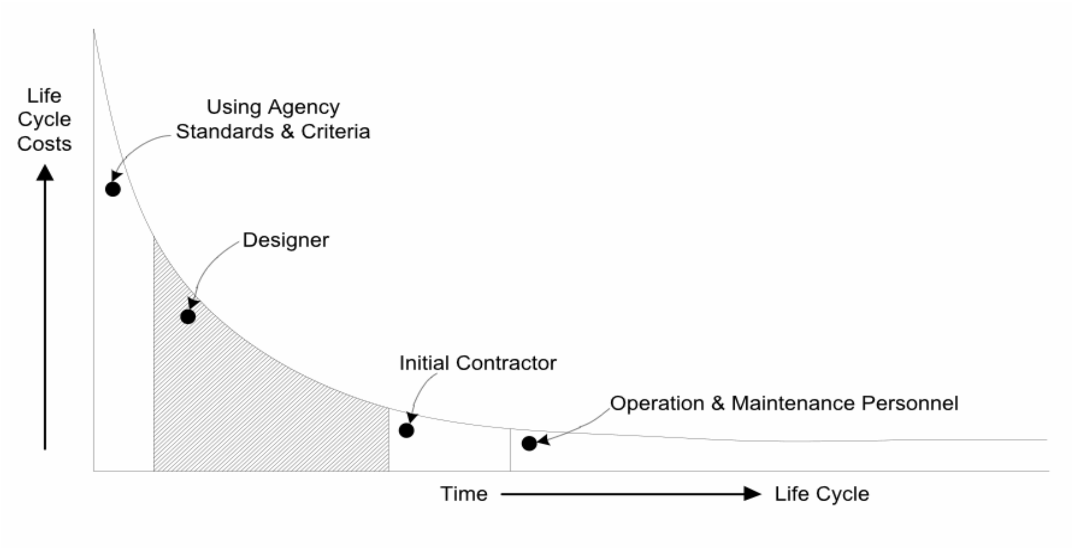


Figure 9: Stakeholders and their impact on costs[9]

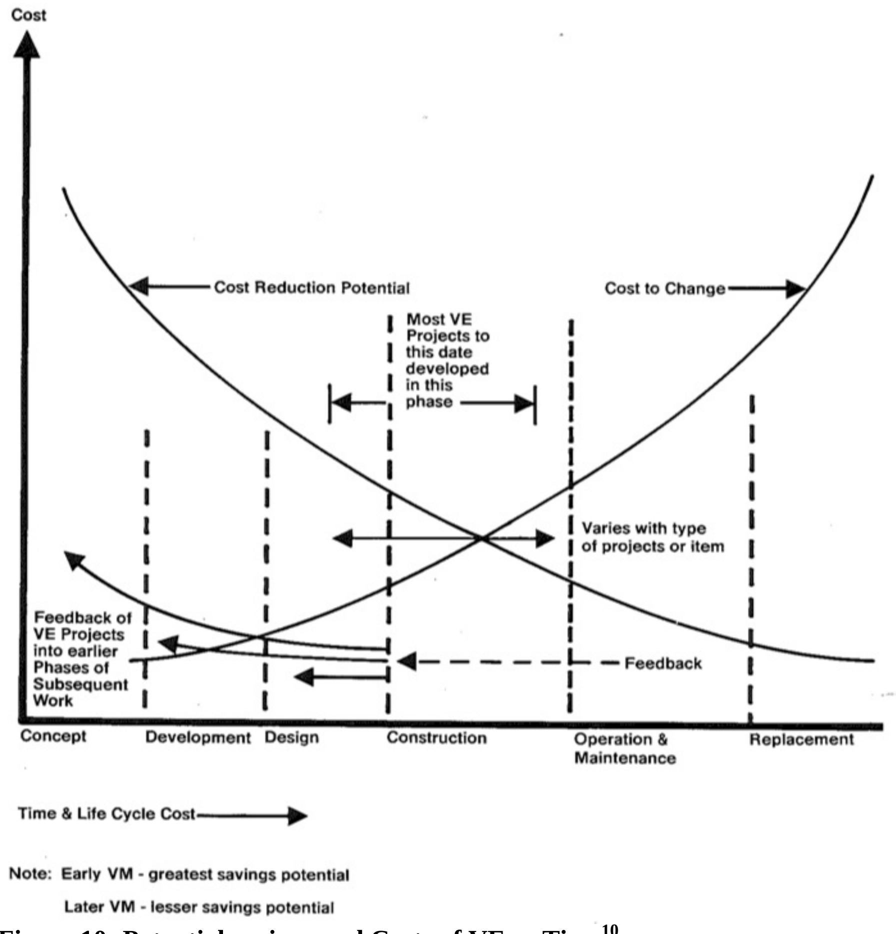


Figure 10: Potential savings and Costs of VE vs Time[10]

[9] Taken from (Dell'Isola, 1982)
[10] Taken from (Dell'Isola, 1982)

Next, a small number of elements of a system or facility usually contain the bulk of costs. The Pareto principle states that, for many events, roughly 80% of the effects come from 20% of the causes. Thus, a general rule is that approximately 20% of the elements of a system will contain 80% of the total costs. Therefore, there will also be a small number of elements which will contain the bulk of unnecessary costs and where VE efforts will therefore yield the greatest rewards.

Finally, traditional planning and design approach tends to compartmentalize various disciplines involved in decision making. Figure 11 illustrates this tendency with an approximate schematization of cost impact main disciplines involved in a chemical plant project have. Typically, the different disciplines engaged in a construction project design strategies and plans which seek to conform to owner's requirements. In the traditional planning and design approach, these disciplines develop solutions in their own area of expertise, cost them out, and later review the project, focusing on their own impact.

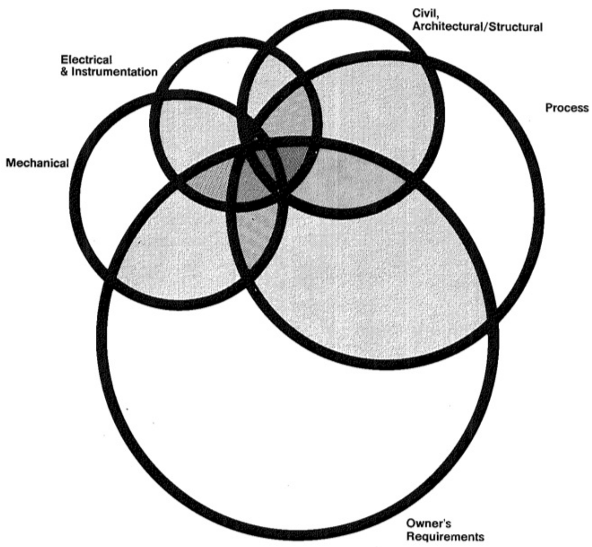


Figure 11: Cost impact of various disciplines[11]

This approach tends to optimize subsystem performance at the expense of total system performance. Similarly, there is certain reluctance to challenge owner requirements which present poor cost and value ratios. Often, resulting decisions are not the most economical for the end function of the system. In many cases, there is a failure to properly consider initial total system costs and total life cycle costs. In this regard, studies have identified significant potential savings in the overlapping areas shown in Figure 11. In many instances, the owner sets requirements which are too costly for his budget, or one discipline tends to dominate in the design and/or decision making input adding over design or redundancy in that area. This all results in unnecessary contributions to project costs.

In VE, another factor to be considered is the validity of cost estimates. Accuracy varies dramatically among owners and designers. Additionally, cost estimate formats are not normally standardized, requiring deciphering in each disciplines' costing procedures. (Dell'Isola, 1982) stresses the need to produce cost estimates using a

[11] Taken from (Dell'Isola, 1982)

phased approach - e.g., budget, concept, design development, working drawings, etc. - in a standardized and detail format which may easily be substantiated by other professional disciplines. This will enhance the effective applicability of the VE methodology in the construction industry. (Dell'Isola, 1982)

3.4. American and European regulations on Value Engineering

The long history of VE and the innumerable examples that corroborate its enhancing attributes for managing projects have led to the emergence of several standards, guidelines and laws, which regulate its use throughout the world. This section is meant to exposing such documents that attempt to standardize terminology and procedures across countries (Europe) and even enforce VE deployment at national levels (USA).

3.4.1. Dictated Value Engineering in USA

Not surprisingly, the long history of VE within the Federal Government and among several industries, including the transportation industry, has led to the inception and adoption of regulatory and mandatory guidelines on the use of this methodology. The Federal-aid Act of 1970 required VE and cost reduction analyses on Federal-aid projects. In May 1993, the Office of Management and Budget (OMB) issued its Circular A-131 where all Federal Agencies were required to use VE and report on VE practices on an annual basis. In late 1995, the US Congress passed the National Highway System (NHS) Designation Act which included a provision requiring the Secretary to establish a program that would require States to carry out a VE analysis for all Federal-aid highway funded projects on the NHS with an estimated total cost of US$ 25 million or more.

This impetus, led by the Federal Government, availed from Alphonse Dell'Isola's work on the application and use of VE in the construction industry and his expert testimony to several committees of the Senate and House of Representatives of the United States of America. In fact Alphonse Dell'Isola has been instrumental in introducing VE programs in over 35 countries, 30 government agencies and 30 large corporations. He has conducted over 1.000 VE workshops for various organizations and agencies on projects valued at over US$ 55 billion that resulted in implemented savings of US$ 2,5 billion.

Thus the Federal Government finally enacted Public Law 104-106 in February 1996 entitled National Defense Authorization Act for Fiscal Year 1996, which is also known as the Construction Value Engineering Law. In its Section 4306 – Value Engineering for Federal Agencies, this law amends the Office of Federal Procurement Policy Act by adding a section about VE (Section 36) in which all executive agencies of the Federal Government are asked to "establish and maintain cost-effective value engineering procedures and processes." In addition, it formally defines VE as an "analysis of the functions of a program, project, system, product, item of equipment, building, facility, service, or supply of an executive agency, performed by qualified agency or contractor personnel, directed at improving performance, reliability, quality, safety, and life cycle costs."

In the case of the Federal Highway Administration (FHWA), the compliance to Public Law 104-106, directed it to publish, on February 14 1997, its VE regulation. Through its Code of Federal Regulations in part 627 of title 23 (23 CFR 627), it formally establish its institutional VE program. After the FHWA published, in December 2002, the final rule establishing regulations for the design-build project delivery method, the VE regulations in 23 CFR 627 were amended so that State Transportation Departments (STDs) were obliged to performed VE studies prior to the release of the Request for Proposals document. More recent modifications to the VE regulations require VE studies to be performed not only in Federal-aid highway funded projects with an estimated total cost of US$ 25 million or more, but also to:

- A bridge project with an estimated total cost of US$ 20 million or more, and
- Any other project designated by the Secretary of Transportation.

Furthermore, the Secretary of Transportation is now entitled to require more than one VE study for a major project – estimated total cost of US$ 500 million or more.

3.4.2. Value for Europe

The European standard EN 12973:2000 "Value Management" was approved by CEN (Comité Européen de Normalisation – European Committee for Standardization) on October 7th 1999. Even though its application is not meant to be compulsory, it endorses the use of good practices in management at all levels, be it strategic, organizational and/or operational. It defines Value Management as a style of management designed to motivate people, develop skills and promote synergies and innovation. This standard indicates that the goal of Value Management is to reconcile differences in view among stakeholders, internal and external customers as to what constitutes value and by so doing enable an organization to achieve the greatest movement towards its stated objectives using the minimum of resources.

This standard reckons that Value Management has been proven effective in a wide range of activities and outlines three underlying principles for this approach, namely:

- A continuous awareness of value for the organization, establishing measures or estimates of value, and monitoring and controlling them. It defines value as a relationship between satisfaction and the resources used in achieving that satisfaction.
- Attention to the identification of objectives and targets before seeking solutions.
- Maximizing innovative and practical outcomes by focusing on function.

The standard also addresses styles, functional focus and base techniques of Value Management. In respect of style, the standard highlights the importance of a four-part approach involving teamwork and communication, a focus on what things do rather than what they are (function approach), an atmosphere that encourages creativity and innovation, and a focus on customers' requirements. Examples of pro forma frameworks for value analysis and the Work Plan/Job Plan are included in the standard.

The functional focus relates to customers or product needs described as "use needs" and "esteem needs". "Use needs" which correlate with user related functions (URFs) are identified as tangible measurable activities. "Esteem needs" are the parts of the total need that are subjective, attractive or moral.

The standard incorporates some useful information, guidance and frameworks for Value Management. It defines successful Value Management as working within a context of human dynamics, methods and tools, management style and environment (see Figure 12). The environment described is the environment within which Value Management operates and takes into account the broader environments of customers, suppliers, statutory and legal constraints and ecological considerations. The methods and tools relate both to the method of undertaking a value study including the study plan or agenda, and the techniques used within a value study. The latter include value analysis, function analysis, function cost, functional performance specification, design to cost and design to objectives.

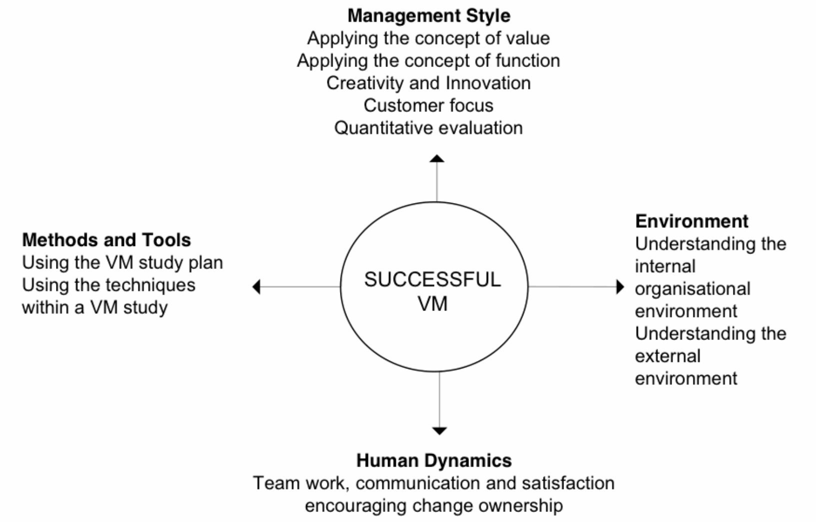


Figure 12: Essential ingredients for a successful VM study

Other methods and tools used concurrently are described as well, like creativity, failure mode effects, criticality analysis, life cycle costs, and quality function deployment among others.

3.5. Summary and Conclusions

VE is not a new invention. It has a long and successful history that spans more than 50 years, back until the days of World War II. It emerged as an optimization tool in the manufacturing sector and has spread throughout all economic sectors after decades of development and practice among pioneers. Both public and private sectors have benefited from its implementation. The construction industry has not been exempted from VE's proliferation. In fact, several public works organizations around the world currently utilize VE for the inception and development of infrastructure projects and the benefits drawn from it have been so significant that governments have even enacted laws to make it mandatory among their executive agencies. VE has proven effective for improving the value of infrastructure projects, among others, through the optimization of life cycle costs. A major issue in the development of public infrastructure projects is the focus on capital costs and neglecting maintenance and operation costs. VE always examines the life cycle costs of projects.

Geopolitical boundaries have not stopped VE's global proliferation and nowadays it stands as a renowned methodology in many countries[12]. However, its wide use among practitioners with different backgrounds and working cultures has led to an array of definitions and terminologies that sometimes collide and generate confusion. However the basic concepts remain identical. Value Analysis, Value Engineering, Value Methodology and Value Management are common terms used when referring to VE but, as many authors argue, the choice of names is trivial, as long as the original systematic process – the Job Plan – is carefully executed. For the sake of clarity and consistency, this document will attach to the term Value Engineering (VE).

While some refer to VE as a management technique others consider it a problem solving methodology or design tool. However, from the literature review presented in this chapter, it may be derived that VE stands beyond a mere problem solving methodology. The narrow definition as a design tool is much in line with the original conception by L.D. Miles whose objective was mainly the optimization of products through a careful analysis of functions. The more comprehensive definition as a management technique is more closely related with Green's concept of a soft systems thinking approach based upon team building procedures and continuous learning exercises.

Therefore, in order to have a more comprehensive appraisal of VE, it is defined herein as a management technique that uses recognized tools in a systematic manner, namely the Job Plan, and by a multidisciplinary team – the VE Team. Such tools are used to identifying the function of a product, service or process and establishing a value system for that function. Ultimately, they are deployed so to provide the necessary function reliability at the lowest overall cost. This definition embraces two levels of deployment of VE: 1) strategic, which is referred to as the Learning Paradigm in section 3.2.2 and 2) tactical, which relates to the Optimizing Paradigm explained in section 3.2.1.

The former focuses on creating a common language by which stakeholders can define and agree upon a value system for particular functions. This is essential during the early phases of projects where problems arise as fuzzy and ill-structured situations. The latter is more suitable during later stages of a project life cycle where problems have already been clearly defined and hence value enhancement is sought through optimization of designs and preservation of functionality.

Figure 13, graphically illustrates the relationship between VE and the array of ever expanding tools available for each of the Job Plan phases. It offers a glimpse of those recognized tools mentioned in the previous definition of VE.

[12] A list of international associations of Value Engineering can be found in Appendix D. Taken from (Thiry, 1997)

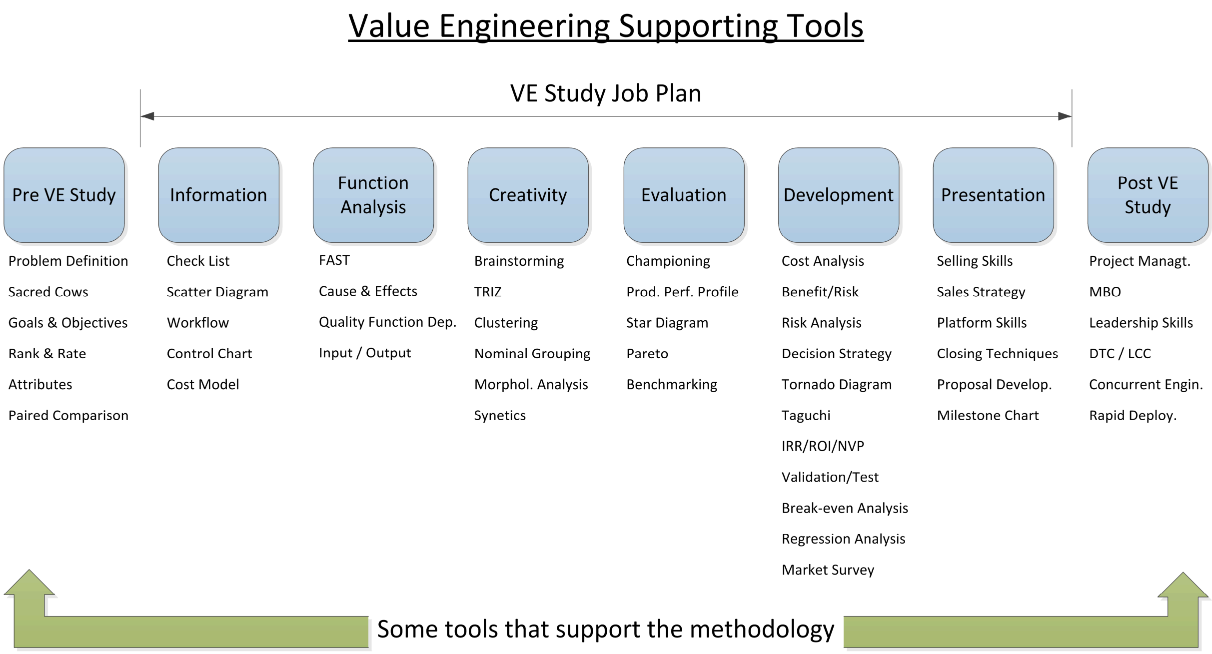


Figure 13: Value Engineering and some supporting tools (Kaufman, 2000)

4. Value Engineering: Optimizing Contribution to Pubic Works Organizations

This chapter constitutes the benchmarking study of this document. It dives into the practice and experience of similar public works organizations that have long benefited from the qualities of VE. The objective of this chapter is to expose the results of mature VE programs in this type of organizations and specifically to demonstrate their accomplishments with regard to the optimizing paradigm or hard systems aspects of this methodology.

For this purpose, the next sections of this chapter will present the results obtained from the application of VE by the Federal Highway Administration (FHWA) and, in particular, by one of the most VE experienced American State Department of Transportation, and the Highways Agency (HA) in the UK. The selection of these particular organizations to perform this benchmark study is based upon existing collaboration programs between them and RWS and their similarities with this Dutch agency.

On the one hand, the FHWA appears as an appropriate benchmark for the integration of a VE program in this case since The Netherlands and the United States have a lot in common in the field of road and traffic management. In fact, knowledge exchange programs exist between RWS and FHWA. For instance, in November 2009, they signed a Memorandum of Cooperation where they agreed to work together on matters such as improving road safety and developing performance indicators for their projects. Additionally, RWS is member of the steering group of an American Transportation Research Board (TRB) program on reliable journey times. Furthermore, the FHWA is also facing the challenge of reducing construction project lead times by 50%, just like RWS is currently envisioning; and is very interested in the Dutch Priority Road Works Program.

Moreover, RWS and the road authority in the state of California (Caltrans) have strong ties that make Caltrans an appropriate benchmark as well. Besides strong similarities between the road network around Los Angeles and the Randstad[13], these two organizations are actually aiming to set up joint research projects in the longer term where they will share knowledge on the use of ITS and the impact of climate change on the performance of their road networks.

On the other hand, the HA is also partnering with RWS in research projects. In the summer of 2009, they started a pilot project in Flanders using LED lights on the highways and together they are investigating the implementation of European air quality regulations. RWS is also learning from its English partner about innovative performance contracts and procurement strategies, while the HA is learning from its Dutch partner about the safety of rush-hour lanes. (Rijkswaterstaat - Ministry of Infrastructure and the Environment, 2010).

13 The Randstad is a conurbation in the Netherlands that consists of the four largest Dutch cities – Amsterdam, Rotterdam, The Hague and Utrecht – and the surrounding areas.

4.1. Value Engineering and the Federal Highway Administration

The Federal Highway Administration (FHWA) is one of the operating administrators within the US Department of Transportation (DOT). It is charged with the administration of the Interstate System of Highways in the United States of America. This task ranges from new construction of highways, bridges and tunnels, to maintenance and preservation. It also leads research programs and innovation projects to create better and safer highways. The FHWA provides technical assistance to its Federal, State and local partners to develop safer highways that incorporate the most efficient construction techniques and take into account the protection of the environment. Through its Federal-aid Highway program, the FHWA provides Federal financial assistance to State and local governments for constructing, preserving and improving national highways. Through its Federal Lands Highway Program, the FHWA provides funding for public roads and highways within Federally owned and tribal lands.

To comply with national legislation, specifically with Public Law 104-106, the FHWA established in 1997 a program requiring the application of a VE analysis for all Federal-aid highway projects on the National Highway System (NHS) with an estimated cost of US$ 25 million or more. Thus, the FHWA acquired the responsibility to monitor the application of VE on Federal-aid projects and produce annual summary reports on State DOTs' VE practices.

4.1.1. Value Engineering during Development and Design Phases

This initiative generated a considerable increase in the use of VE by the State DOTs. From 1997 to 2003, on average, 382 Federal-aid VE studies were performed annually. This represented an increase of approximately 18% over the annual average number of studies observed from 1993 and 1997, before the FHWA VE regulations were mandated. During the 7-year period from 1997 to 2003, the FHWA observed the State DOTs' VE trends depicted in Table 1.

Federal-aid Program Value Engineering Summary, 1997-2003

Source: Federal Highway Administration, Washington DC. [Online]. Available: www.fhwa.dot.gov/ve/vereport.htm
Notes: Amounts shown in millions of dollars. N/A = Not Available.

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Total/Avg.
VE Program Metrics								
No. of VE Studies	369	431	385	388	378	377	344	2,672
Cost of VE Studies Plus Administrative Costs	$ 5.10	$ 6.58	$ 7.47	$ 7.78	$ 7.29	$ 9.02	$ 8.45	$ 51.69
Estimated Construction Cost of Projects Studied	$ 10,093	$ 17,227	$ 18,837	$ 16,240	$ 18,882	$ 20,607	$ 19,241	$ 121,127
Total No. of VE Recommendations	N/A	2,003	2,082	2,017	2,013	2,344	2,144	12,603
Total Value of VE Recommendations	N/A	$ 3,084	$ 3,227	$ 3,483	$ 2,375	$ 3,050	$ 3,163	$ 18,382
No. of Approved VE Recommendations	N/A	743	848	1,057	1,017	969	914	5,548
Value of Approved VE Recommendations	$ 540	$ 770	$ 846	$ 1,128	$ 865	$ 1,043	$ 1,016	$ 6,208
Return on Investment	106:1	117:1	113:1	145:1	119:1	116:1	120:1	120:1

Table 1: FHWA's VE Summary Report 1997-2003

During the 6-year period from 2004 to 2009, the FHWA observed the State DOTs' VE trends depicted in Table 2.

Federal-aid Program Value Engineering Summary, 2004-2009

Source: Federal Highway Administration, Washington DC. [Online]. Available: www.fhwa.dot.gov/ve
Notes: Amounts shown in millions of dollars.

	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Total/Avg.
VE Program Metrics							
No. of VE Studies	324	300	251	316	388	427	2,006
Cost of VE Studies Plus Administrative Costs	$ 7.67	$ 9.80	$ 8.15	$ 12.54	$ 12.47	$ 17.08	$ 67.71
Estimated Construction Cost of Projects Studied	$ 18,700	$ 31,580	$ 21,530	$ 24,810	$ 29,930	$ 29,160	$ 155,710
Total No. of VE Recommendations	1,794	2,427	1,924	2,861	3,022	3,297	15,325
Total Value of VE Recommendations	$ 3,040	$ 6,760	$ 3,060	$ 4,600	$ 6,580	$ 4,160	$ 28,200
No. of Approved VE Recommendations	793	1,077	996	1,233	1,323	1,460	6,882
Value of Approved VE Recommendations	$ 1,120	$ 3,190	$ 1,780	$ 1,970	$ 2,530	$ 1,700	$ 12,290
Return on Investment	145:1	325:1	219:1	157:1	203:1	99:1	192:1

Table 2: FHWA's VE Summary Report 2004-2009

The return on investment demonstrates the high profitability of VE programs in USA State Departments of Transportation. The lowest figure observed in this item is that of Fiscal Year 2009, with 99:1. This means the approved VE recommendations yielded US$ 99 of savings for every one dollar invested in all VE studies carried out during that time period. The return on investment is obtained by dividing the Value of Approved VE Recommendations over the Cost of VE Studies Plus Administrative Costs.

Another important observation that may be drawn from the previous two tables is the average % savings attained by Federal-aid VE programs. These % savings are obtained by dividing the Value of Approved VE Recommendations over the Estimated Construction Cost of Projects Studied. Data in Table 1 result in 5% average savings from VE studies undertaken during the 7-year period from 1997 to 2003. A comparison on this specific metric with typical results achieved in other sectors and by other public agencies, proved that more can be achieved by improving the effectiveness of VE programs within State DOTs. In fact, other sectors achieve 10% savings on average from their VE studies and some agencies involved in capital projects realize up to 20%. (Wilson & National Cooperative Highway Research Program., 2005)

Data in Table 2 validate such prediction. During the 6-year period from 2004 to 2009 State DOTs realized not just a 5% but almost 8% average savings from their VE programs.

In its report No. MH-2007-040 on VE in the Federal-aid Highway Program, issued on March 28 2007, the Office of Inspector General (OIG) of the US Department of Transportation presents the results of an audit to the FHWA's oversight of VE in this program and the effectiveness of the State DOTs' respective VE processes.

The OIG observed that between FY 2001 and FY 2004, States collectively reported over US$ 4 billion in recommended VE savings (about US$ 1 billion annually). Moreover, it estimated potential additional savings worth US$ 725 million had all required VE studies been conducted and had more VE recommendations been accepted. Consequently, additional planned projects could have been started.

Several recommendations were drawn from this audit. One of them advises the FHWA to "require that VE studies be conducted between the concept phase and 35% completion stage of the project design". This recommendation surfaced from the analysis of best practices identified in some State DOTs VE programs. It is in line with the FHWA's policy implying that early timing of a VE study in a project is optimal, yet more precise.

The FHWA's *Fiscal Year 2008 Value Engineering Accomplishment Report* identified successful practices States across the country are using to enhance and improve their VE programs. In addition to highlighting the more than $2 billion in savings on transportation projects obtained in 2008, this report asserts that the VE process can also shorten project times, encourage innovation, lower life-cycle costs, and improve quality.

Best practices identified in this report include those in the area of scheduling, coordinating, and conducting VE studies. Several States, for example, are utilizing flexibility in how they accomplish their VE evaluations. The California Department of Transportation (Caltrans) holds a VE workshop that is split into two 3-day sessions, with a gap of typically 1 week in between. The result for Caltrans has been better time management for VE team members, including allowing time to gather necessary project information between sessions. The Missouri Department of Transportation, meanwhile, conducts streamlined studies known as VE/Practical Design Reviews ranging from 2 hours to 2 days. The abbreviated studies are typically conducted during the final design stage to ensure value is optimized.

Several States noted that a more functionally diverse VE team leads to a more successful VE study. The New Jersey Department of Transportation, for example, invites local authorities to participate in many of their studies, providing municipalities an opportunity to discuss their project needs and priorities.

In terms of the timing for VE studies, an increasing number of States are opting to conduct the study prior to the completion of preliminary designs (less than 30% of design completion) for design-bid-build projects. Several States connect the timing of their VE studies to the environmental compliance process. When applying VE to design-build projects, several States also use the 30% design milestone. The Georgia Department of Transportation (GDOT) is among the agencies that conduct their VE studies in the same manner for both design-bid-build and design-build projects. GDOT also shares the results of its VE studies with the contracting firms that have been shortlisted as project candidates.

For major projects costing more than $500 million, a few States described their process for conducting multiple studies. For example, Pennsylvania would conduct three VE studies, timed at the 30%, 60%, and 90% design stages. Nevada, meanwhile, would conduct its first VE analysis at the development phase to help minimize project impacts. A second study would then be performed in the intermediate design phase to address issues such as geometrics, drainage, roadbed design, and structure details, and fine-tune the project before making the final right-of-way decisions.

The accomplishment report also details other ways States are applying the VE process, beyond just the design of transportation projects. Montana, for example, has used VE to develop recommendations for its Interstate rehabilitation process, while Wisconsin performed a freeway maintainability review using an accelerated VE format. The New York State Department of Transportation (NYSDOT) has conducted several VE studies dedicated to work zone safety. Unlike traditional VE studies, savings were measured in safety enhancements rather than dollars. VE team members included representatives from NYSDOT, the State police, the construction industry, and FHWA.

For the 2008 report, States were also asked to share information regarding successful practices that encourage implementation of VE proposals after the award of construction contracts. The Iowa Department of Transportation is one of several State transportation agencies seeking ways to increase industry awareness of the post-award VE process, with a standard note included on construction plans that directs contractors to a general VE specification. Elsewhere, the Florida Department of Transportation (FDOT) reported that post-award VE proposals are a standing agenda topic for its preconstruction and quarterly contractor meetings. This allows contractors to discuss their VE proposals with FDOT staff before many funds have been spent on construction. (Federal Highway Administration, 2011)

4.1.2. Value Engineering during Construction Phase

In addition to performing VE studies during the development and design phases of a project, VE principles can also be applied during the construction of the project through Value Engineering Change Proposals (VECPs). VECPs are post-award VE proposals made by construction contractors during the course of construction under a VE clause in the contract. Provisions for VECPs encourage contractors to develop VE proposals, so that the State would eventually benefit from a contractor's design and construction ingenuity, experience and ability to work with new techniques.

The Federal-aid Policy Guide, FAPG G011.9[14], defines VECPs as "a construction contract provision which encourages the contractor to propose changes in the contract requirements which will accomplish the project's functional requirements at a less cost or improve value or service at no increase or a minor increase in cost. The net savings of each proposal is usually shared with the contractor at a stated reasonable rate."

Unlike the use of VE during Development and Design, there is no specific requirement in federal highway law for the use of VE clauses in construction contracts. The application of VE during construction is instead addressed by regulations and other means. The regulations establishing the VE Program in the FHWA (23 CFR Part 627) contain several clauses relative to the use of VECPs, like:

[14] http://www.fhwa.dot.gov/legsregs/directives/fapgtoc.htm

- *23 CFR 627.5 (a) (4), Incentives:* Allows VE clauses in contracts by stating that "The program may include a VE or cost reduction incentive clause in a State DOT's standard specifications or project special provisions that allows construction contractors to submit change proposals and share the resulting cost savings with the State DOT".
- *23 CFR 627.5 (a) (5), Monitoring:* States that "The program may include procedures for monitoring the implementation of VE study team recommendations and VE change proposal recommendations submitted by construction contractors".

Thus, the FHWA strongly encourages State DOTs to use VE throughout highway project development, design and construction.

A VECP is the last chance the owner has to lower the cost and improve the value of the project. It also gives the contractor an incentive to seek ways and means to increase his profit without lowering the value of the project. A successful VECP benefits both the owner and the contractor. (Kasi, 2009)

Some people may argue that there is no need for a VECP if the designer did his job right in the first place. However, the expertise of the FHWA demonstrates that VECPs should not be considered a weakness of the designer, but should be considered an opportunity for a positive team effort between the designer and contractor. This positive team effort may be justified by the following reasons:

- There is often a long time gap between the design and construction phases, and the market conditions may change dramatically during this period.
- During construction, field conditions become more precise.
- Constraints that exist during design may not exist during construction.
- Designers assume a method of operation and staging of construction suitable for all qualified bidders. The successful bidder, because of their unique expertise or location to the site, may be in a position to select a different or familiar construction method for less cost.

A VECP should follow the following steps (Kasi, 2009):

Step 1. Documentation

- Present comparison between design and VECP, detailing advantages and disadvantages.
- Itemize changes to the contract.
- Submit a cost estimate for both design and VECP including the cost of development and implementation of the redesign by the contractor.

Sep 2. Submission

- The contractor should submit the VECP to the resident engineer with a copy to the owner.

Step 3. Acceptance

- The contractor should set a time limit for a response. Beyond this limit, the contractor has the option to withdraw the VECP. The owner should have the right to accept or reject the proposal.

Step 4. Sharing

- The contract will detail the method by which the contract price would be adjusted if the proposal is accepted.

It is worth noting that the probability of success of a VECP depends mainly upon how receptive the designer is towards the changes, and how much the owner wants to participate in the technical aspects of the project. No matter how good a VECP is, without this receptiveness and participation, the contractor may not want to risk time, money and the possibility of antagonizing the designer. (Kasi, 2009)

4.2. Value Engineering and Caltrans

The California Department of Transportation (Caltrans) began conducting VE studies in 1969. Currently, Caltrans also assists State practitioners in using VE more often and to improve VE reporting to the FHWA. Since 1990, the Department's VE program has achieved almost US$2.4 billion in savings as a result of nearly 600 value studies performed. This historical performance of its VE program is indicated in the following chart.

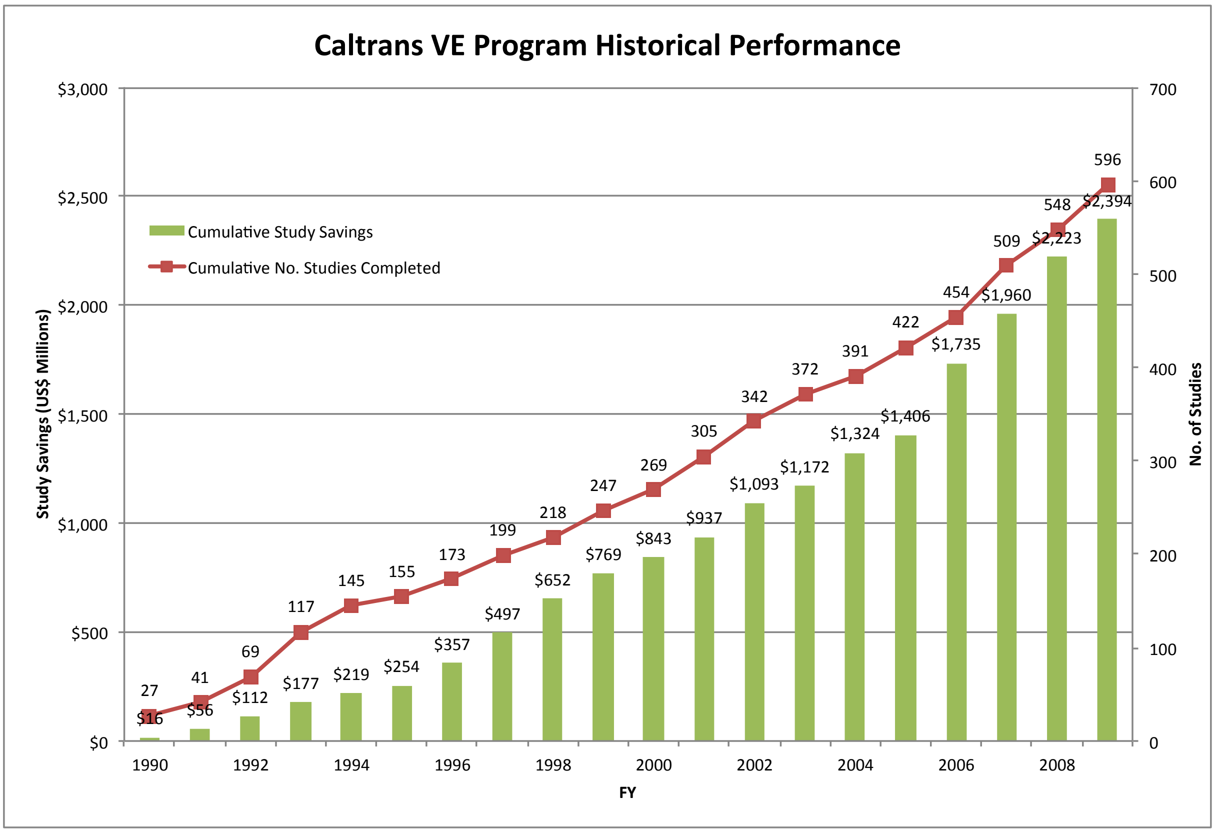


Figure 14: Caltrans VE Program historical performance

Typical VE studies in Caltrans involve a team of 7-10 multi-discipline Subject Matter Experts (SMEs) and one CVS (Certified Value Specialist) team leader. The studies are typically six working days over a two or three week period of time. Including Pre and Post study meetings, they are usually resourced with approximately 500 hours in the project work plan. Typical total costs of a study are less than US$ 100.000. Additionally, they are typically organized as follows:

Pre-Study Preparation (8 hrs):

- Initiate Study
- Organize Study
- Form VE Team

- Prepare Data

Study Workshop (40 hrs):

- Inform VE Team
- Analyze Functions
- Create Ideas
- Evaluate Ideas
- Develop Alternatives
- Critique Alternatives
- Present Alternatives
- Assess Alternatives
- Resolve Alternatives
- Present Alternatives

Post-Study Activities (8 hrs):

- Approving Alternatives
- Implementing Alternatives
- Publish Results
- Close out Study

All VE studies performed by Caltrans must follow Chapter 19 of its Project Development Procedures Manual (PDPM). Here, Caltrans adopts the policy of performing VE studies on all projects totaling US$ 15 million or more "to take advantage of the VE tools to enhance the project's value and to avoid having to perform the study late in the project development process if project costs should escalate above the mandate [Federal] thresholds. The VE study is most effective in the beginning stages of project development, but it may be performed at any stage of project development". (California Department of Transportation - Office of State Project Development Procedures and Quality Improvement, June 3, 2010)

Caltrans uses VE as an effective problem solving and quality assurance tool to facilitate the agency's goals – i.e. maximize Safety, Mobility, Delivery, Stewardship and Service. It makes use of this methodology when specifically seeking to:

- Meet or exceed standards and safety objectives;
- Foster a team approach to problem solving and project development;
- Improve a project's performance while maximizing quality;
- Identify and develop strategies to mitigate or avoid risks and the associated costs;
- Identify opportunities which promote Context Sensitive Solutions, and;
- Validate project's scope, need and purpose, and baseline design.

For Caltrans, VE also provides an opportunity for a structured and thorough review by functional experts, which often reveals new information that fosters the project's advancement in a timely manner. In addition, it has effectively used VE to ensure that the agency's responsibilities and liabilities as owner of the asset are adequately addressed in the project design. Plus, this has all been facilitated – in a balanced manner – without compromising competing project objectives of partner agencies and other project stakeholders. In fact, according to Caltrans' PDPM, "VE can aid in obtaining project stakeholder consensus on key project decisions, leading to the best possible design that is sensitive to the context of the impacted communities and environment". (California Department of Transportation - Office of State Project Development Procedures and Quality Improvement, June 3, 2010)

Caltrans' vast expertise on VE has led to the identification of potential benefits dependent on the phase of the project when the studies are performed. Often, the earlier a VE study is undertaken, the more beneficial it will be. Studies conducted in the later phases of a project, after significant amount of resources have been committed to a chosen design, usually reveal fewer opportunities for viable improvements without compromising the delivery schedule. (California Department of Transportation - Office of State Project Development Procedures and Quality Improvement, June 3, 2010)

Figure 15 depicts the benefits that, according to Caltrans, VE can derive during four primary phases of project development. The four primary phases in the previous table are defined in Caltrans' PDPM as follows:

1. Concept or Project Initiation Phase: the input to this phase is a list of potential projects, each with a clear statement of purpose and need. During this phase, a Project Initiation Document (PID) is generated. This PID must contain a well-defined project scope, a reliable capital and support cost estimate for each alternative solution, and a project workplan for the alternative recommended for programming the project.
2. Approval or PA&ED Phase: the input to this phase is the PID generated in the previous phase. Any project must receive official federal, state, and environmental approvals as well as consensus from all the stakeholders and the public. Thus, during this phase activities to gain "Project Approval" and regulatory acceptance are performed. The main output of this phase is a Project Approval and Environmental Document (PA&ED). This document further refines the purpose and need of the project, identifies the alternative selected, describes how that alternative was decided upon, and describes how consensus was reached between Caltrans and stakeholders. Also during this phase, expanded engineering studies are completed to support the environmental evaluation and stakeholder input to the project and its alternatives.
3. Final Design or PS&E Phase: activities in this phase include the development of contract Plans, Specifications, engineer's Estimates, contract bid documents, allocation of funds, contract award, and contract approval. Besides, any environmental commitment from the PA&ED must be resolved prior to the complition of this phase. When this phase is complete, the project should be biddable and buildable.
4. Construction Phase: after the construction contract has been awarded, this phase can begin. Ultimately, this phase delivers the constructed physical improvement, the final quantity and cost of the works, the As-Built plans, the project history file and the certificate of environmental compliance.

Potential VE Benefits vs. Project Timing

Potential VE Benefits ● = High ⊙ = Medium ○ = Low	Project Timing Concept	Approval	Final Design	Construction
Support sound decision-making	●	●	●	●
Develop solutions to difficult engineering challenges	●	●	●	●
Identify/Assess risks and associated costs	●	●	●	●
Reduce Project Development Support Cost - Expedite delivery	●	●	●	●
Extend expected (LOS) service life	●	●	●	⊙
Reduce capital cost to construct	⊙	●	●	⊙
Reduce cost to operate/maintain	⊙	●	●	○
Clarify need and purpose	●	⊙	○	○
Ensure land use compatibility	●	⊙	○	○
Identify best alternatives to meet Caltrans' safety and performance standards	⊙	●	⊙	○
Early discovery of opportunities and constraints	●	●	⊙	○
Build stakeholder consensus	●	●	⊙	○
obtain input from community representation	●	●	⊙	○
Avoid/Minimize environmenrtal impacts	●	●	⊙	○
Avoid/Minimize Right of Way impacts	●	●	●	○
Improve modal choices and connectivity	●	●	⊙	○
Identify optimum phasing/staging opportunities	⊙	●	●	○
Validate project scope	⊙	●	●	○
Validate/refine current project design	○	⊙	●	○
Reduce the need for Construction Change Orders	○	⊙	●	○

Figure 15: Caltrans VE Benefits vs. Project Phase

The following figure illustrates the common timing of VE studies in Caltrans' Project Development Workflow.

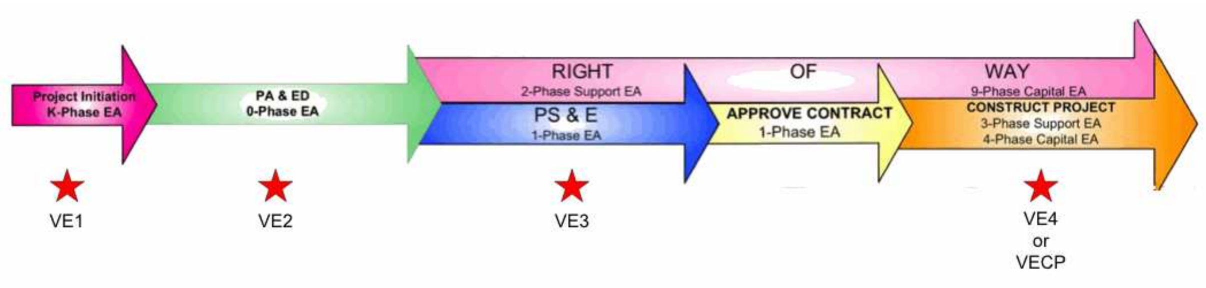
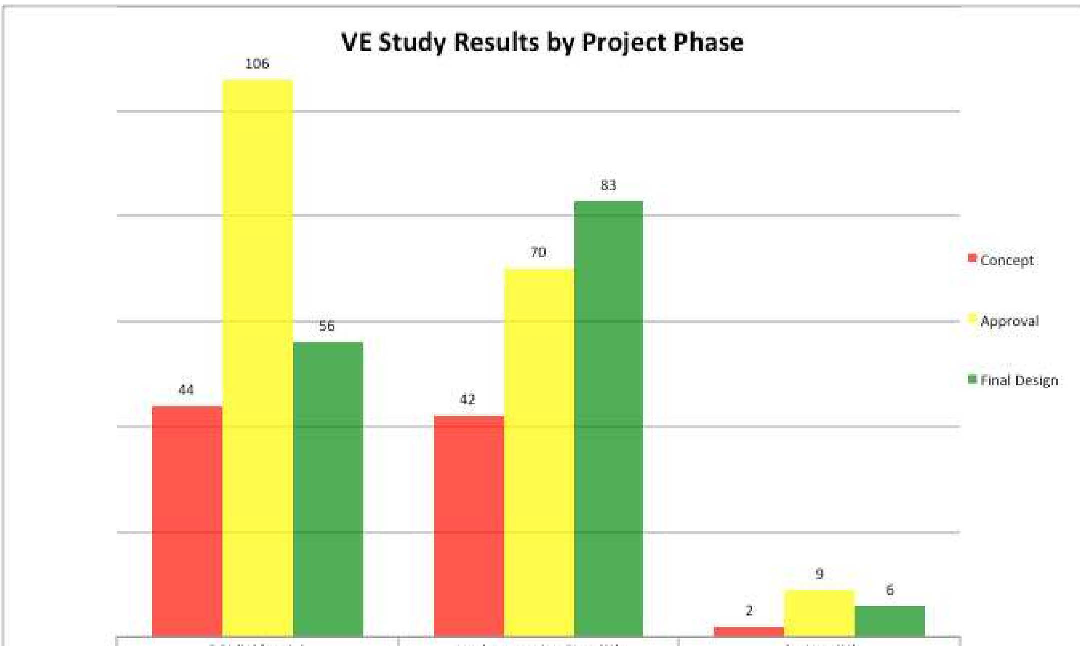


Figure 16: Timing of VE Studies in Caltrans' project life cycle

Nonetheless, Caltrans has obtained differing results from its VE studies depending on the project development phases during which these have been performed. For instance, according to Caltrans, one of the main barriers to implementation of VE recommendations is the timing of the study. The next figure shows the average Return on Investment (ROI), Implementation Rate and Savings by project phase.



	ROI (US$ ratio)	Implementation Rate (%)	Savings (%)
Concept	44	42	2
Approval	106	70	9
Final Design	56	83	6

Figure 17: Caltrans VE Study results by project phase[15]

The greatest Return on Investment has been experienced when the value study is performed in the Approval phase (prior to Draft Environmental Document). If the project is not well defined or already bound by constraints, the Implementation Rate and Return on Investment fall dramatically. Similarly, Figure 17 reveals that the greatest Savings have been experienced when the value study is performed in the Approval phase. That is, when sufficient information is available so to develop high impact alternatives and when major decisions have not yet been taken so that there is still room for maneuver.

[15] (California Department of Transportation, 2009)

Caltrans does not only make use of VE for optimizing transportation projects but it also performs value studies in products and processes. Here, products refer to items and systems described in Caltrans' Standard Plans and Specifications, including reports and other documents Caltrans develops for various customers. For that matter, Product Value Studies have helped Caltrans identify products that need to be updated due to changing technology, outdated applications or other changes that affect standards. For example, VE studies of headlight glare screens, concrete barriers, and overhead signs have led to state wide modifications.

Similarly, VE has helped Caltrans improve the effectiveness of processes, such as policies, procedures and business practices. Process Value Studies have included workload balancing, project development procedures, intergovernmental reviews, district business plans, information access and distribution, regional strategic traffic operations plans, tort liability claims, maintenance operations, and support services. For example, during fiscal year 2008-2009, Caltrans performed four Process Value Studies, including: GIS Corporate Structure, Hazardous Material Process, Bridge Design Project Delivery Process, and Document Retrieval System.

4.2.1. Caltrans' VE Study on the New State Route (SR) 138

This chapter describes one particular highway project where Caltrans successfully applied VE. It is intended to exemplify the general description of the Department's VE program presented above. Thus, it depicts real case results of a mature VE program. This project is an example of a public works organization that avails from the optimizing benefits of this methodology. The information presented in this section was adopted from the Value Engineering Study Report on the New State Route (SR) 138, dated June 24, 2008[16].

This VE study was conducted by Caltrans District 7 and facilitated by Value Management Strategies, Inc. The workshop took place on October 30-31and November 1-6 and 8, 2007 and was led by Robert B. Stewart, CVS-Life, PMP. The subject of the study was the New State Route (SR) 138 in Palmdale, California. This VE study was conducted at the start of the Approval phase.

New State Route (SR) 138 Project Description

At the time of this VE study, the baseline design concept consisted of the realignment and construction of SR 138 between SR 14 and 100th Street in Palmdale, California. The alignment would be to the north of the existing SR 138 alignment. The highway would be 8 lanes wide from SR 14 to 15th Street and then taper down to 4 lanes from 15th Street to 100th Street. A new highway-to-highway interchange with SR 14 would be constructed with direct ramp connectors. The project also included 7 local interchanges, 2 overcrossings and 2 viaduct structures. The Los Angeles World Airport (LAWA) had agreed to provide the majority of the new right-of-way east of 15th Street for the project. The project's estimate for the original design was $860 million in 2007 US Dollars.

[16] (Stewart, 2008)

Project Need and Purpose

The project's need and purpose was to provide new infrastructure to support residential growth in the vicinity of the cities of Palmdale and Lancaster. The existing State Route was constricted by development and the construction of a new highway was needed to replace SR 138 and alleviate congestion. This project was also considered to be part of the High Desert Corridor, which sought to create a new east-west connection between SR 14 and I-15.

VE Study Objectives

The VE Study was intended to focus on alternatives that would help to finalize the scope of this highway project. It also sought to identify cost-saving alternatives that would make this a fundable project and that would satisfy the local stakeholders. In addition, any alternatives that would help reduce or mitigate the project risks would be considered beneficial.

Value Metrics

Caltrans VE process makes use of Value Metrics to provide a systematic and structured means of considering the relationship of a project's performance and cost as they relate to value. Project performance must be properly defined and agreed upon by the stakeholders at the beginning of the VE Study. The performance attributes and requirements developed are then used throughout the study to identify, evaluate and document alternatives.

As the VE team develops alternatives, the performance of each is rated against the original design concept. Changes in performance are always based upon the overall impact to the total project. Once the VE team has developed performance and cost data, the net change in value of the VE alternatives can be compared to the original design concept. The resulting Value Matrix provides a summary of these changes and allows a way for the Project Development Team (PDT) to assess the potential impact of the VE alternatives on total project value and for decision-makers to make an objective selection of the best alternative.

In conjunction with the VE team, the PDT and other relevant stakeholders identified and defined the performance attributes and requirements, and then developed the rating scale to measure performance. Performance requirements represent essential, non-discretionary aspects of project performance. Performance attributes represent those aspects of a project's scope and schedule that may possess a range of potential values.

The following are the key project performance attributes which were used in this VE Study:

Performance Attribute	Description
Mainline Operations	An assessment of traffic operations and safety on the mainline facility, including off-ramps and collector-distributor roads. Operational considerations include level of service relative to the 20-year traffic projections, as well as geometric considerations such as design speed, sight distance, lane widths, and shoulder widths.
Local Operations	An assessment of traffic operations and safety on the local roadway infrastructure, including on-ramps and frontage roads. Operational considerations include level of service relative to the 20-year traffic projections; geometric considerations such as design speed, sight distance, lane widths; bicycle and pedestrian operations and access.
Construction Impacts	An assessment of the temporary impacts to the public during construction related to traffic disruptions, detours and delays; impacts to businesses and residents relative to access, visual, noise, vibration, dust, and construction traffic; environmental impacts relative to water quality, air quality, soil erosion, and local flora and fauna.
Environmental Impacts	An assessment of the permanent impacts to the environment including ecological (i.e. flora, fauna, air quality, water quality, visual, noise); socioeconomic impacts (i.e. environmental justice); impacts to cultural, recreational, and historic resources. Also considered under this attribute are drainage and hydraulic issues.
Project Schedule	An assessment of the total project delivery from the time of the VE Study to completion of construction.
Maintainability	An assessment of the long-term maintainability of the transportation facility. Maintenance considerations include the overall durability, longevity, and maintainability of pavements, structures and systems; ease of maintenance; accessibility and safety considerations for maintenance personnel.
Land-Use Compatibility	An assessment of the overall compatibility of transportation facilities with existing and planned land uses. This attribute considers how a transportation facility will directly affect the quality and viability of the land uses around it.

VE Study Results

A thorough function analysis was performed resulting in the FAST diagram attached in Appendix A1. This revealed the key functional relationships for the project. This analysis provided a greater understanding of the total project and how the issues, project cost, and function requirements were related. The FAST Diagram arranges the functions in logical order so that when read from left to right, the functions answer the question "How?". When read from right to left, the functions answer the question "Why?". Functions connected with a vertical line are those that happen at the same time as, or are caused by, the function at the top of the column (a "When?" relationship).

Subsequently, VE alternatives were generated during the Creative phase of the Value Study. Eventually, the Project Development Team (PDT) accepted eight VE alternatives. The implementation of these alternatives resulted in significant changes to the project. These included:

- Realigning SR 138 so that the geometry is straighter and slightly shorter while increasing the spacing between interchanges.
- Reducing the size of the project's environmental footprint.
- Improving operations at the SR 138 – SR 14 interchange.
- Reducing the amount of imported borrow required by nearly a million cubic yards.
- Improving the project's stormwater detention facilities.
- Converting SR 138 to an expressway east of 50th Street.
- Improving the Joshua Tree Mitigation Program.

The net result of these changes also reduced project costs by approximately US$ 74 million.

Table 3 presents a summary of the accepted and rejected VE alternatives for this project with their corresponding cost savings and performance improvements. For a more detailed documentation of this VE Study's outcomes, the reader is invited to refer to Appendices A2 and A3 where two fully analyzed VE alternatives, one accepted and one rejected, are included for illustration purposes.

VE Alternatives for New State Route (SR) 138

Accepted Alternatives

Alt.	Description	Initial Cost Savings (US$)	Performance Improvement
1.0	Shift alignment of SR 138 just south of Avenue P-8 between 30th Street and 100th Street	$6,162,000	+23%
3.0	Provide separate southbound SR 14 off-ramp to Palmdale Boulevard	-$6,583,000	0%
4.0	Reconstruct existing on-ramp at Rancho Vista and extend beyond southbound SR 14-SR 138 connector	-$1,031,000	+2%
6.0	Coordinate with city's Drainage Master Plan to reduce roadway embankment height	$46,874,000	+4%
7.0	Create detention basins south of SR 138 and use the excavated materials for roadway embankment	$11,408,000	+2%
8.0	Construct spur dikes at viaduct abutments at Little Rock Wash to reduce structure length	$1,239,000	-4%
10.0	Convert SR 138 to east of 50th Street to an expressway	$16,018,000	-5%
11.0	Establish Joshua Tree Mitigation Program	$0	+6%

No.	Strategy Description	Initial Cost Savings (US$)	Change in Performance	Change in Value
1	Accepted Alternatives	$74,087,000	+22%	+33%

Rejected Alternatives

Alt.	Description	Reason for Rejection
2.0	Depress SR 138 between Division Street and 10th Street East	There are not any nearby receiving streams or drainage facilities in the vicinity to receive water from the large watershed that is 9m below original ground. The cost of maintenance for pumping and cleaning is too high in a long run. This would have such
5.0	Construct collector-distributor road along southbound SR 14 between Palmdale Boulevard and Rancho Vista Boulevard	This was rejected due to the additional cost relative to the small benefits that would be realized.
9.0	Construct 2:1 side slopes on SR 138 between 50th Street and 100th Street	The current geotechnical information indicates that 2:1 side slopes may not be viable. Side slopes of 2:1 or steeper are considered non-recoverable and non-traversable, and they may have erosion issues. Safety should not be compromised over environmental

Table 3: Summary VE Alternatives for New State Route (SR) 138 Project

4.3. *Value Engineering and the Highways Agency*

The Highways Agency (HA) is an executive agency of the English Department for Transport (DfT) and is responsible for the stewardship, operations and development of the strategic road network. The strategic road network includes most motorways and the major 'A' roads. It is valued at over £85 billion and carries a third of all road traffic in England and two thirds of all road freight traffic.

It is also responsible for delivering a program agreed with the DfT for additions and enhancements to the strategic road network. It manages traffic, tackles congestion, provides information and improves safety and journey reliability on the strategic road network. Furthermore, it is responsible for acquiring, managing and disposing of land and property and paying compensation in relation to schemes on this network. It is expected to deliver a cost effective program of day-to-day maintenance and to influence the development of the DfT's longer term planning and policies for the strategic road network.

The Highways Agency has 3.500 employees and manages an annual budget in the region of £3 billion. This covers the costs of improving and maintaining the network including improvements funded from Regional Funding Allocations – a program by which regions have the opportunity to advise the Government on their long-term investment priorities for elements of transport, housing and regeneration, and economic development to support sustainable economic growth[17].

Unlike the FHWA and American State DOTs, whose application of VE is mandated by Federal Law, the Highways Agency's VE Program is not a result of any national legislation. In this case, the application of VE relies on European Standards – i.e. EN 12973:2000 – and internal guidelines like the Project Control Framework (PCF) and the Value Management Handbook for Major Projects.

4.3.1. Value Engineering in HA's Major Projects

The Project Control Framework (PCF) is a joint DfT and HA approach to managing major projects – those projects costing more than £5m. It comprises: a standard project lifecycle, standard project deliverables, project control processes, and governance arrangements. VE[18] studies are a vital part of these products.

The project lifecycle presented in the PCF decomposes the development and delivery of major projects into three phases and seven stages. This is shown in Figure 18.

[17] (Great Britain. Highways, 2009a)

[18] The terminology utilized in the HA is Value Management and therefore their Value studies are abbreviated VM. For the sake of consistency, however, this report continues to use irrespectively the term Value Engineering (VE).

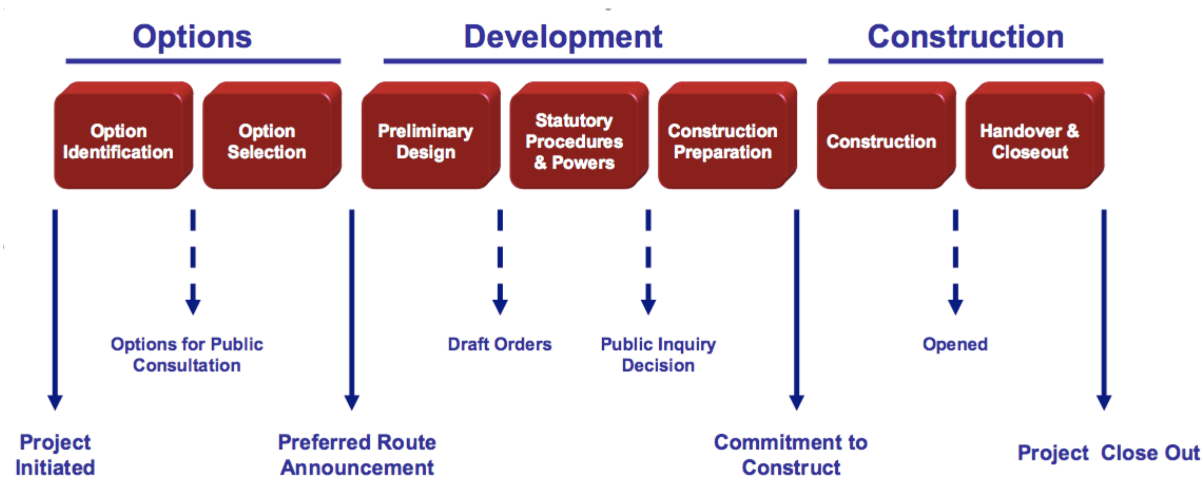


Figure 18: Highways Agency's Standard Project Lifecycle[19]

The HA uses VE as a strategic tool to maximize value for money by challenging the need for a project, leading to confirmation of project objectives. Once initial project objectives are agreed, VE is used to continuously reviewing objectives and controlling the development of a project. Hence, the VE process consists of workshops at key phases of scheme development.

As schemes are developed through feasibility, design, statutory process and construction, Value opportunities are identified and assessed. To be effective, the VE process is carried out in a systematic and structured manner so to ensure opportunities are maximized and not missed.

Thus, VE is helping the HA and the DfT to realize the following[20]:

- Clarity in project objectives that reflect DfT's and HA's needs and expectations while optimizing the balance between differing external stakeholders' requirements,
- Enable DfT and HA to make timely and informed decisions about the project design that take into account the value of monetary and non-monetary factors,
- Ensure that the project is developed and implemented in the most cost effective and efficient manner to deliver its objectives and maximize the planned benefits,
- Facilitating constructive challenge of the status quo by supporting better communication, joint learning and greater team working, which will encourage improved and innovative solutions at all stages of the project lifecycle,
- Deliver to time and budget the program of major schemes, and
- Deliver the HA's contribution to the DfT's efficiency target.

As an integral part of the Project Control Framework, VE is considered a complement to other processes of the HA, such as risk management, cost management and scheme appraisal. VE workshops shall be undertaken, at a minimum, during all the main stages of the PCF and prior to all Stage Gate Assessment Reviews. Aside from formal VE workshops, project teams are expected to manage down costs and to continuously challenge and seek innovative value for money solutions. In order to have a clearer view on the integration of VE within the standardized project lifecycle

[19] Adopted from Highways Agency's Value Management Manual version 23-03-09
[20] (Great Britain. Highways, 2009b)

defined by the PCF, the reader is referred to Appendix B where a flowchart, adopted from the HA's Value Management Manual, illustrates such integration.

As previously mentioned, the effectiveness of the VE process relies heavily on an early structured planning. Using VE in a preventive manner has shown more effective than doing so only in a corrective manner. Figure 19 shows the importance of an early structured VE process applied continually over time as the project develops.

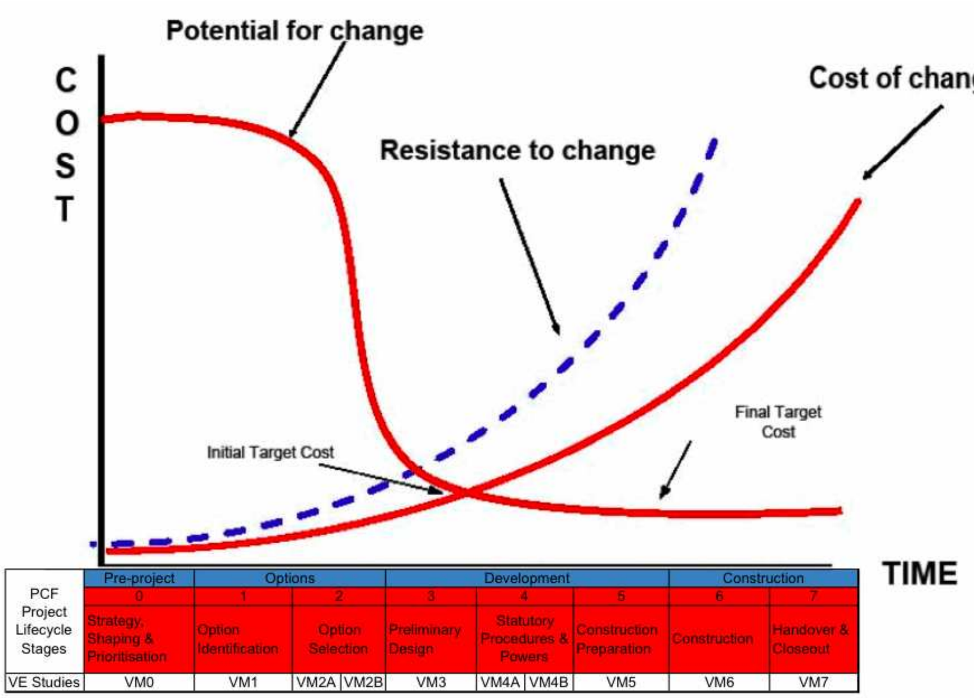


Figure 19: Project Lifecycle vs Value Engineering Studies[21]

The maximum opportunity for cost or functionality change occurs during the earliest phases of a project – i.e. Stages 0 (Strategy Shaping and Prioritisation) and 1 (Option Identification). It is during these stages that priorities and objectives are set and the scoping of options to meet these is produced. The key point at which the opportunity for negative cost ceases and increasing resistance and cost of change become palpable occurs at the end of the Preliminary Design (Stage 3), just prior to commencing the Statutory Procedures & Powers process (Stage 4).

Value Engineering Workshop 0 (VM0)

This first VE workshop is usually undertaken after initial data collection and analysis, approximately ¼ to ½ of the way through the Strategy, Shaping & Prioritisation stage. Its average duration is 1 day and its primary purpose includes:

- Defining the problem or opportunity on route, corridor or area.
- Identifying key constraints.
- Developing a statement of need in functional terms which forms the basis of the project brief.
- Developing and agreeing upon the objectives and functions and broad scope of the project(s) required delivering the brief.
- Identifying a range of high-level options to satisfy the project objectives.

[21] Adapted from Highways Agency's Value Management Manual version 23-03-09

- Identifying the key risks.
- Reviewing the forward program.
- Agreeing on actions arising and their timescales.

Value Engineering Workshop 1 (VM1)

This VE workshop is usually undertaken ¼ of the way through the Option Identification stage. It lasts normally 1 day. It comprises a facilitated workshop with stakeholders to achieve the following:

- To review the project objectives and brief with stakeholders and obtain their feedback and views.
- To present any options currently being considered and to enable stakeholders to engage with the project team in assessing the costs and benefits of these options.
- To encourage stakeholders to identify value improvements to the current options and/or to identify any alternative concept options.
- To explain the forward program to stakeholders.
- To confirm the options being taken forward for further investigation.

Value Engineering Workshop 2A (VM2A)

The output from the earlier VM1 stakeholder workshop is likely to be a number of potential project options, which will have been assessed and appropriately developed by the project team. Those project options remaining are brought to the VM2A workshop for review and further refinement. This workshop usually takes 1 day and is carried out approximately ¼ of the way through the Option Selection stage. Its purpose includes the following:

- To present the options developed since VM1 and those which have been discarded.
- To investigate the functionality of the various options by establishing the needs for the various improvements.
- To identify various value improving proposals to deliver the need and required functionality.
- To undertake initial assessments of the value improving proposals for technical feasibility, benefits and ease of implementation.
- To confirm which proposals are to be taken forward for further investigation.

Value Engineering Workshop 2B (VM2B)

This 1-2 day workshop is undertaken approximately ¾ of the way through the Option Selection stage – normally when all the main option appraisal work has been completed. The options generated during VM1 and refined over time, including at VM2A, are brought to this workshop. This workshop is meant to achieving the following objectives:

- Verification that the project objectives remain valid.
- To present the options developed since the VM2A workshop.
- To review, modify where necessary and agree the criteria for a comparative assessment of the project options, based on the project objectives.
- To undertake a matrix assessment of the improvement options against the criteria including weighting to test for sensitivity as required. The matrix assessment is to be supplemented by background presentations as required.
- To undertake a risk assessment of the options.

- Taking into account the outputs from the comparative matrix assessment, capital costs, economics, value ratio, and risk assessment, make decisions as to which is/are the preferred option(s).
- To identify any key issues resulting from the value appraisal process to be addressed in closing out the Option Selection stage and to confirm any actions arising.

Value Engineering Workshop 3 (VM3)

This is usually a 1-day workshop undertaken approximately ¼ - ½ of the way through the Preliminary Design stage. It is similar in format to the VM2A workshop but addresses in greater detail the design and buildability of the proposed solution(s). Depending on the procurement method chosen, the contractor may be appointed and this workshop enables them to fully participate in the VE process and incorporate their expertise in construction to leverage better value. This workshop has the following objectives:

- To investigate and clarify the detailed functionality of the preferred project option(s) through all component elements of the preliminary design.
- Identification of various alternative value improving proposals to achieve required design functionality.
- Undertake an initial assessment of the alternative value improving proposals for technical feasibility, benefits, buildability and ease of implementation against the current design.
- Confirm the value solutions to be taken forward for incorporation into the design.

Value Engineering Workshops 4A & 4B (VM4A & VM4B)

These are VE reviews that usually last ½ day each. They are undertaken by the project team both ahead and following the results of the Statutory process – e.g. Publication of Draft Orders, Environmental Impact Statement, Public Exhibitions and outputs from Public Inquiry. These reviews will appraise the outputs form earlier VE exercise, incorporate any new changes and optimize the design taking into account the latest information.

Value Engineering Workshop 5 (VM5)

This workshop is undertaken approximately ¼ to ½ of the way through the Construction Preparation stage and its duration normally ranges between ½ and 1 day. It is similar in format to the VM3 workshop but addresses in depth the detailed design and construction sequencing/activities of the proposed solutions. The contractor team is a key participant in this workshop along with members of their supply chain – e.g. specialist subcontractors/suppliers – and their involvement enables them to fully participate in the VE process and incorporate their expertise in construction to leverage better value. This workshop seeks to:

- Undertake a detailed review of the proposed detailed design, construction program, methods and processes, and identify various alternative solutions to maximize value for money.
- Undertake an initial assessment of alternative value improving proposals for technical feasibility, benefits, buildability and ease of implementation against current design.
- Confirm the value improving proposals to be taken forward for incorporation into the design.

- Identify specific processes where the use of lean/six sigma applications would increase efficiency and remove waste.

Value Engineering Workshop 6 (VM6)

These are VE review meetings to be held during the Construction stage to plan, manage and report on the outputs of ongoing VE construction efficiency improvement exercises. The exercises may involve optimizing designs, procurement and supply chain efficiencies, re-sequencing of activities and/or, improving construction processes through the use of lean/six sigma applications.

Value Engineering Workshop 7 (VM7)

This workshop is undertaken at project completion/handover, preferably not later than 3 months after this date. It usually takes between ½ and 1 day, and has the following objectives:

- To assess how well the project met its objectives.
- To identify Lessons Learnt from the project – strengths, weaknesses, opportunities and threats addressed in all stages of project execution.
- To identify useful lessons for future projects.
- To review the value opportunities register to assess which value proposals were and were not implemented and why.
- To assess the effectiveness of the implemented value improving proposals and any Lessons Learnt from their adoption.
- To undertake a reconciliation of the value opportunities register to assess the benefits resulting from VE adoption.
- To assess how well the VE process assisted in the delivery of the Asset Management Plan.

Exceptional Formal Value Engineering Workshops

Exceptional VE workshops are those which are undertaken outside the planned program of the VE process. The DfT sponsor and/or the HA project manager can call a VE workshop at any time during the PCF lifecycle. They may be initiated for several reasons like, objectives change, project cost or time overrun, financial budgetary allowances for the project change, change in procurement strategy, changes imposed by external stakeholders, changes resulting from the Statutory process, increased complexity in construction operations, etc.

4.4. Summary and Conclusions

Two public works organizations that share similarities in terms of institutional setup and business configuration with RWS were presented herein as benchmark organizations in the use of VE. One belongs to the USA government and has adopted this methodology to deploy in certain public projects not only because legislation demands it to do so but also because it has improved, since its adoption, the value of its processes and assets. The other belongs to the UK government and though it does not follow legislative rules in this regard, it does integrate VE in its standard project delivery framework and adheres to European standards which establish best practices for the use of VE. The former is the Federal Highway Administration (FHWA) and the latter is the Highways Agency (HA).

Two distinct styles in the application of VE can be identified in this benchmark study, although they share basic principles in terms of VE study timing. The Americans commonly perform one single but exhaustive VE study during the early stages of a project lifecycle, before it is procured to the construction industry market. Conversely, the English prefer executing several shorter VE studies spread throughout the project lifecycle, including construction and handover stages.

The Americans maintain a comprehensive record of the savings achieved by VE in every project, unlike the English. That is why it was possible to present clear and detailed proof on the optimizing benefits VE has provided the FHWA for the last 13 years.

Concurrently, this benchmark study revealed VE studies' effectiveness is closely affected by the timing of the study within the project lifecycle. Accordingly, it was found that the earlier the timing of the VE study, the higher its potential for improving the value of the project. Particularly, the middle stage, after conceptualization and before detailed design – Approval stage in Caltrans project development framework – has surfaced as the favored stage for achieving better results from a value study.

5. Value Engineering: Collaborative Contribution to Public Works Organizations

The previous chapter has validated the optimizing or hard systems thinking benefits of VE. This chapter, on the other hand, exposes the results obtained from the attempt to validating the soft systems thinking advantages offered by this methodology. Faced by the very limited documentation available on these aspects of VE, the selected method for attempting this validation includes interviews with experts and a survey which is expected to reveal the personal experience of accomplished VE team leaders on the soft capabilities of this methodology.

Public works organizations are under constant scrutiny by citizens, taxpayers, end users of public assets and other stakeholders. Furthermore, they often belong to intricate and large networks made of very different participants. These traits often translate into excessively long decision-making processes and therefore in unacceptably long duration projects. The soft traits of VE presented in chapter 3.2.2 seem, at first sight, appropriate for public works organizations to incite collaboration within the complex networks they belong to. How can VE enhance the process management capabilities of public works organizations?

In order to answer this question, this chapter presents first the survey's setup and then the outcomes regarding the possible connection between VE and Process Management in public works organizations. It concludes with a summary and findings obtained from experts interviews, relative to additional soft capabilities of VE in the conception and development of public infrastructure projects.

5.1. Value Engineering and Public Management

According to de Bruijn and ten Heuvelhof, "a good process is an open process, in which parties' core values are protected, which has sufficient incentives for speed and offers sufficient guarantees for the substantive quality of the results"[23]. Therefore, considering the environment in which public works organizations function, the objective of this chapter is to demonstrate, through VE experts' testimonies, the contribution of VE to a 'good process'.

Designing the perfect process is hardly possible. However, a structured and systematic methodology like VE might provide the necessary means to achieving successful process management in large public infrastructure projects. It might offer an effective way of dealing with some of the inevitable challenges most processes face and decrease the risk for these challenges to lead to conflicts and deadlocks among the involved actors.

In order to conduct an analysis it is important to stress on some mechanisms that characterize process management. Regarding major infrastructural projects, the initiative was traditionally taken by governmental authorities, planned and implemented by unitarily decision. However, private actors, such as companies, organizations and the public, have recently become increasingly important in these

[23] (Bruijn, et al., 2002)

decision making processes and governmental authorities are experiencing increasing dependency on these private actors, not mentioning the fact that they have also gained increasing influence in society's development and behavior. This tendency has augmented the complexity of decision-making processes, especially when it comes to infrastructural development. According to (Bruijn & Heuvelhof, 2008) a network can be defined as: "(1) a number of actors with (2) different goals and interests and (3) different resources, (4) who depend on each other for the realization of their goals". This indicates that typical decision-making processes in public works organizations must reckon the multi-actor trait of their networks and must realize that the involved parties are depended on each other in order to comply with their goals.

Even though this could sound appealing and logical to most people, collaboration between private and public actors on major infrastructure projects is complex and does not always guarantee a successful outcome. However, there are indications of an increased possibility for a positive output, in terms of the degree of satisfaction achieved among stakeholders, when these are involved in the decision making process (Edelenbos & Klijn, 2006). Thus, effective process management rises as a crucial ingredient for making collaboration between private and public sectors a successful way around major infrastructure projects.

According to (Bruijn, et al., 2002), a good decision-making process should always satisfy 4 main elements. These elements are openness, protection of core values, speed and substance. The process designer should always take these elements into consideration when leading a decision-making process. However, since no two single projects are identical, trade-offs must be made between these four elements in order to forge the process to the specific conditions surrounding the particular project.

5.1.1. The Openness of Decision Making

A decision making process is open when decisions are not taken unilaterally and when various relevant parties are allowed to participate in it. The process and its agenda are decided upon collectively.

An open process is characterized by 1) the inclusion of all relevant parties in the decision-making, 2) the transformation of substantive choices into process agreements and 3) the transparency of the process and its management.

5.1.2. The Protection of Parties' Core Values

Mere openness does not guarantee a 'good process'. The risk of being unable to advance your own interest must be addressed. That is why the parties participating in a 'good process' must be given sufficient protection of their core values. The process should be a safe environment for the participating stakeholders.

This element of a 'good process' entails the following:

- Parties' key interests should be protected,
- Parties should commit themselves to the process rather than to the result,
- Parties may postpone their commitments to decisions made, and
- The process should offer participants an exit option.

5.1.3. The Speed of Decision Making

Alone the previous two elements do not guarantee a good decision making process. In fact, they tend to spawn consultations and negotiations that may turn it into a lethargic process, which will never produce a clear result. Hence, a ‘good process’ should avail from certain speed to guarantee progress and consistency.

In order to obtain speed in a decision making process,

- The process should create prospects of gain as well as incentives for cooperative behavior,
- The participants in the process should have commitment power,
- The process should have an environment, which is used to speeding it up,
- Conflicts should be transferred to the periphery of the process, and
- Command and control approaches may be used as an incentive to speed up the process.

5.1.4. The Substance of Decision Making

A good decision making process should meet the requirement of substantive quality in order to avoid the often sharp conflicts of interest among stakeholders from generating meager or substance-less decisions. For this purpose, (Bruijn, et al., 2002) recommend that the process should prevent the process-drives-out-content mechanism – i.e. the roles of experts and stakeholders should be both bundled and unbundled. Additionally, the process should move from substantive variety to selection.

5.2. Survey on Value Engineering Soft Systems Thinking Traits

“Recent developments in the field of systems thinking show that conventional project management theory is essentially rooted in hard systems thinking and there are now increasing calls to augment this theory with ideas and approaches from soft systems thinking” (Checkland P and Winter M, 2003). Following this inquiry and taking into account the soft traits of VE highlighted in the theoretical framework of this report, a survey was conducted among experienced VE study leaders in order to reveal the connection between and potential contribution of VE to the management of complex decision making processes, like those commonly faced by public works organizations.

Several Value Engineers with vast experience in the conduction of Value studies for projects pertaining to public works organizations have been contacted in countries like USA, England, Canada. These countries have long been making use of this methodology and therefore their experience constitutes a benchmark for organizations like the Dutch Ministry of Transportation. Similarly, local (Dutch) Value Engineers were also included in the surveyed sample in order to reflect any possible local particularities in the execution and outcomes of Value studies.

5.2.1. Sample

The survey questionnaire was initially distributed among various attendees to the 51st SAVE International Annual Conference held in Portland, USA between the 6th and 9th of June 2011. In addition, several questionnaires were also sent via email to contacts of the author of this report, whose expertise on VE is well acknowledged by either the international or local VE community.

Respondents were selected according to their VE qualifications and their experience in the conduction of VE studies for the construction industry in both the private and public sectors. The sample population includes Value Engineers from USA, England and Canada and the majority is in one way or another connected to public works organizations.

Thus, the survey covers experts from organizations like:

- US Departments of Transportation – e.g. California (Caltrans) and Virginia (VDOT)
- The UK Highways Agency
- The American Association of State Highway and Transportation Officials (AASHTO) through its VE Technical Committee
- Rijkswaterstaat
- ProRail, and renowned consultants like,
- Arcadis, and
- Value Management Strategies, Inc.

Even though the amount of responses obtained were ultimately fewer than expected thus affecting the statistical significance of the survey, supplemented with the personal interviews with VE experts, it may still be considered indicative of plausible utility of VE in Public Management.

5.2.2. Questionnaire

The questionnaire is designed to retrieve qualitative data from respondents and its objective is to appraise the potential relationship between the Learning Paradigm or Soft Systems Thinking traits of VE and some of the aspects addressed in Process Management. A sample filled in questionnaire of the original survey can be found in Appendix C.

In essence, respondents were required to agree or disagree with four assertions implying the "soft" traits of VE contribute to the effective management of decision-making processes in public networks. Furthermore, they were asked to indicate any other particular aspect of VE which could defend the hypothesis that the learning paradigm of this methodology is rooted in the ideas of soft systems thinking.

Case Summaries

	VE provides openness to a process	VE stimulates the protection of core values	VE feeds the speed of a process	VE improves the substance of a process
(missing) 1	.	.	.	.
1	Agree	Disagree	Disagree	Strongly agree
(missing) 3	.	.	.	.
(missing) 4	.	.	.	.
2	Strongly agree	Strongly agree	Strongly agree	Agree
3	Strongly agree	Strongly agree	Strongly agree	Strongly agree
4	Agree	Neutral	Agree	Strongly agree
5	Strongly agree	Agree	Strongly agree	Strongly agree
6	Strongly agree	Agree	Agree	Agree
7	Strongly agree	Neutral	Agree	Agree
(missing) 11	.	.	.	.
8	Strongly agree	Strongly agree	Agree	Agree
9	Strongly agree	Strongly agree	Strongly agree	Strongly agree
(missing) 14	.	.	.	.
(missing) 15	.	.	.	.
10	Strongly agree	Strongly agree	.	.
(missing) 17	.	.	.	.
(missing) 18	.	.	.	.
(missing) 19	.	.	.	.
11	Agree	Strongly agree	Neutral	Strongly agree
Total N	11	11	10	10

Table 4: VE experts' responses on VE vs Process Management

5.2.3. Survey processing and results

Questionnaires were retrieved by email and data were recorded and sorted using statistical software PASW Statistics 18.0. The four variables included in the survey – i.e. Openness, Core Values, Speed and Substance – are evaluated through the corresponding assertions, that is:

- VE provides openness to a process,
- VE stimulates the protection of core values,
- VE feeds the speed of a process, and
- VE improves the substance of a process.

These variables were measured in an ordinal scale. For that reason, respondents were required to fill in "1" in case they "Strongly disagree" with the particular assertion, "2" if they "Disagree", "3" in case they neither agree nor disagree with the assertion, and "4" or "5" if they agreed or strongly agreed with the statement.

Table 4 presents the responses obtained from the surveyed VE experts and Table 5 summarizes the processing of the retrieved data.

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
VE provides openness to a process	11	55.0%	9	45.0%	20	100.0%
VE stimulates the protection of core values	11	55.0%	9	45.0%	20	100.0%
VE feeds the speed of a process	10	50.0%	10	50.0%	20	100.0%
VE improves the substance of a process	10	50.0%	10	50.0%	20	100.0%

Table 5: Survey's case processing summary

Since all questionnaires were not returned completely filled in, it was decided to analyze only the cases whose data were complete and to exclude those cases where data were missing. Table 5 summarizes this exclusion process, which will have to be taken into consideration when analyzing the statistics describing the data obtained from this survey. Even though the amount of responses obtained were ultimately fewer than expected thus affecting the statistical significance of the survey, supplemented with the personal interviews with VE experts, it may still be considered indicative of plausible utility of VE in Public Management.

presents the frequencies and percentages that describe the responses obtained from the surveyed VE experts. It reveals that two out of the four aspects of process management addressed in this survey received negative reactions. The assertions implying that the Soft Systems Thinking facet of VE stimulates the Protection of Core Values and feeds the Speed of a Process both received at least one Neutral and one Disagreeing reaction. It is important to stress these negative reactions, since they come from Value Engineers who are promoting the inclusion of this methodology in the construction industry and are keen on using it for their consulting services in construction projects.

Frequency Table

VE provides openness to a process

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	3	15.0	27.3	27.3
	Strongly agree	8	40.0	72.7	100.0
	Total	11	55.0	100.0	
Missing	System	9	45.0		
Total		20	100.0		

VE stimulates the protection of core values

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	5.0	9.1	9.1
	Neutral	2	10.0	18.2	27.3
	Agree	2	10.0	18.2	45.5
	Strongly agree	6	30.0	54.5	100.0
	Total	11	55.0	100.0	
Missing	System	9	45.0		
Total		20	100.0		

VE feeds the speed of a process

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	5.0	10.0	10.0
	Neutral	1	5.0	10.0	20.0
	Agree	4	20.0	40.0	60.0
	Strongly agree	4	20.0	40.0	100.0
	Total	10	50.0	100.0	
Missing	System	10	50.0		
Total		20	100.0		

VE improves the substance of a process

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	4	20.0	40.0	40.0
	Strongly agree	6	30.0	60.0	100.0
	Total	10	50.0	100.0	
Missing	System	10	50.0		
Total		20	100.0		

Table 6: Survey's frequency table

Considering the composition of this survey's sample – professionals with high VE certifications, who have been using this methodology for a relatively long time and have led various VE studies in construction projects –, it was decided to assess the responses by grouping them into two ranges. Table 7 presents this division. Responses were assembled either in a totally supporting group or in a doubtful/contradictory group. Thus, this table presents the proportion of responses falling under the “Agree” – “Strongly agree” range and those falling under the “Strongly disagree” – “Neutral” range.

Notice that assertions 1 and 4 – *VE provides openness to a process* and *VE improves the substance of a process* – were totally supported by the sample of Value Engineers; whereas assertions 2 and 3 – *VE stimulates the protection of core values* and *VE feeds the speed of a process* – generated doubt or contradiction among them. Almost 30% of respondents do not consider the use of VE a vehicle to protecting parties’ core values, while 20% do not consider it being an accelerator to the management of a process.

Respondent 1, for example, asserts that “Quite often VE means we have to do rework to apply the ideas generated, this might save money but doesn’t speed the process. This is a symptom of bad timing and the contractual position we are in regarding target cost and the contractor wishing to keep VE ideas in his back pocket until the construction phase”. This argument stresses on the importance of a proper timing of VE studies and endorses the theory presented in chapter 3.3.2 and particularly in Figure 10.

	VE provides openness to a process	VE stimulates the protection of core values	VE feeds the speed of a process	VE improves the substance of a process
Grand Total Mean	5	4	4	5
> 3	100.0%	72.7%	80.0%	100.0%
In 1 to 3	.0%	27.3%	20.0%	.0%

Table 7: Summary analysis survey’s responses

According to Respondent 11, “Some think VE slows down design and/or production of a product, however overall resulting VE ideas often accelerate overall completion of the construction of project or manufacturing of product. As for speed of actual VE process – yes a consist, condensed focus workshop with detailed agenda to hour help foster best results in short period.” The first part of this reaction acknowledges the presence of some sense of deceleration, among individuals in the construction industry, when VE is introduced in the management of a process. The second part, proposes the use of compressed VE workshops to counterbalance such perception, which is a trend identified in the case of the UK’s Highways Agency in the benchmark study presented in chapter 4.

Respondent 7 argues “The results are what the VE process is looking for”. This is opposite to the definition presented above on the protection of core values for the sake of a good process. On the same note, Respondent 1 considers “The opposite at the moment due to budget reductions, suppliers are looking to reduce scope and change functionality, of course Clients challenge this. Suppliers are focused on the final result i.e. funding, and sometimes see the process as generating income rather than saving time and money." This may be a result of the fragmentation in the chain supply of the construction industry, where not all parties may take advantage of the optimization generated by VE.

Additional revelations that surface in Table 7 relate to the potential contribution of VE's *soft* traits to the Openness and Substance of decision making processes. Unlike the previous two assertions, these obtained total support from the surveyed Value Engineers. Respondent 5, for example, claims "All three items of openness can be provided within the VE-process, this depends strongly on the goal with which VE is applied. One of the pillars of a good VE-study is having the right team which represents all relevant parties, some parties can be brought in only for the evaluation-phase, others bring the most benefit worth involvement in the entire study. The 6 or 8 step job-plan is very transparent."

Similarly, Respondent 6 argues "VE allows all project owners, designers, and stakeholders an open forum to discuss and brainstorm ways to work together for the common good while accomplishing individual interests. The VE process is well documented and extremely transparent to all parties involved. This allows individual stakeholders present their needs and desires while maintaining a group evaluation of the best direction for the project to progress without weighting a single set of demands above the overall good of the project outcome."

It is possible to identify here some of the effects linked to the *soft* traits of VE, just like it was highlighted in chapter 3.2.2. Aspects like collaboration, team building, common goals and transparency capture the essence of the respondents' recognition to this methodology.

On the other hand, when referring to the Substance of a process, respondents identified several benefits that may be drawn from VE. For instance, Respondent 9 concluded that VE improves the substance of a process since "A properly performed VE Study, again – assuming that it considers elements other than cost (i.e., performance, time and risk) greatly contributes to a rational and logical approach that is anchored to the basic functions of the project. It requires opposing or dissenting views to be articulated within this framework and provides full consideration to them."

Likewise, Respondent 6 asserts the following: "Several tools within the VE tool box can and should be used to evaluate recommendation in non-monetary ways, such as "performance measures." This tool allows VE teams and project owners additional information to form implementation decisions on ground other than money. Sometimes spending more money to increase performance is a smarter choice rather than accepting nonsensical recommendations based solely on dollars and cents. The VE process, when done correctly, has the ability to drive decision makers to the best overall functional solutions for the project, not just the "slash and burn" adage that has been so common associated with the profession by outsiders."

Furthermore, he claims "VE has an uncanny ability to discover the "unknown" within a project. It always amazes me that within a few hours of a VE study, someone can come up with a seemingly obvious observation about the project that has gone unnoticed by the owners and design team for months or years. I think this has to do with methodology dictating that everyone take a step back and look at the overall big picture and asking the questions “why are we doing this?” or “why are we doing it in this way?”. Engineering design is a somewhat arbitrary field where there are many different ways to achieve the same goals. A lot of times a few simple assumptions early in the project can lead down an undesirable path. When VE can challenge and overturn those basic early assumptions, the project can make major changes, and the results can be staggering.”

5.3. Summary and Conclusions

This chapter, as well the preceding chapter, seeks to validate the theoretical framework about VE presented in chapter 3. It is limited to the second part of that framework – i.e. the Learning paradigm of VE. Due to the reduced amount of available documentation related to the soft traits of VE, unlike that related to the hard traits, a different approach for this validation was undertaken. So, instead of a benchmarking to VE programs in similar public works organizations, this time the selected approach was a series of interviews and a survey directed to specific members of the VE community. They were utilized to obtain experiences, from certified Value Engineers, concerning the adequacy of VE in the domain of Soft Systems Thinking.

Since end users and the general public avail from greater influence in decision making processes concerning public infrastructure, public works organizations can no longer lead their decision making processes based on a hierarchical model but instead, they must use soft systems methodologies to deal with intricate networks of stakeholders. This phenomenon has caused process management to become an essential competency of such organizations. Therefore, the validation of VE’s soft systems thinking advantages relies here on the assumption that VE may help process managers realize better decision-making processes.

With this in mind, the traits of a good decision-making process were defined. These correspond to four main elements identified by (Bruijn, et al., 2002). Thus, this chapter evaluates the extent to which VE may contribute to the Openness, Substance, Speed and Protection of Core Values of decision-making processes. The survey and interviews revealed consistent recognition of VE’s contribution to the former two elements but a more moderate one regarding the latter two. On the one hand, VE is by definition a multidisciplinary effort and its effectiveness is directly proportional to the diversity of the VE team, especially when referring to VE studies carried out during early stages of a project life cycle. On the other hand, it enables decision makers to take well-informed decisions supported by substantive VE recommendations. VE’s attention to functionality and provision of a common understanding of the problem feed the substance of processes.

Nonetheless, the practice of VE entails a certain amount of resources. In Caltrans, for example, VE studies are usually resourced with approximately 500 hours in the project work plan. Plus, VE team members participate in a VE study at the expense of their day-to-day activities. Therefore decision to undertake a VE effort must be clearly justified for the sake of processes overall speed, even if there are noteworthy cases where VE has helped shorten their duration[24].

[24] See for instance FHWA’s Fiscal Year 2008 Value Engineering Accomplishment Report.

In conclusion, VE should not be applied to every infrastructure project. Project selection for VE studies must be done carefully, since a VE effort should be previously justified by potential value improvements. Yet, this chapter has evidenced the soft benefits of VE, which can enhance the management of decision-making processes by public works organizations, in particular when utilized during early phases of a project life cycle. Hence, this practice arises as a strategic tool for public management in complex networks environments.

6. RWS Towards a Progressive Transformation

The preceding chapters have presented the main attributes of VE, have exposed what mature VE programs look like and have identified best practices in terms of correct timing for VE studies in public works organizations. This chapter takes in those findings and attempts to disclose the best way for RWS to avail from VE's potential benefits. Before taking on this customization, it explores the singularities of the organization. Finally, it concludes by presenting one of the organization's flagship projects – the SAA project – and its breakthrough efforts towards an organic employment of VE.

RWS is the executive branch of the Dutch Ministry of Infrastructure and Environment. Founded in 1798, RWS currently counts with more than 9.000 employees and has long been in charge of the execution and maintenance works of national roads and waterways. It counts with 240 locations throughout the entire country. It is divided into 10 regional departments and 5 specialized departments, 35 districts and 3 project directorates (see Figure 20).

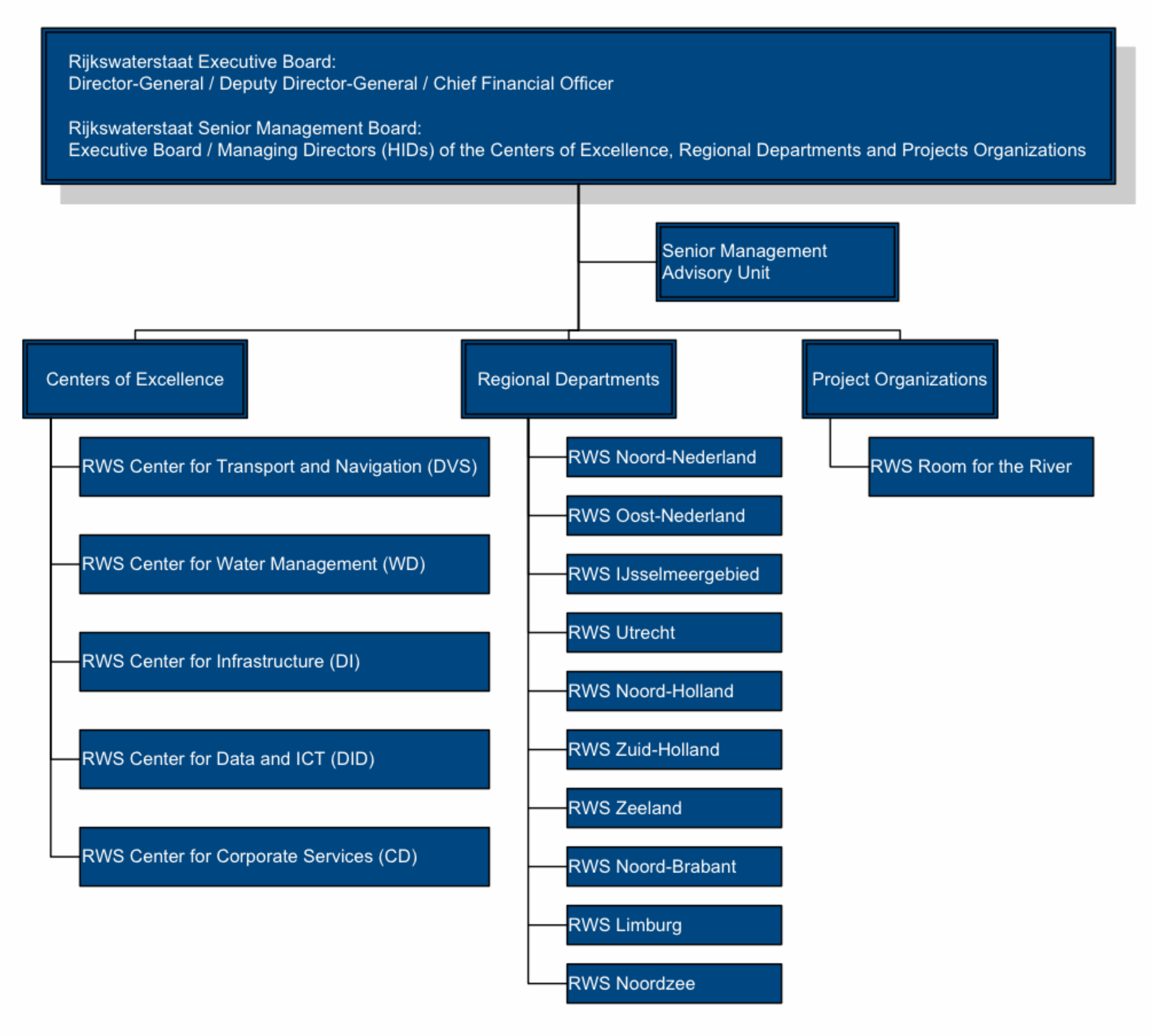


Figure 20: RWS's organizational overview

These 10 regional departments are more specifically concerned with the supervision of RWS’s annual budget of €4-5 billions. RWS’s mission is to ensure a safe and smooth flow of traffic throughout the extensive network of roads and waterways of The Netherlands, to guarantee a safe, clean and user-oriented water system of main canals, rivers and also part of the North Sea, and to protect the country of “The Low Lands” against the constant threat of floods.

The accomplishment of this mission is based on the management of three different systems. RWS manages three national infrastructure networks, namely the National Highway Network, the National Waterway Network, and the National Main Water System. Figure 21 depicts these three areas of management.

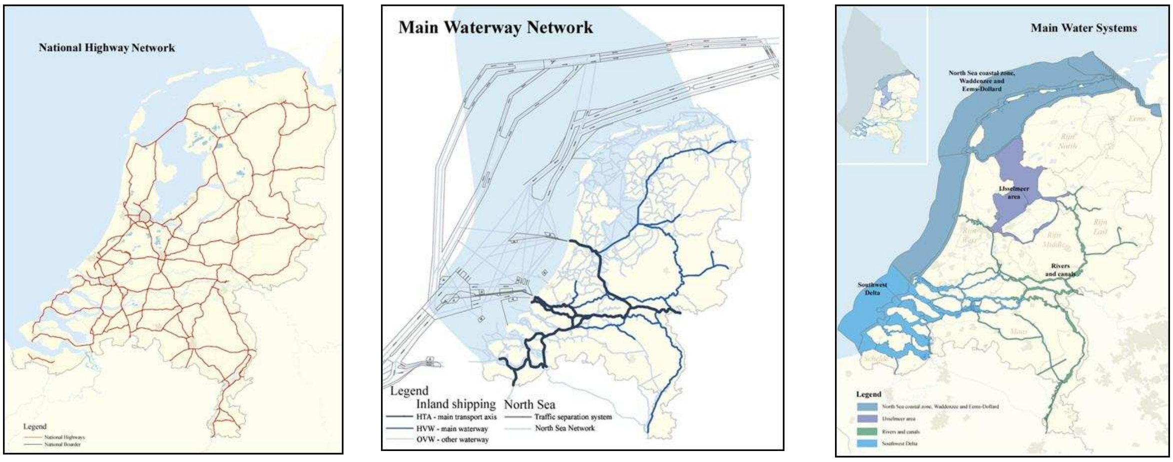


Figure 21: RWS’s areas of management

Within the National Highway Network, RWS is responsible for:

- 3.102Km of highways including traffic signaling systems,
- 1.259Km of slip roads and connecting roads,
- 25 rush-hour lanes,
- 2.533 viaducts,
- 15 tunnels,
- 715 moveable and fixed bridges and,
- 7 “ecoducts” or wildlife crossings.

Within the National Waterway Network, RWS is responsible for:

- 1.686Km of canals and rivers, of which 1.462Km represent main traffic axes,
- 6.165Km of open sea waterways,
- 83 locks and,
- 422 bridges.

In its agenda for 2015, RWS envisions itself as a leading organization of public works that is more concerned with the end users’ requirements, that attains closer collaboration with similar authorities and public bodies, that may rely more on the building and construction industry market and that may perform more efficiently than before. RWS wants to become a more compact organization without affecting its operational capacity.

6.1. RWS's institutional setup

RWS is the agency in charge of the executive branch of the Ministry of Infrastructure and Environment. It functions under the Principal-Agent model of delegation. This model has become common among all European countries during the last three decades, due to the rise of "regulatory capitalism" (Gilardi, 2008). Considering the literature on Independent Regulatory Agencies (IRAs), these are defined as government entities that frequently exercise executive, judicial and legislative power over a specifically defined area of government interest. In other words, IRAs are the fourth branch of government, operating separately from but under the oversight or review of the other three (Peters, 1988). Appendix E presents the Ministry's organization chart where the lines of authority that affect RWS may be observed.

Independence is important for agencies because they administer a range of statutes which are complex and require high degree of technical expertise that is readily acquired and maintained by them. However, it is difficult to determine the extent to which these agencies are independent. There are different extents to which IRAs are formally independent from elected politicians. Not surprisingly, RWS's independence from the Ministry is difficult to appraise.

RWS's relationship with the Ministry is contract-based. However they handle two different types of contracts: 1) Maintenance and 2) New Infrastructure[25]. In Maintenance projects, RWS could be labeled an IRA. It enjoys relatively high independence from the Ministry who, in this case, limits its requirements to service levels in the corresponding infrastructure networks and reimburses the agency based on an annually agreed fee. Conversely, in the case of new infrastructure projects, RWS behaves more like a governmental body under the Ministry's control. Here, contracts between the two are assigned per project and contain more detailed requirements, like budget and milestones.

Referring again to Appendix E, RWS's institutional setup reveals the following relationships:

- The Secretary-General may be seen as the *owner* who decides about the mission, vision, core businesses and tariffs of RWS and is responsible for the quality and continuity of the organization. He assigns and discharges the agency's top management and steers it to comply with government-wide policies.

- The different Directorate-Generals may be seen as principals in this delegation model. They strive to make agreements with RWS about new infrastructure projects and lay them down in the multiyear infrastructure, spatial planning and transport program (MIRT), which requires in turn Parliament's consent.

- The Secretary-General acts also as principal when it comes to maintenance works and traffic management.

In conclusion, RWS's independence as an agency is limited. The delegation model it belongs to exhibits several traits of conservative governmental regulation. Therefore,

[25] Aanlegprojecten in Dutch. This type of contract includes also maintenance projects with a budget over €35 million.

RWS's mission must adhere to the Ministry's policies. Actually, one such policy implies RWS must evolve into an agency that can deliver new motorway projects faster while reducing its personnel. In other words, higher performance with reduced resources. For that matter a new strategy has been envisioned.

6.2. Strategic aims of the organization

RWS's major infrastructure projects have usually an average duration of 14 years. This has affected its reputation among end users and taxpayers, who are constantly demanding for higher value in public projects. In consequence, the actual situation has also become politically unacceptable, to the extent where the higher level government has demanded RWS to accelerate the delivery of their projects.

This has spawned the design of a new program that seeks to reduce the average duration of projects by half. Tenets of Systems Engineering are being used to optimize the delivery of projects in RWS by enabling a more efficient inter institutional collaboration and synchronism – e.g. between the RWS and the Inspectorate for Housing, Spatial Planning and the Environment – and by allowing people to contribute ideas in advance instead of consulting with them in retrospect.

The new project management framework is entitled Sneller & Beter (Faster & Better) and its main objective is to be able to "cut the tape" within two terms of office. It draws upon four aspects required for a new way of conceiving and delivering projects, namely, Acceleration, Debate, Public Involvement and Collaboration. A systems overview of this new project management framework can be seen in Figure 22. It is an overview of the products generated during different stages of the project lifecycle.

The framework presents 14 reference points along the average project life cycle (BO MIRT 1 through 14) that split it up into 13 stages. Each stage is expected to last on average 6 months, so that projects may be developed, from concept to delivery, in approximately 7 years. Similarly, 5 gates (MIRT 1 through 5) control the project delivery process. These gates are instances where project maturity is appraised and coincide with major decision points. They determine whether a project stands in its concept, planning, or building stage and are used to assessing whether the project may or may not proceed from one phase to the next.

6.2.1. Acceleration

Sneller & Beter entails "a structural improvement of legislation, public participation, and official and administrative procedures". For instance local and regional authorities shall be involved in plans concerning new infrastructure as co-initiators. They will be fully included in the decision-making process. Moreover, before any further steps are taken, there should be clarity on the available budget, the planning and the organization. All of these aspects will be laid down in an initial decision statement. In addition, all parties that may possibly be concerned with the particular project shall be involved in the planning process. Finally, transparency emerges as an essential requirement to guaranteeing acceleration: making sure to include as many as possible of the parties concerned around the negotiation table, for the sake of clarity on the problem to be solved, the stakeholders expected to generate a solution and the selected approach towards the project.

6.2.2. Debate

In the initial phase, stakeholders should be allowed to conduct a constructive debate where mutual choices can be made at an abstract level. All should have a chance to participate and contribute ideas, so that eventually a robust decision can be reached. Instead of early exhaustive research into various options and their corresponding financial implications, Sneller & Beter is meant to studying various alternatives only in broad outlines – e.g. impacts on air quality, noise levels, ecological and landscape impacts. Only the three alternatives that pass this first phase filter are assessed in greater depth. In consequence, Sneller & Beter only allows for a maximum of two years for the exploratory phase. During this phase, a number of solutions should be scrutinized. The following step is to take a preferred alternative decision. This period of two years is indicative of the urgency addressed by the new framework and thus the exploratory phase is given formal status.

6.2.3. Public Involvement

Following the preferred alternative decision, which defines the projected route, the next eighteen months are to be spent drawing up a detailed list of all the possible consequences of the selected option. Public participation should be fostered during this appraisal, which shall focus on how the plans will blend in with the landscape and the environment. Construction contractors need to be involved during this phase and following this eighteen months' period, the official decision on the projected route shall be taken.

Shortly after the resolution on the projected route is adopted, the construction phase, which will take up to three years on average, may commence. The early inclusion of contractors in this new project management framework will facilitate the rapid issuing of the required permits, if necessary under government coordination.

Sneller & Beter, with its regard for public participation, is expected to significantly reduce the number of appeal proceedings, which are currently a major cause of delay in public infrastructure projects. The room offered for comprehensive feedback right from the start of the process will avoid litigations and, in such situations, will make the procedures be reviewed in a more diligent manner by the controlling entities.

6.2.4. Collaboration

An increasing dependency on local and regional authorities is driving the government towards more collaborative ways of undertaking public projects. Sneller & Beter will include a participation code to help provinces, municipalities and regional authorities implement the new project delivery method. As co-initiators of projects, regional authorities will behave more cooperatively than when all decisions are dictated by higher government authorities.

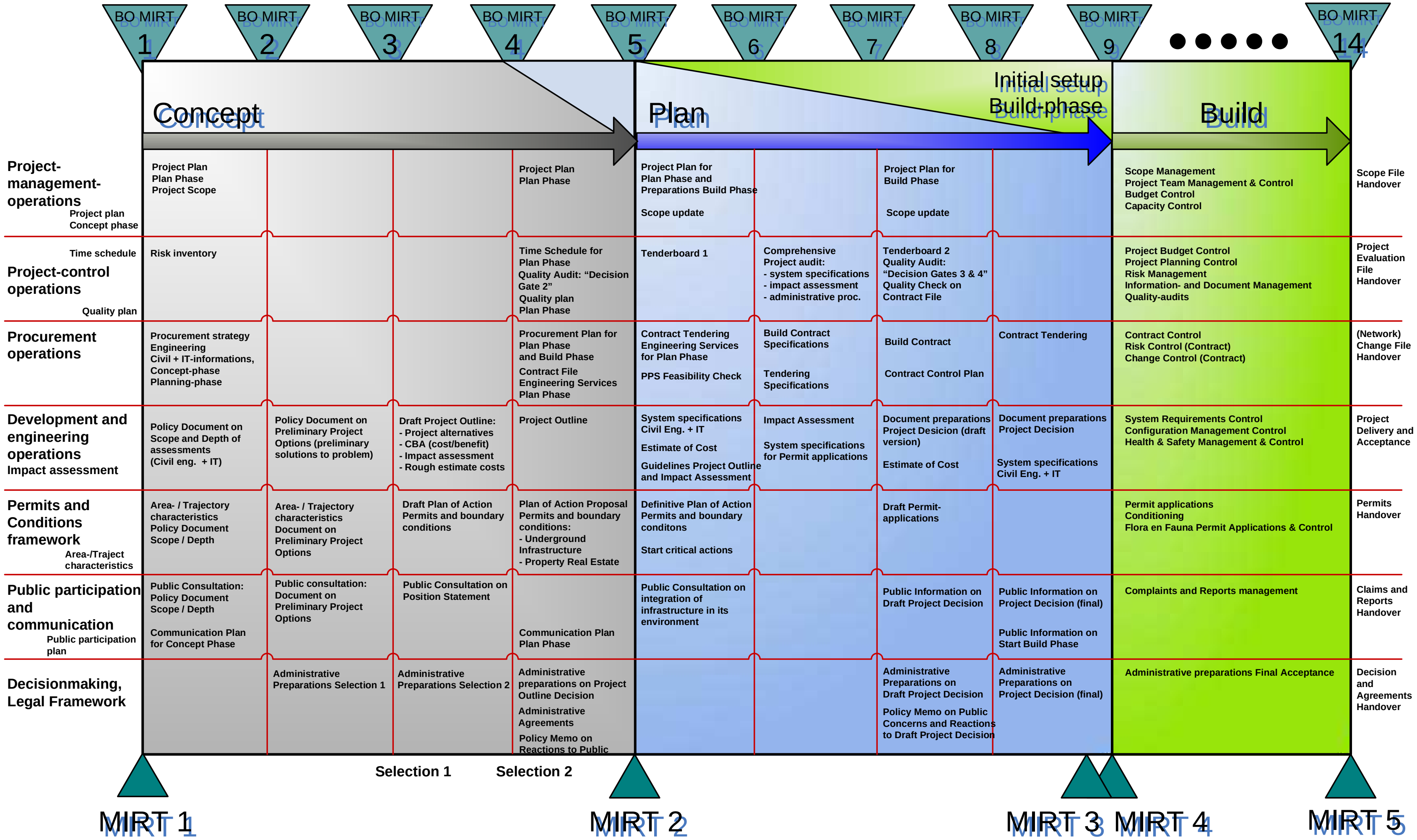


Figure 22: Sneller & Beter Products

Additionally, the possibilities of appeal for local and regional authorities have been removed from the law, and thanks to the new project management framework, these possibilities of appeal will no longer be necessary. Yet another aspect that may be inspiring for members of the Provincial Executive and aldermen is the fact that Sneller & Beter will ensure that the time lapse between the initiative to build a new road and the actual start of construction be reduced to just three and a half years. This shall minimize the risk they usually have when changes in administrative views take place.

6.3. Sneller & Beter

As previously mentioned, RWS's actual vision includes the implementation of a faster and better system for the delivery of major infrastructure projects. A schematic representation of the new Sneller & Beter project delivery process to be adopted by RWS, is shown in Figure 23, while the original version is included in Appendix F.

Note that projects are handed over to RWS, by the other Directorate-Generals, only after Gate 2 – i.e. once a preference decision has been made. Before this gate, the project's scope must have already been defined and even a budget with an accuracy of ±25% has already been elaborated. Gates 3 and 4 coincide with the OTB and TB[26], respectively. Only with a TB agreement would the project be committed to construction. The Sneller & Beter process is very similar to the HA's Standard Project Lifecycle (see Figure 18) and its three stages – Concept, Plan and Build – are comparable to those utilized in the UK's HA – Options, Development and Construction.

Finally, this figure shows as well the possible moments when private contractors may be involved in Sneller & Beter. Three different instances can be identified. All of them conform to RWS's aim to becoming a more market-oriented organization. Unlike Design-Bid-Construct procurement methods, they entail using D&C methods that encourage closer collaboration between public and private parties and foster innovation in the construction industry. Even though instance 1 has not yet been used, it remains a current aim for RWS to deploy in future projects.

6.4. SAA project

The SAA is currently one of RWS's flagship projects under development. It concerns the expansion of Holland's strategic corridor connecting Schiphol, Amsterdam and Almere. Its scope includes:

- Broadening and partial laying of around 63 Km of motorway,
- Construction of 3 tunnels, 1 aqueduct and 2 large bridges,
- Alteration/modernization of around 100 civil structures,
- Large-scale reconstruction of six junctions and,
- Integration measures such as sound barriers, expansion of wet areas, and reduction of environmental impacts.

[26] OTB stands for Dutch Ontwerp-tracébesluit and TB, for Tracébesluit. The former is equal to the Draft Route Decision and the latter, to the Final Route Decision. They both define the general alignment for the new motorway project.

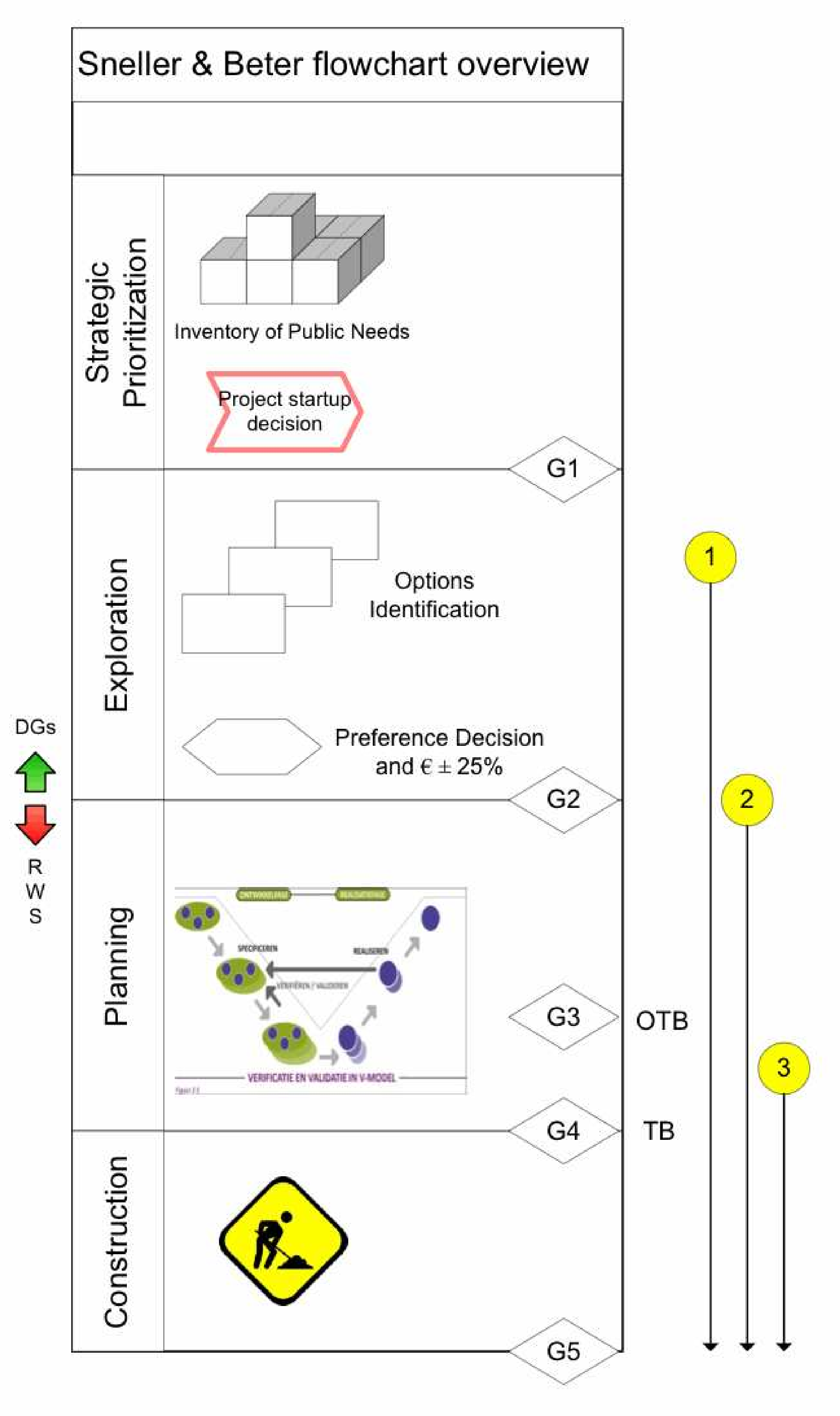


Figure 23: RWS's forthcoming project delivery framework

The project is divided into five geographically based subprojects, and these are:

1. A10-East and A1 Diemen junction up to and including Watergraafsmeer junction.
2. A1 Muiderberg junction – Diemen junction (including renovation of Diemen junction and the new bypass from the South-East to the A9).
3. A9 Gaasperdammerweg, from Diemen junction up to and including Holendrecht-North junction, and A2 Holendrecht junction to Amstel junction.
4. A9 Holendrecht-South junction up to but excluding Badhoevedorp junction.
5. A6 Almere Buiten-East connection up to and including Muiderberg junction.

Appendix G presents an overview plan of the SAA project.

The minister signed off the SAA's TB on March the 21st 2011. An overview of the actual status of this project is included in Appendix H. It is possible to observe here that only subproject 1 has been awarded and its realization stage has begun on June the 15th 2011. The rest of subprojects have not yet been awarded nor have their realization stages begun either.

6.4.1. Value Engineering in the SAA project

In an attempt to discover more efficient methods for delivering infrastructure projects and thus comply with ministerial policies, RWS has already undertaken several VE studies. With the consent of SAA's project manager director, Jan Slager, who is fond of this methodology, three VE studies have been perfomed to seek better value on three critical sectors of this project: 1) Junction Diemen, 2) Junction Muiderberg and 3) Gaasperdammerweg. The first two will be briefly presented next.

The VE study on junction Diemen was performed on October 2010, when the project was standing at approximately 50% of its planning stage. This new junction is meant to widen the A1-A9 bypass in order to increase the road capacity. Some of the challenges encountered in this case relate to the crossing over the railway that connects Weesp with Amsterdam and the need to change the location of some rail track shifters while keeping hindrance to the rail traffic at the lowest possible. This brought to the design table a critical actor – ProRail – whose collaborative involvement with RWS was key for the success of this design challenge. Additional constraints arose when considering the bypass need to cross major high-voltage cables and gas pipes, plus a bridge to cross the Amsterdam-Rijnkanaal. This VE study generate 10 VE alternatives and the value analysis concluded the baseline design was the alternative which improved most the value of this sector according to time, cost and performance criteria. Here, the learning paradigm of VE was reckoned by most stakeholders after having explicitly shown the added value of the baseline alternative. Allegedly, this created greater consensus and by-in of stakeholders and decision makers who needed to choose the best alternative to cope with this particular challenge.

On the other hand, the VE study on junction Muiderberg was performed on November 2010 during a similar moment of the planning stage. A main objective of the original design was to increase road capacity by widening highway A1. This highway crosses beneath a viaduct of the railway that connects Almere to Amsterdam. The fixed abutments of the viaduct presented a serious challenge for widening A1. Previous considerations included the construction of temporary railtracks to enable expansion works in A1, which would cause large budget overruns. In fact, ProRail, who had not been involved from the early design, estimated the viaduct would cost 15% more than the original budget. A VE study was called upon to tackle this budget problem, and thus ProRail initiated it in a joint effort with RWS. Innovative proposals were brainstormed and developed in this VE study and ultimately 9 VE alternatives came out of it. One high value alternative, which had not been considered before the VE study, included changes in the design of lane widths to enable expansion of the A1 without disrupting rail traffic by making use of space devoted for existing abutments. The alternatives were presented to decision makers whose selection is conditioned by safety concepts from RWS DVS (Center for Transport and Navigation).

These two cases demonstrate RWS's interest on VE. Even though it has been used merely in a conjectural manner as a problem solving technique, it has yielded important results. However, a more structured implementation of a VE program would certainly achieve higher value in RWS's projects and would help it steer the organization in line with governmental policies on public works.

7. Conclusions and Recommendations

VE's intrinsic attributes were presented in this document and its potential benefits were validated by a benchmark study exposed in chapter 4 and experts' survey and interviews exhibited in chapter 5. The literature review presented in chapter 3 revealed two distinctive aspects of VE. One refers to the Optimizing paradigm, based on Hard Systems Thinking principles (HST), whereas the other is based on Soft Systems Thinking (SST) and was labeled the Learning paradigm of VE.

It was found that these aspects of VE become more relevant depending on the timing of the VE studies relative to the lifecycle of the project that is being value engineered. The Learning paradigm surfaces during the early stages, while the Optimizing paradigm surfaces when the project is more "mature". Additionally, the potential value improvements and the cost of implementing VE proposals were found to vary inversely alongside the project lifecycle. Early VE studies enjoy higher implementation rates, higher returns on investment and broader possibilities to improving the value of a project. Later VE studies may even hinder the streamline development of a project and require more effort for the implementation of their proposed alternatives. These VE characteristics are clearly summarized by the lever of value in the next figure.

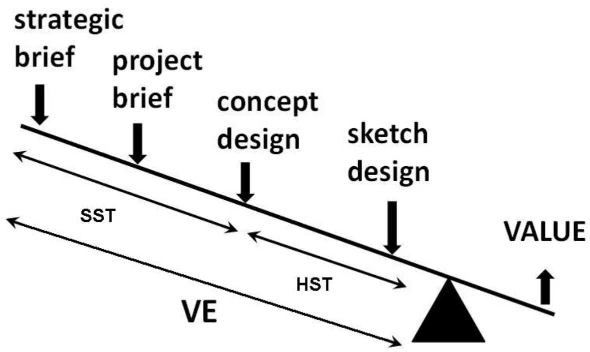


Figure 24: Lever of value and the two paradigms of VE

On the one hand, VE's Learning paradigm is allegedly an effective vehicle to improving the value of projects especially when these are conceived to solve ill-structured problems or fuzzy situations. In fact, it was shown that in these particular cases, VE offers a clear and common language for stakeholders to understand and justify the rationale behind the project by focusing on functionalities. Thus, it fosters team building among parties, improves commitment to decision-making processes and increases stakeholders' buy-in to the project. Deprived from these aspects, even technically efficient projects may ultimately lack from success. Such elements are often essential in public management, so it may be concluded that VE is especially beneficial for public works organizations, like RWS. In this particular moment when RWS is seeking to become a more end-user oriented agency and come closer to collaboration with the construction industry's private sector, VE may provide it with the right tools for realizing its vision.

On the other hand, VE's Optimizing paradigm has proven to enhance the balance between functionality and resources. Totally integrated VE programs, like the one in place in the Highways Agency's project development framework, have succeeded at making use of innovation in the construction industry and hence finding new alternatives to deliver the same functionality at lower life cycle costs, without affecting the quality of the final product. Public works organizations like Caltrans have thus managed to engage more projects with a constraint budget. Hence more public needs can be addressed with the same amount of resources. Besides, not only have they experienced the optimizing benefits of VE in the enhanced value of their projects, but they have also experienced increased organizational productivity after using this methodology upon their internal processes. Again, VE appears appropriate for RWS to integrate it in its currently changing project delivery framework – Sneller & Beter – and to utilize in the quest to its current vision.

RWS's Sneller & Beter is comparable to HA's and Caltrans' standard project delivery frameworks. Its *Exploration* phase is similar to HA's *Options* phase and its *Planning* phase relates closely to HA's *Development* phase and Caltrans' *Approval* phase. It has been previously shown how VE facilitates the creation of a value system against which robust selection between competing alternatives may be drawn. VE makes more explicit such selection processes and a wisely selected VE team may guarantee the commitment of key stakeholders to the selected alternative. Two important selection points are part of the Sneller & Beter's *Exploration* phase. These could certainly avail from VE. Therefore, 2 VE studies – VE1 and VE2 – are recommended to be integrated in this phase. In this case, VE's benefits could be drawn predominantly from its Learning paradigm.

According to Caltrans' statistical records on VE's performance for its public infrastructure projects, VE studies carried out in their *Approval* phase normally yield the best returns on investment and the largest savings. For that reason, and considering that approvals of the OTB and TB are sought in Sneller & Beter's *Planning* phase, one VE study – VE3 – is recommended to be integrated in this phase. Here, VE's benefits could be drawn predominantly from its Optimizing paradigm.

One final instance for the integration of VE in RWS's new project delivery framework concerns the use of VECPs during the *Construction* phase. Even if the TB is signed off by this moment, and only minor changes would be allowed in the overall alignment of the planned highway, contractors should be encourage to use VECP – as it is done in the FHWA – to optimize constructability and staging of projects and/or to innovate in building processes and technologies.

The previous recommendations are illustrated in Figure 25.

Finally, it may be concluded that, presently, recommendations for using VE in the SAA project are limited. As it may be noted in Appendix H, the final route decision (TB) for this project has already been signed off by the minister. Therefore, implementing VE proposals at this stage of the project may be costly at the expense of potential value improvements. It is even possible for VE proposals to hinder the actual advancement of the project and to cause rejection from the project development team. Nonetheless, the positive results obtained from the VE study performed over Gaasperdammerweg after the signature of the TB discredit the affirmations above. This implies that the size, complexity and impacts of the SAA are so significant, they make it a project prone to taking great advantage from the use of VE studies.

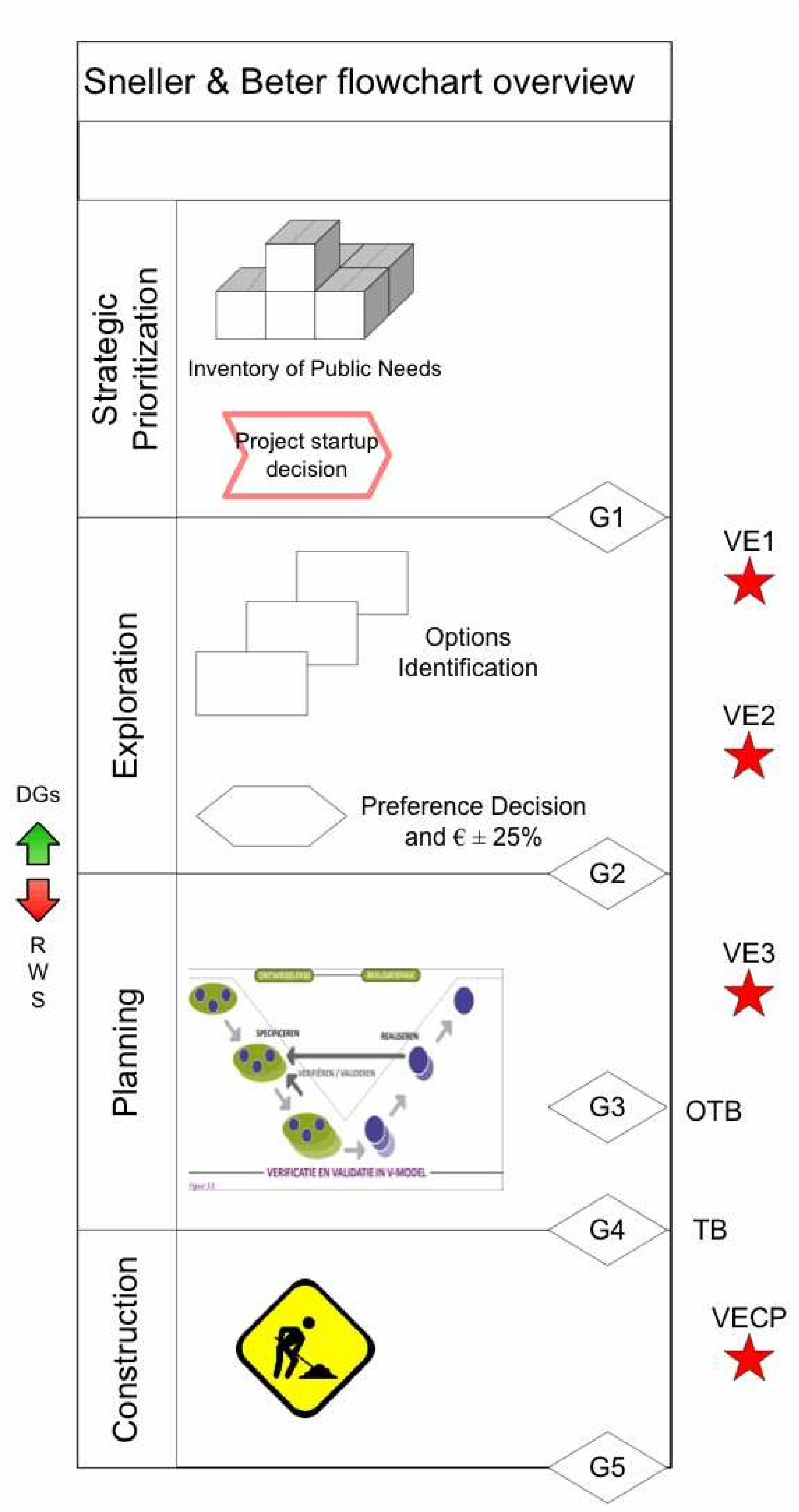


Figure 25: VE in Sneller & Beter

Since one of SAA's subprojects has already been procured and the rest will be soon also awarded or initiate their contractual process, VECP can be recommended at this moment. Subprojects which have not yet begun their contractual processes are encouraged to include VECP clauses in their requests for proposals. This will eventually allow them to profit most from specialized private contractors' ingenuity.

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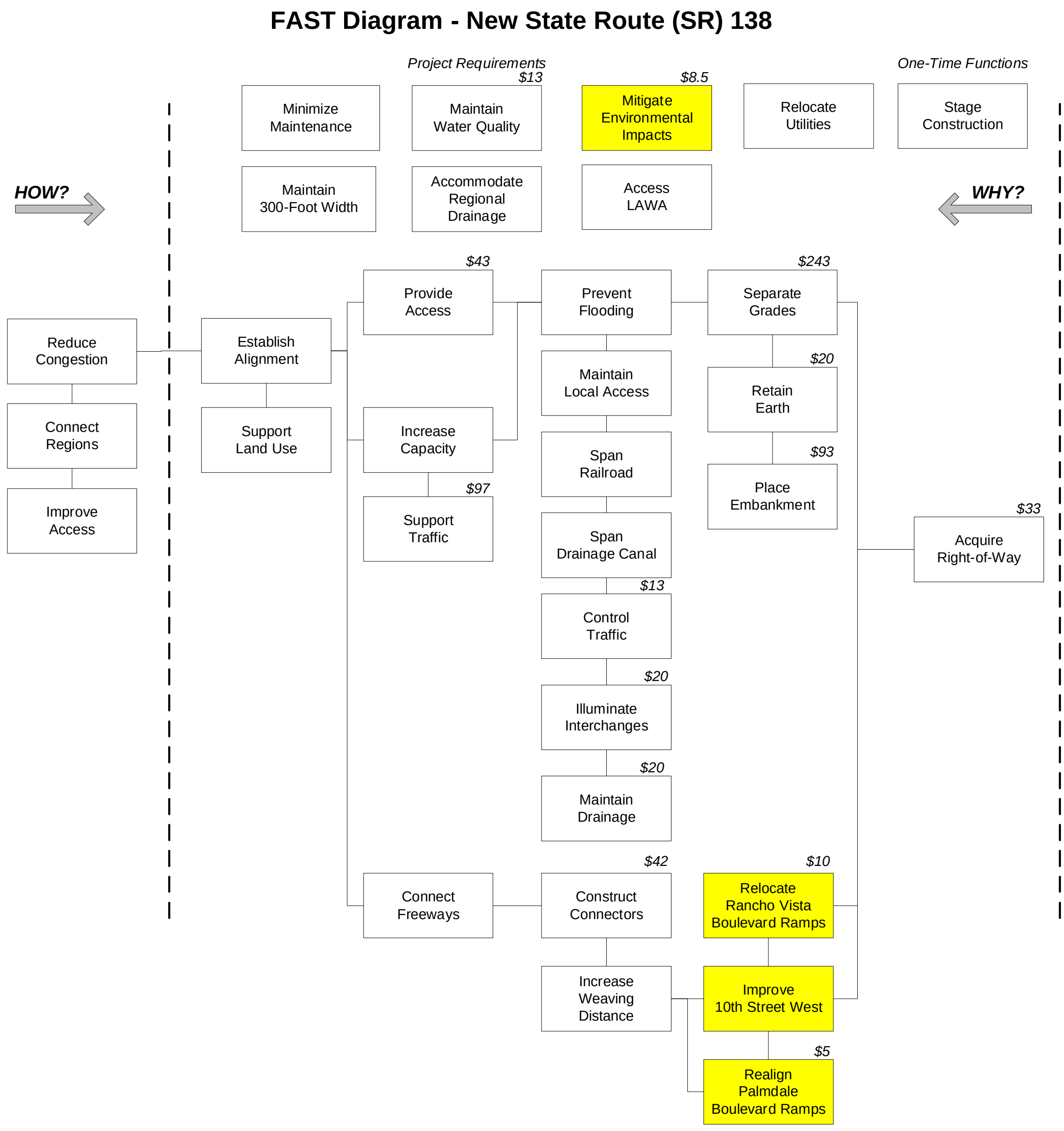
Appendix A – VE Study Results on Caltrans's New State Route (SR) 138

A1 – FAST Diagram



A2 – Value Engineering Alternative: Accepted Recommendation

VALUE ANALYSIS ALTERNATIVE *New State Route (SR) 138*		Caltrans	
FUNCTION:	Prevent Flooding	**IDEA NO.** PF-1	**NUMBER** 6.0
TITLE:	Coordinate with City's Drainage Master Plan to Reduce Roadway Embankment Height		**PAGE NO.** 1 of 5

ORIGINAL CONCEPT:

The original concept assumes that most of SR 138 (i.e., east of 10th Street) will be placed on embankment to elevate the roadway out of the floodplain. It is assumed that this embankment will be at a minimum eight feet above grade. It is also assumed that roadway drainage will be sheet flow and that there is no provision for regional drainage and integration with the City's Drainage Master Plan (DMP).

ALTERNATIVE CONCEPT:

The alternative concept would better integrate the roadway design with the DMP by installing interceptors and cross culverts under SR 138. Under this concept, the embankment can be lowered to about four feet above the original ground.

ADVANTAGES:

- Reduces number of culverts from 20 to 7
- Reduces fill materials from 1.75 million cy to 0.81 million cy
- Reduces roadway right-of-way take
- Reduces environmental mitigation needs
- Reduces flow impacts to downstream areas

DISADVANTAGES:

- Need City approval for culvert location and downstream interim channel
- Need temporary construction easements (TCE) for downstream grading for interim channel
- May need larger and longer interceptor channel south of the roadway

COST SUMMARY	Initial Cost	Present Value Subsequent Cost	Present Value Highway User Cost	Net Present Value
Original Concept	$ 93,629,000	$ 0	$ 0	$ 93,629,000
Alternative Concept	$ 46,755,000	$ 0	$ 0	$ 46,755,000
Savings	$ 46,874,000	$ 0	$ 0	$ 46,874,000

Team Member: George Hsu Elton Lee	**Discipline:** Hydraulics	**PERFORMANCE:**	+4%

VALUE ANALYSIS ALTERNATIVE *New State Route (SR) 138*		Caltrans	
TITLE:	Coordinate with City's Drainage Master Plan to Reduce Roadway Embankment Height	**NUMBER** 6.0	**PAGE NO.** 2 of 5

DISCUSSION / JUSTIFICATION:

The proposed SR 138 alignment would pass through the northern portion of Palmdale, where no drainage improvement currently exists. To avoid the roadway from uncontrolled flooding, the roadway needs to be raised to a certain height, say a minimum eight feet, from original ground elevation. This height would require a lot of fill material and large roadway footprints. The bigger footprints would increase right-of-way and result in greater environmental impacts to be mitigated. Numerous cross-culverts, which may be equally spaced, would be needed. These outlets would need the City's approval so that they will not cause flooding impacts to downstream properties.

To avoid the roadway from uncontrolled flooding, the roadway could install cross-culverts per the DMP. The latest DMP was approved in 1999, which identified several trunklines crossing the project alignment at the major streets. This alternative would coordinate with the DMP and identify the locations and sizes of culverts. The project would build the cross-culverts within the Caltrans right-of-way. A series of interceptor channels located on the south (upstream) side of the roadway would be needed, similar to the case of the original concept, to collect the runoff to the DMP trunklines. Coordination with the City would be needed to build an interim channel downstream of the crossing. The interim channel will follow DMP alignment, so the potential flow impact would be minimal and obtaining the City's approval would be easier. The interim channel could be mainly earthen and constructed as part of this project, but maintained by the City.

Under this concept, the embankment can be lowered to about four feet above the original ground.

TECHNICAL REVIEWER COMMENTS:

None noted.

PROJECT MANAGEMENT CONSIDERATIONS:

None noted.

PERFORMANCE MEASURES *New State Route (SR) 138*			Caltrans	
TITLE: Coordinate with City's Drainage Master Plan to Reduce Roadway Embankment Height			**NUMBER** 6.0	**PAGE NO.** 3 of 5
ATTRIBUTES and RATING RATIONALE for ALTERNATIVE	**Performance**	**Original**	**Alternative**	
MAINLINE OPERATIONS: No significant change.	Rating	5	5	
	Weight	25	25	
	Contribution	125	125	
LOCAL OPERATIONS: No significant change.	Rating	5	5	
	Weight	21	21	
	Contribution	105	105	
ENVIRONMENTAL IMPACTS: Reduces environmental footprint by nearly 1,000,000 square feet and reduces impacts to Joshua tree habitat by about 300,000 square feet.	Rating	5	6	
	Weight	14	14	
	Contribution	70	84	
LAND-USE COMPATIBILITY: No significant change.	Rating	5	5	
	Weight	18	18	
	Contribution	90	90	
CONSTRUCTION IMPACTS: Reduces volume of imported borrow by 1.1 million cubic yards; therefore, construction traffic is reduced.	Rating	5	6	
	Weight	4	4	
	Contribution	20	24	
MAINTAINABILITY: No significant change.	Rating	5	5	
	Weight	11	11	
	Contribution	55	55	
PROJECT SCHEDULE: No significant change.	Rating	5	5	
	Weight	7	7	
	Contribution	35	35	
	Rating			
	Weight			
	Contribution			
Total Performance:		**500**	**518**	
Net Change in Performance:			**+4%**	

ASSUMPTIONS and CALCULATIONS *New State Route (SR) 138*		**Caltrans**	
TITLE:	Coordinate with City's Drainage Master Plan to Reduce Roadway Embankment Height	**NUMBER** 6.0	**PAGE NO.** 4 of 5

Cost Estimating Assumptions

1. The 1999 City of Palmdale DMP is current.
2. The City can provide enough temporary construction easements for downstream grading for interim channels.
3. The embankment is between 15th Street and 70th Street, or 5.5 miles in length.
4. Total number of overcrossings is 7. The height at each overcrossing (length of 100 feet) cannot be changed under this alternative.
5. The culvert is 8 feet by 10 feet reinforced concrete box for all.

Number of Culverts:

Original = 20

Alternative = 7

Fill Material – SR 138 Mainline:

Original (8-foot height) = 1,664 sf x (5.5 miles x 5,280 ft) = 1.79 million cy

Alternative (4-foot height) = 768 sf x (5.5 miles x 5,280 ft) = 0.83 million cy

Fill material for interchange approaches and ramps:

<u>Original</u>

Assume 30-foot high overcrossing with 4% grades on approaches and ramps

Each approach is 42,000 cy x (7 overcrossing) x (2 approaches per overcrossing) = 588,000 cy

Each ramp is 21,000 cy x (6 interchanges) x (4 ramps per interchange) = 504,000 cy

<u>Alternative</u>

Each approach is 36,000 cy x (7 overcrossings) x (2 approaches per overcrossing) = 504,000 cy

Each ramp is 18,000 cy x (6 interchanges) x (4 ramps per interchange) = 432,000 cy

Mitigation area reduced is 32 x (2 x 5,280) = 337,920 sf / 2,500 sf = 135 Joshua trees. Assume 5:1 mitigation ratio at a cost of $1,000 per tree = $5,000 x 135 = $675,000.

INITIAL COSTS *New State Route (SR) 138*							**Caltrans**	
TITLE Coordinate with City's Drainage Master Plan to Reduce Roadway Embankment Height							**NUMBER** 6.0	**PAGE NO.** 5 of 5
CONSTRUCTION ELEMENT	**Unit**	**ORIGINAL CONCEPT**			**ALTERNATIVE CONCEPT**			
Description		**Quantity**	**Cost/Unit**	**Total**	**Quantity**	**Cost/Unit**	**Total**	
ROADWAY ITEMS								
Imported Fill (Embankment for Ramps and Approaches)	cy	1,092,000	$12	$13,104,000	936,000	$12	$11,232,000	
Imported Fill (Embankment for SR 138)	cy	1,790,000	$12	$21,480,000	830,000	$12	$9,960,000	
Drainage Culverts	ea	20	$1,200,000	$24,000,000	7	$1,200,000	$8,400,000	
Joshua Tree Mitigation	ea	135	$5,000	$675,000			$0	
ROADWAY SUBTOTAL				*$59,259,000*			*$29,592,000*	
ROADWAY MARK-UP	*58%*			*$34,370,220*			*$17,163,360*	
VA ADDED MARK-UP				*$0*			*$0*	
ROADWAY TOTAL				*$93,629,220*			*$46,755,360*	
STRUCTURE ITEMS								
STRUCTURE SUBTOTAL								
STRUCTURE MARK-UP								
VA ADDED MARK-UP								
STRUCTURE TOTAL								
RIGHT-OF-WAY ITEMS								
Right-of-Way Acquisition								
Utility Relocation								
Relocation Assistance								
Demolition								
Title and Escrow Fees								
RIGHT-OF-WAY TOTAL								
ENVIRONMENTAL MITIGATION ITEMS								
CAPITAL OUTLAY SUPPORT ITEMS								
Reengineering and Redesign								
Project Engineering								
TOTAL				$93,629,220			$46,755,360	
TOTAL (Rounded)				$93,629,000			$46,755,000	
						SAVINGS	$46,874,000	

A3 – Value Engineering Alternative: Rejected Recommendation

VALUE ANALYSIS ALTERNATIVE *New State Route (SR) 138*		Caltrans
FUNCTION: Separate Grades	**IDEA NO.** SG-2	**NUMBER** 2.0
TITLE: Depress SR 138 Between Division Street and 10th Street East		**PAGE NO.** 1 of 9

ORIGINAL CONCEPT:

The original concept places SR 138 on elevated structure from the SR 14/SR 138 connectors to 10th Street. From 10th Street East, SR 138 is placed on embankment.

ALTERNATIVE CONCEPT:

The alternative concept would bring the connectors over Technology Drive and Division Street, and then drop the profile of SR 138 in a depressed section so that it passes beneath 3rd Street, Sierra Highway, Union Pacific and Metrolink rail alignments, 8th Street, and 10th Street before coming back onto raised embankment.

ADVANTAGES:

- Reduces construction costs
- Reduces noise and visual impacts by placing SR 138 in a depressed section
- Reduces total structure by over 500,000 square feet, along with associated maintenance costs
- Provides fill for raised section of SR 138 and reduces volume of imported borrow by 1.6 million cubic yards

DISADVANTAGES:

- Requires additional on-site drainage systems
- Requires pump stations
- Maintenance costs related to pumps
- Increases potential for encountering contaminated soil
- May require fencing along top of cut to prevent coyotes from crossing the highway

COST SUMMARY	Initial Cost	Present Value Subsequent Cost	Present Value Highway User Cost	Net Present Value
Original Concept	$ 310,852,000	$ 0	$ 0	$ 310,852,000
Alternative Concept	$ 221,036,000	$ 802,000	$ 0	$ 221,838,000
Savings	$ 89,816,000	$ (802,000)	$ 0	$ 89,014,000

Team Member: Rob Stewart	**Discipline:** VA	**PERFORMANCE:** 0%

VALUE ANALYSIS ALTERNATIVE *New State Route (SR) 138*		Caltrans
TITLE: Depress SR 138 Between Division Street and 10th Street East	**NUMBER** 2.0	**PAGE NO.** 2 of 9

DISCUSSION / JUSTIFICATION:

The VA team considered placing a portion of SR 138 in a depressed section in order to reduce the costs associated with constructing an elevated structure from SR 14 to 10th Street East. The VA team assumed that the depth of this depressed section will be approximately 30 feet, which would include vertical clearance for vehicles as well as sufficient depth for the overcrossing structures. 2:1 side slopes would be constructed, and the total resulting width of the cut would be 298 feet. This provides for eight 12-foot lanes, 10-foot shoulders, and a 62-foot wide center median. This section is consistent with the baseline cross section and accommodates future widening on SR 138.

Based on a preliminary design analysis, the vertical profile should be workable to make the grade transitions work. It may be necessary to raise the profile of 3rd Street somewhat in order to make the grades work properly.

The major challenges of this concept relate primarily to drainage. There are two drainage issues that must be addressed. These include:

- Collect and convey surface drainage across SR 138. One potential strategy is to collect and detain existing surface drainage south of SR 138 and convey it over SR 138 using pipes attached to the overcrossings at 3rd Street, Sierra Highway, and 8th Street. Another potential strategy would be to collect and detain existing surface drainage south of SR 138 and convey it to the east and west ends of the depressed section. Additional hydraulic analysis will be required.
- Collect and convey surface drainage within the depressed section of SR 138. Stormwater inside the depressed section will be collected with an on-site drainage system and conveyed to two 35 cfs pump stations. These would be located at Sierra Highway and 10th Street East.

Analysis will need to be done to determine whether the 2:1 side slopes can be adequately protected against erosion with landscaping. If this is not possible, then the side slopes will need to be protected, most likely with shotcrete.

TECHNICAL REVIEWER COMMENTS:

None noted.

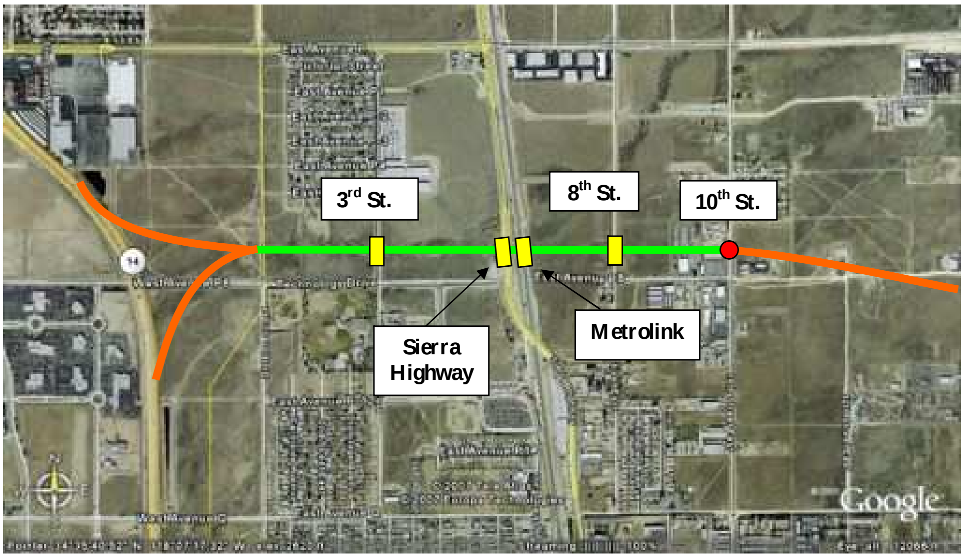
PROJECT MANAGEMENT CONSIDERATIONS:

None noted.

SKETCHES *New State Route (SR) 138*		Caltrans
TITLE: Depress SR 138 Between Division Street and 10th Street East	NUMBER 2.0	PAGE NO. 3 of 9

Alternative Concept

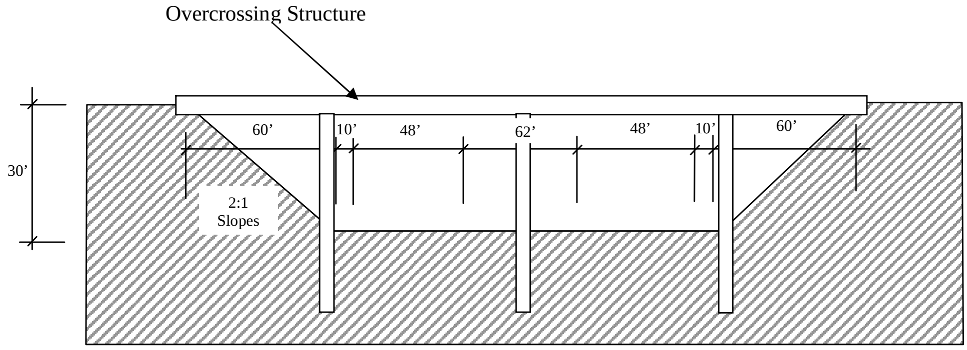
(Depressed Section in Green)



SKETCHES *New State Route (SR) 138*		Caltrans
TITLE: Depress SR 138 Between Division Street and 10th Street East	NUMBER 2.0	PAGE NO. 4 of 9

Alternative Concept

Typical Section (Not to Scale)

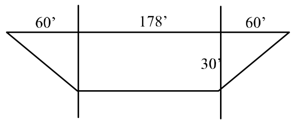


PERFORMANCE MEASURES *New State Route (SR) 138*				**Caltrans**
TITLE: Depress SR 138 Between Division Street and 10th Street East		**NUMBER** 2.0		**PAGE NO.** 5 of 9
ATTRIBUTES and RATING RATIONALE for ALTERNATIVE		**Performance**	**Original**	**Alternative**
MAINLINE OPERATIONS: No significant change.		Rating	5	5
		Weight	25	25
		Contribution	125	125
LOCAL OPERATIONS: No significant change.		Rating	5	5
		Weight	21	21
		Contribution	105	105
ENVIRONMENTAL IMPACTS: A depressed section will reduce noise and visual impacts; however, it will increase drainage requirements. A depressed section will increase the chances of encountering contaminated soils and/or archaeological sites.		Rating	5	5.5
		Weight	14	14
		Contribution	70	77
LAND-USE COMPATIBILITY: No significant change.		Rating	5	5
		Weight	18	18
		Contribution	90	90
CONSTRUCTION IMPACTS: It eliminates the need to import 1.6 million cubic yards of fill material and therefore reduces construction traffic. Requires a shoofly for Metrolink and Union Pacific Railroad. The TMP will need to consider temporary detours for 3rd Street, 8th Street, 10th Street, and Sierra Highway.		Rating	5	5
		Weight	4	4
		Contribution	20	20
MAINTAINABILITY: Eliminates maintenance of over 500,000 square feet of elevated structure. Increases maintenance related to drainage facilities and pump stations.		Rating	5	4.5
		Weight	11	11
		Contribution	55	49.5
PROJECT SCHEDULE: No significant change.		Rating	5	5
		Weight	7	7
		Contribution	35	35
		Rating		
		Weight		
		Contribution		
		Total Performance:	**500**	**501.5**
		Net Change in Performance:		**0%**

ASSUMPTIONS and CALCULATIONS *New State Route (SR) 138*	Caltrans	
TITLE: Depress SR 138 Between Division Street and 10th Street East	**NUMBER** 2.0	**PAGE NO.** 6 of 9

Cost Estimating Assumptions

Excavation: Assume length of depressed section is 1.15 miles = 6,072 linear feet
Assume depth of depressed section is 30 feet
Assume width of depressed section is 298 feet (say 238 feet for rectangular section)
6,072 ft. x 30 ft. x 238 ft. = 43,354,080 cf ÷ 27 cf/cy = 1,605,707 cy, say 1.6 million cy



Surface Drainage: Assume 44 drainage inlets
1.2 miles of 24-inch corrugated steel pipe

Roadway Drainage: VA team assumes that two 35 cfs pumps will be located in the depressed section at Sierra Highway and 10th Street. Assume $5 million per pump station including dry wells, pumps, and pump house.

Structural Section: 178 lf x 1 lf x 6,072 lf = 1,080,816 ÷ 27 cf/cy = 40,000 cy of PCC
20,000 cy of lean concrete base
40,000 cy of aggregate base

Structures: 3rd Street Overcrossing – 84 lf wide x 298 lf long = 25,000 sf
Sierra Highway Overcrossing – 138 lf wide x 298 lf long = 41,000 sf
Southern Pacific / Metrolink Railroad Overhead – 75 lf wide x 298 lf long = 22,000 sf
8th Street Overcrossing – 84 lf wide x 298 lf long = 25,000 sf
10th Street Overcrossing – 104 lf wide x 298 lf long = 31,000 sf
TOTAL STRUCTURE AREA = 144,000 sf

Slope Protection: Protect 2:1 side slopes with 6-inch layer of shotcrete
√(3,600 x 900) = 67 lf per slope
Area of slopes = 2(67 x 6,072) = 814,000 sf x 0.5 lf deep = 407,000 cf ÷ 27 cf/cy = 15,074 cy

Life Cycle Estimating Assumptions

Assumption is that 72 hours of pumping will occur each year.

Annual Energy Costs = 2 pumps x 385 KW per hour x 72 hours $0.10 KWH = $5,540 per year.

Annual Pump Maintenance = $1,000 per pump x 4 pumps = $4,000

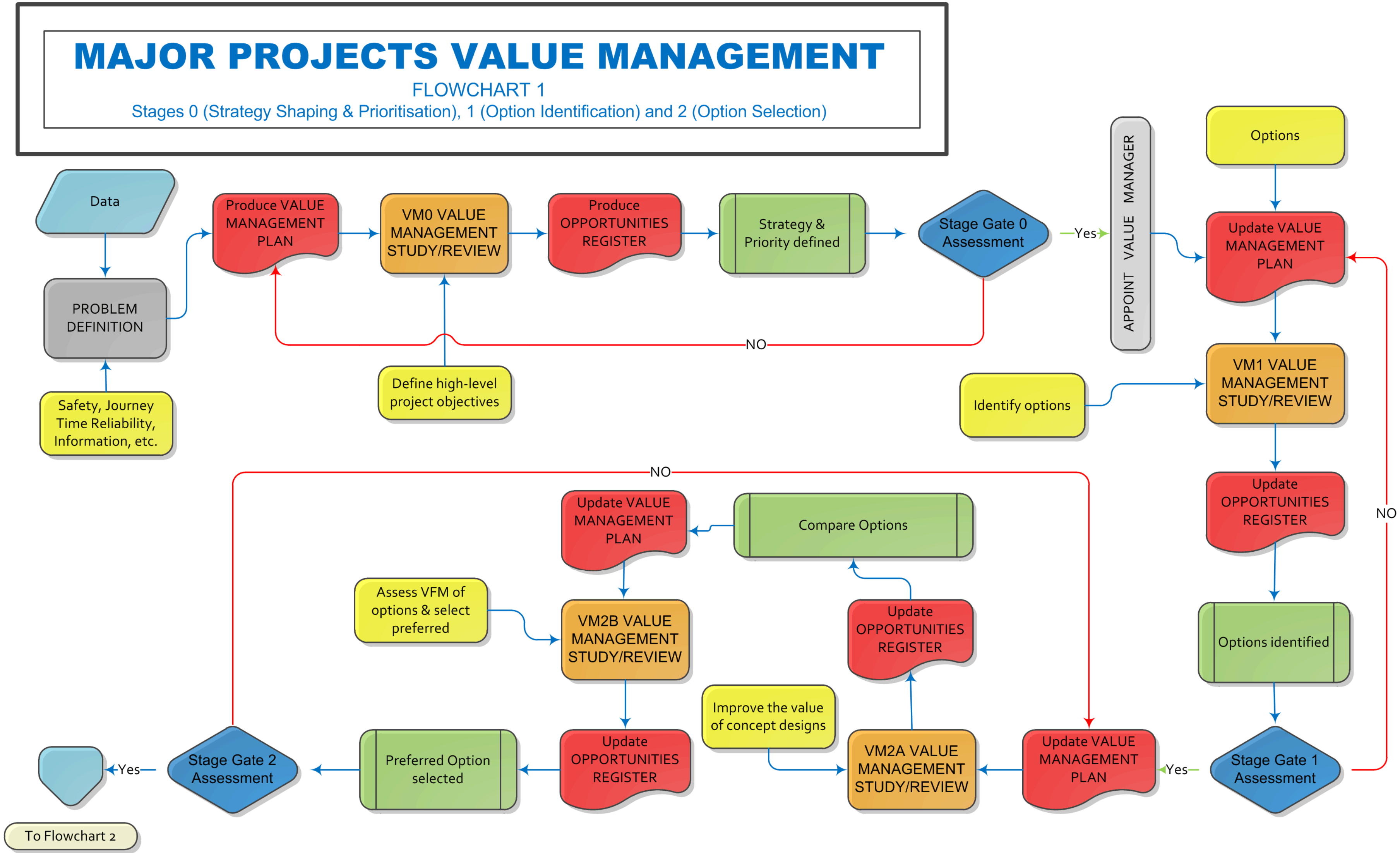
Periodic Repairs = Assume that minor repairs will occur every 2 years on 4 pumps at $2,500/each

Pump Replacement = Assume pumps replace at year 25 (2 pumps per station at a cost of $350,000 each)

INITIAL COSTS *New State Route (SR) 138*								Caltrans
TITLE Depress SR 138 Between Division Street and 10th Street East							NUMBER 2.0	PAGE NO. 8 of 9
CONSTRUCTION ELEMENT	Unit	ORIGINAL CONCEPT			ALTERNATIVE CONCEPT			
Description		Quantity	Cost/Unit	Total	Quantity	Cost/Unit	Total	
ROADWAY ITEMS								
Imported Borrow	cy	6,700,000	$12	$80,400,000	5,100,000	$12	$61,200,000	
Excavation	cy			$0	1,600,000	$10	$16,000,000	
JPCP	cy			$0	40,000	$250	$10,000,000	
Lean Concrete Base	cy			$0	20,000	$160	$3,200,000	
Aggregate Base	cy			$0	40,000	$30	$1,200,000	
Surface Drainage	ls			$0	1	$10,000,000	$10,000,000	
On-Site Drainage System	ls			$0	1	$1,200,000	$1,200,000	
Pump Station	ea			$0	2	$5,000,000	$10,000,000	
Shotcrete on Side Slopes	cy			$0	15,000	$160	$2,400,000	
Shoofly for Rail	ls			$0	1	$1,000,000	$1,000,000	
ROADWAY SUBTOTAL				*$80,400,000*			*$116,200,000*	
ROADWAY MARK-UP	*58%*			*$46,632,000*			*$67,396,000*	
VA ADDED MARK-UP				*$0*			*$0*	
ROADWAY TOTAL				*$127,032,000*			*$183,596,000*	
STRUCTURE ITEMS								
Viaduct Sta. 200+00 to 250+00	sf	707,000	$200	$141,400,000			$0	
Overcrossing Structures	sf			$0	144,000	$200	$28,800,000	
STRUCTURE SUBTOTAL				*$141,400,000*			*$28,800,000*	
STRUCTURE MARK-UP	*30%*			*$42,420,000*			*$8,640,000*	
VA ADDED MARK-UP				*$0*			*$0*	
STRUCTURE TOTAL				*$183,820,000*			*$37,440,000*	
RIGHT-OF-WAY ITEMS								
Right-of-Way Acquisition								
Utility Relocation								
Relocation Assistance								
Demolition								
Title and Escrow Fees								
RIGHT-OF-WAY TOTAL								
ENVIRONMENTAL MITIGATION ITEMS								
CAPITAL OUTLAY SUPPORT ITEMS								
Reengineering and Redesign								
Project Engineering								
TOTAL				$310,852,000			$221,036,000	
TOTAL (Rounded)				$310,852,000			$221,036,000	
						SAVINGS	$89,816,000	

LIFE CYCLE COSTS *New State Route SR-138*				VMS	
Title: Depress SR 138 Between Division Street and 10th Street East				**Alternative No.** 2.0	**Page No.** 9 of 9
Life Cycle Period 50 Years Interest 6 %				**ORIGINAL**	**ALTERNATIVE**
A. INITIAL COST				$310,852,000	$221,036,000
INITIAL COST SAVINGS:					$89,816,000
B. ANNUAL COSTS					
1. General Operations & Maintenance				$0	$4,000
2. Energy				$0	$5,540
3. Periodic Repairs (assume $2,500 every two years for 4 pumps)				$0	$5,000
Total Annual Costs:				$0	$14,540
Present Value Factor (P/A):				15.7619	15.7619
PRESENT VALUE OF ANNUAL COSTS:				$0	$229,177
C. SINGLE EXPENDITURES	**Year**	**Amount**	**PV Factor**	**Present Value**	**Present Value**
1. Replace Pumps (assume 4)	20	1,400,000	0.3118	$0	$436,527
2. Replace Pumps (assume 4)	40	1,400,000	0.0972	$0	$136,111
PRESENT VALUE OF SINGLE EXPENDITURES:				$0	$572,638
D. TOTAL ANNUAL COSTS & SINGLE EXPENDITURES (B+C)				$0	$801,815
E. SALVAGE VALUE				$0	$0
F. TOTAL PRESENT VALUE COST (A+D+E)				$310,852,000	$221,837,815
TOTAL LIFE CYCLE SAVINGS:					$89,014,185

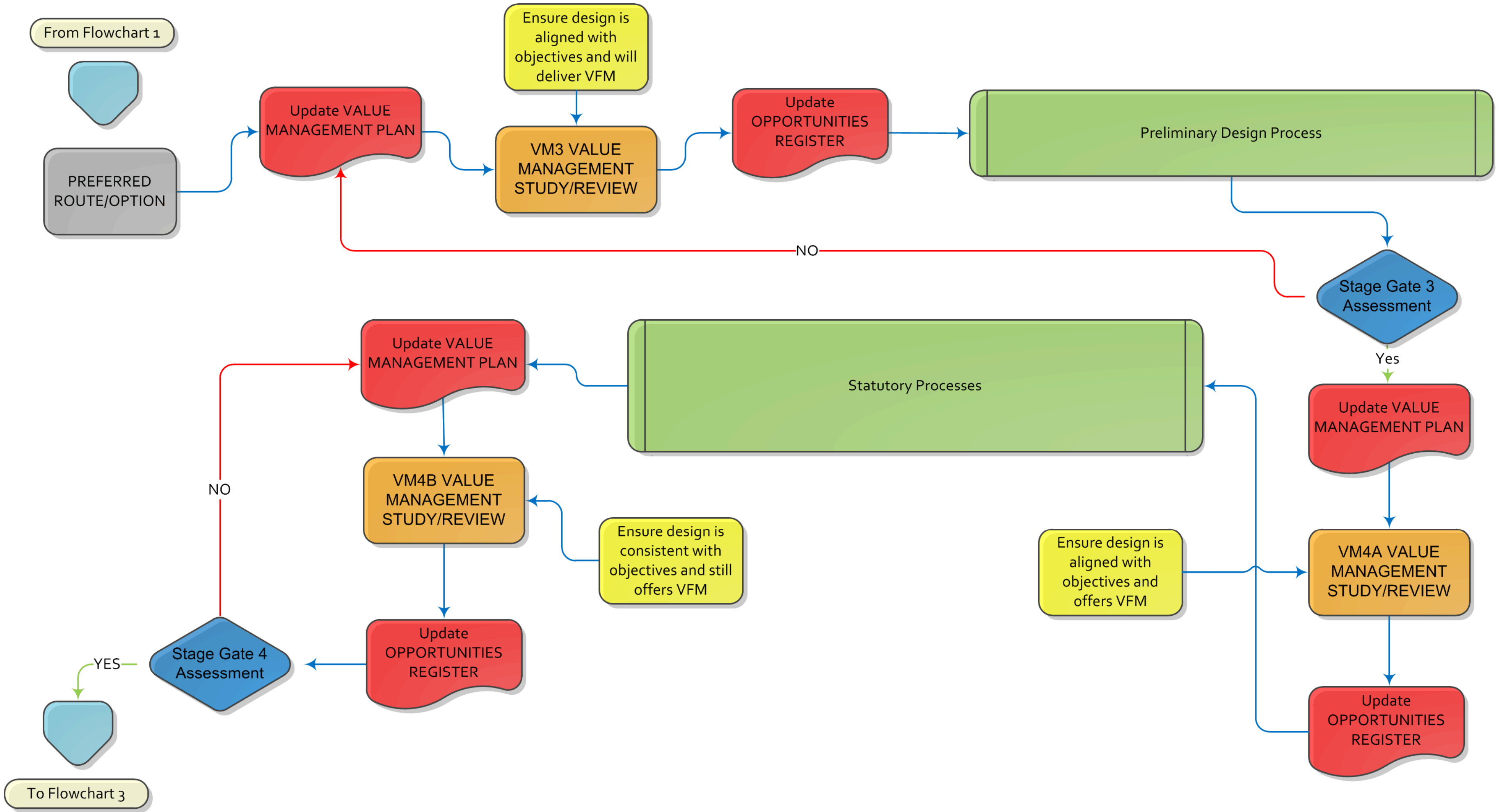
Appendix B – Highways Agency's Value Engineering Workshops Flowchart



MAJOR PROJECTS VALUE MANAGEMENT

FLOWCHART 2

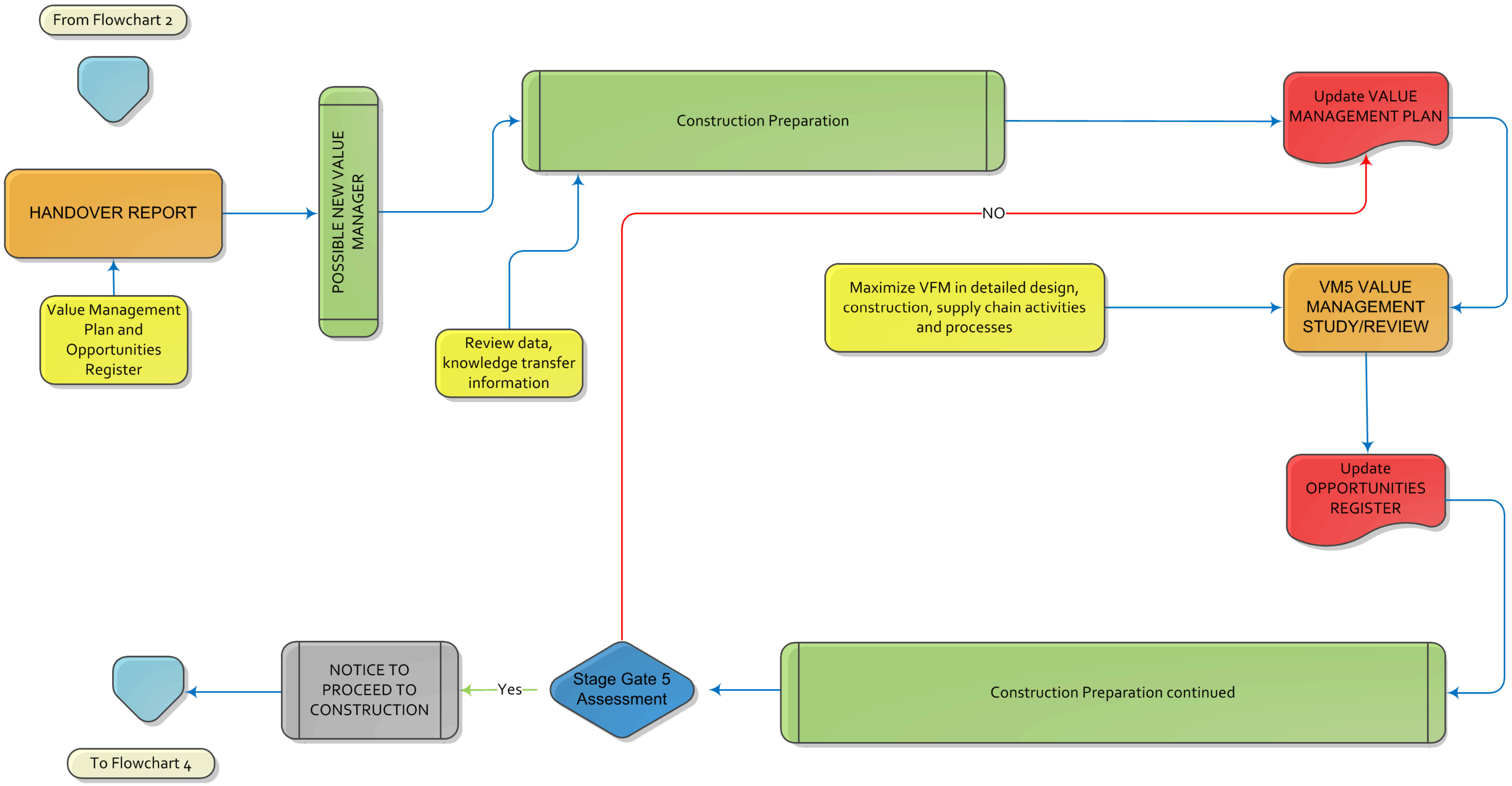
Stages 3 (Preliminary Design) and 4 (Statutory Procedures and Powers)



MAJOR PROJECTS VALUE MANAGEMENT

FLOWCHART 3

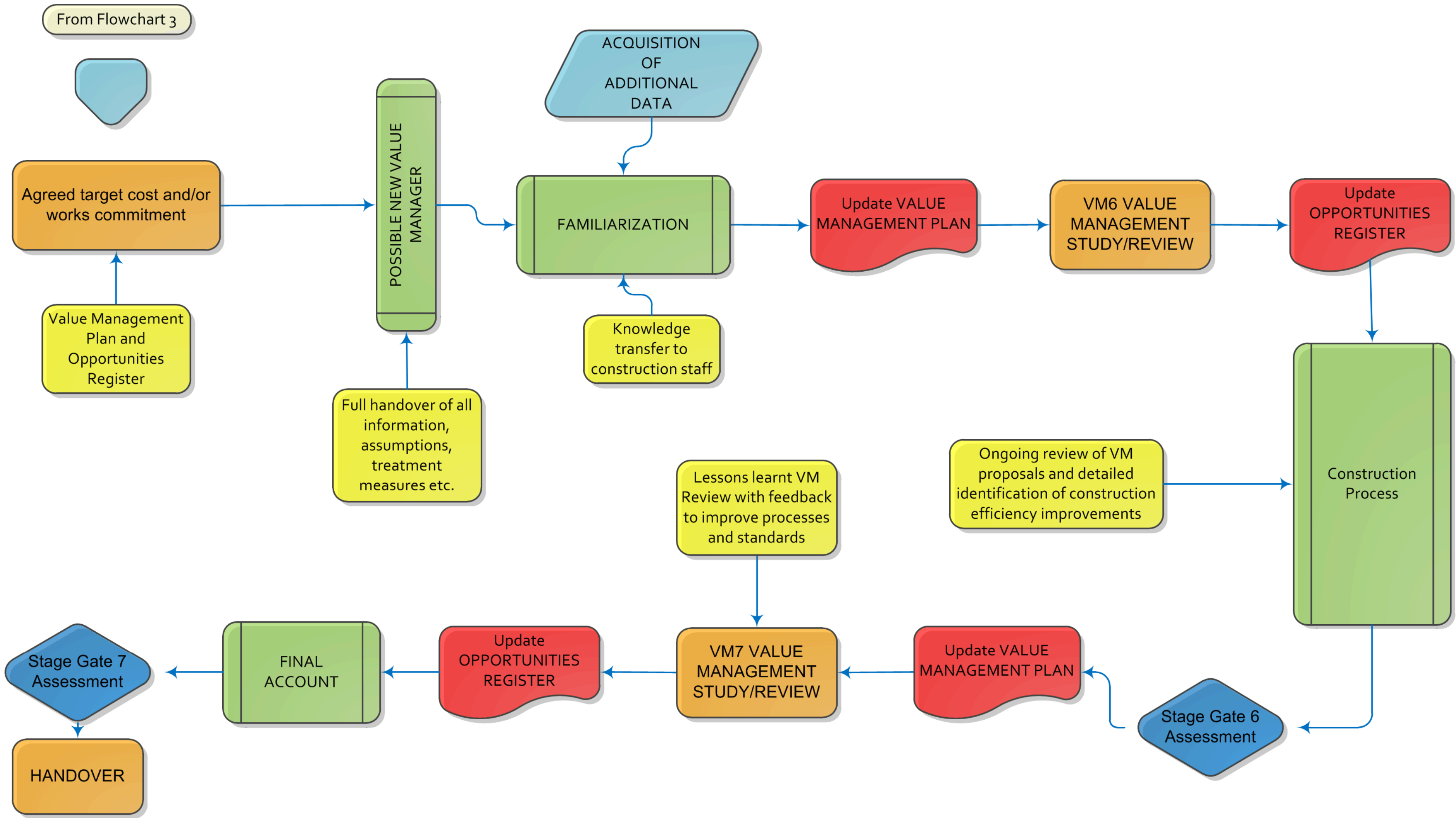
Stages 5 (Construction Preparation)



MAJOR PROJECTS VALUE MANAGEMENT

FLOWCHART 4

Stages 6 (Construction) and 7 (Hand Over & Close Out)



Appendix C – Survey VE and Soft Systems Thinking

Questionnaire Value Engineering and Soft Systems Thinking

Name(s): Kyle Schafersman	Date: 6/22/11
VE certification level: CVS	
Position: Value Engineering Program Manager/ VE Team Leader	E-mail: kyle_schafersman@urscorp.com

Vast evidence is available on the cost optimization capabilities of Value Engineering. Yet, there is relatively little documented evidence on its capabilities to address "soft" or ill-structured problems where decision-making processes are strongly influenced by complex stakeholder networks, like most projects engaged by public works organizations.

According to de Bruijn and ten Heuvelhof, "a good process is an **open** process, in which parties' **core values** are protected, which has sufficient incentives for **speed** and offers sufficient guarantees for the **substantive quality** of the results". A brief explanation of these four principles is as follows:

Openness:

- Involvement of all relevant parties in the decision making process.
- Transparency of the process and its management.
- Substantive choices transformed into process agreements.

Protection of core values:

- Commitment to the process rather than to the final result.
- Protection of parties' key interests.
- Provision of early exit options to all parties involved in the process.

Speed:

- Inclusion of incentives for cooperative behavior.
- Provision of prospects of gain to participants.
- Create environment that fosters speed of the process.
- Transfer of conflicts to the periphery of the process.

Substance:

- Fomentation of scientific criticism.
- Prevention of process from sinking into inconsistencies and nonsense.
- Drive process from substantive choices to selective decisions.

I would like to avail from your expertise on Value Engineering to identify the extent to which it may support the management of complex decision making processes.

Please fill in the following table using a scale from 1 to 5, where **1** indicates you **strongly disagree** and **5** indicates you **strongly agree** with the particular statement. The reasons underlying your rating are highly important so I encourage you to be as explicit as possible when filling in the "Justification" column.

Value Engineering and Process Management

	Grade (1-5)	Justification
Assertion:		
1) VE provides openness to a process.	5	Value engineering allows all project owners, designers, and stakeholders an open forum to discuss and brainstorm ways to work together for the common good while accomplishing individual interests. The VE process is well documented and extremely transparent to all parties involved. This allows individual stakeholders present their needs and desires while maintaining a group evaluation of the best direction for the project to progress without weighting a single set of demands above the overall good of the project outcome.
2) VE stimulates the protection of core values.	4	The process is a common denominator throughout the use of the value methodology. The steps are always the same, and they are always performed in the same sequence. Regardless of the facilitator or the companies and agencies involved, the results are always generated and vetted in the same way. In theory, this should mean that two independent teams with two different facilitators should arrive at somewhat similar results if all other variables are held constant. If specific project constrains are framed appropriately at the onset of a VE study, they will be upheld by almost everyone who uses the methodology. The process encourages challenging the status quo, but it does not promote working toward non-implementable solutions. Therefore, key parties interest can and will be protected.
3) VE feeds the speed of a process.	4	Time is money, so the more everyone works together towards the common goal of improving the value of a project, the more everyone wins. To be more specific, owners and stakeholders want a quick and efficient VE study to show them how to improve their project while saving them time and headache. Quick studies (less than 40 hours) done on short notice which big savings is obviously the goal of most clients. It is common to get the sense the owner is thinking “I want a high quality study with strong results, and I want it done yesterday.” The VE process and subsequent reporting process lends itself well to these high paced demands. During a VE study it is also very probable that recommendations are developed and evaluated that will reduce the overall duration of a project, because again time is money.
4) VE improves the substance of a process.	4	Several tools within the VE tool box can and should be used to evaluate recommendation in non-monetary ways, such as “performance measures.” This tool allows VE teams and project owners additional information to form implementation decisions on ground other than money. Sometimes spending more money to increase performance is a smarter choice rather than accepting nonsensical recommendations based solely on dollars and cents. The VE process, when done correctly, has the ability to drive decision makers to the best overall functional solutions for the project, not just the “slash and burn” adage that has been so common associated with the profession by outsiders.

Additional “soft” capabilities of Value Engineering

Had you experienced any additional noteworthy capabilities of Value Engineering related to Soft Systems Thinking, please mention them hereafter:

Value engineering has an uncanny ability to discover the “unknown” within a project. It always amazes me that within a few hours of a VE study, someone can come up with a seemingly obvious observation about the project that has gone unnoticed by the owners and design team for months or years. I think this has to do with methodology dictating that everyone take a step back and look at the overall big picture and asking the questions “why are we doing this?” or “ why are we doing it in this way?”. Engineering design is a somewhat arbitrary field where there are many different ways to achieve the same goals. A lot of times a few simple assumptions early in the project can lead down an undesirable path. When VE ca n challenge and overturn those basic early assumptions, the project can make major changes, and the results can be staggering.

Your collaboration to this survey is highly appreciated. Should you have any comments, questions or suggestions, please do not hesitate to contact me.

Sincerely,

Felipe Castro Arenas
MSc CME student at TU Delft
Intern for graduation project at Rijkswaterstaat
M: +31 64 735 4979
E: felipe.castroarenas01@rws.nl / fcarenas@gmail.com

Appendix D – International Associations of Value Engineering

Australia
Institute of Value Management Australia Inc. (IVMA)
http://www.value-management.com.au/

Austria
Zentrum Wertanalyse im Wirtschaftsforderungsinstitut der Bundeskammer der Gewerblichen Wirtschaft
http://www.wertanalyse.at/

Belgium
Association pour le Développement de L'Analyse de la Valeur (AVD)
http://www.avd-asbl.be/

Brazil
Associação Brazileira de Engenharia e Análise do valor (ABEAV)
http://www.abeav.com.br/

Canada
Canadian Society of Value Analysis (CSVA) / Société Canadienne d'Analyse de la Valeur (SCAV)
http://www.scav-csva.org/

Denmark
Danish Technological Institute (DTI)
http://www.dti.dk/

France
Association Française pour L'Analyse de la Valeur (AFAV)
http://www.afav.eu/

Germany
Verein Deutcher Ingenieure, Zentrum Wertanalyse (VDI ZWA)
http://www.wertanalyse.de/

Greece
Federation of Greek Industries
http://www.sev.org.gr/

Hong Kong
Hong Kong Institute of Value Management (HKIVM)
http://hkivm.org/introduction.htm

Hungary
Society of Hungarian Value Analysts (SHVA)
Website not available or in construction

India
Indian Value Engineering Society (INVEST)
http://www.invest-in.org/

Italy
Associazione Italiana per la Gestione e l'Analisi del Valore (AIAV)
http://www.aiav-valore.it/

Japan
Society of Japanese Value Engineering (SJVE)
http://www.sjve.org/en/

The Netherlands
Dutch Association of Cost Engineers (DACE)
http://www.dace.nl/

Portugal
Associação Portugesa para a Analise do Valor (APAV)
Website not available or in construction

South Africa
Value Engineering and Management Society of South Africa (VEMSSA)
Website not available or in construction

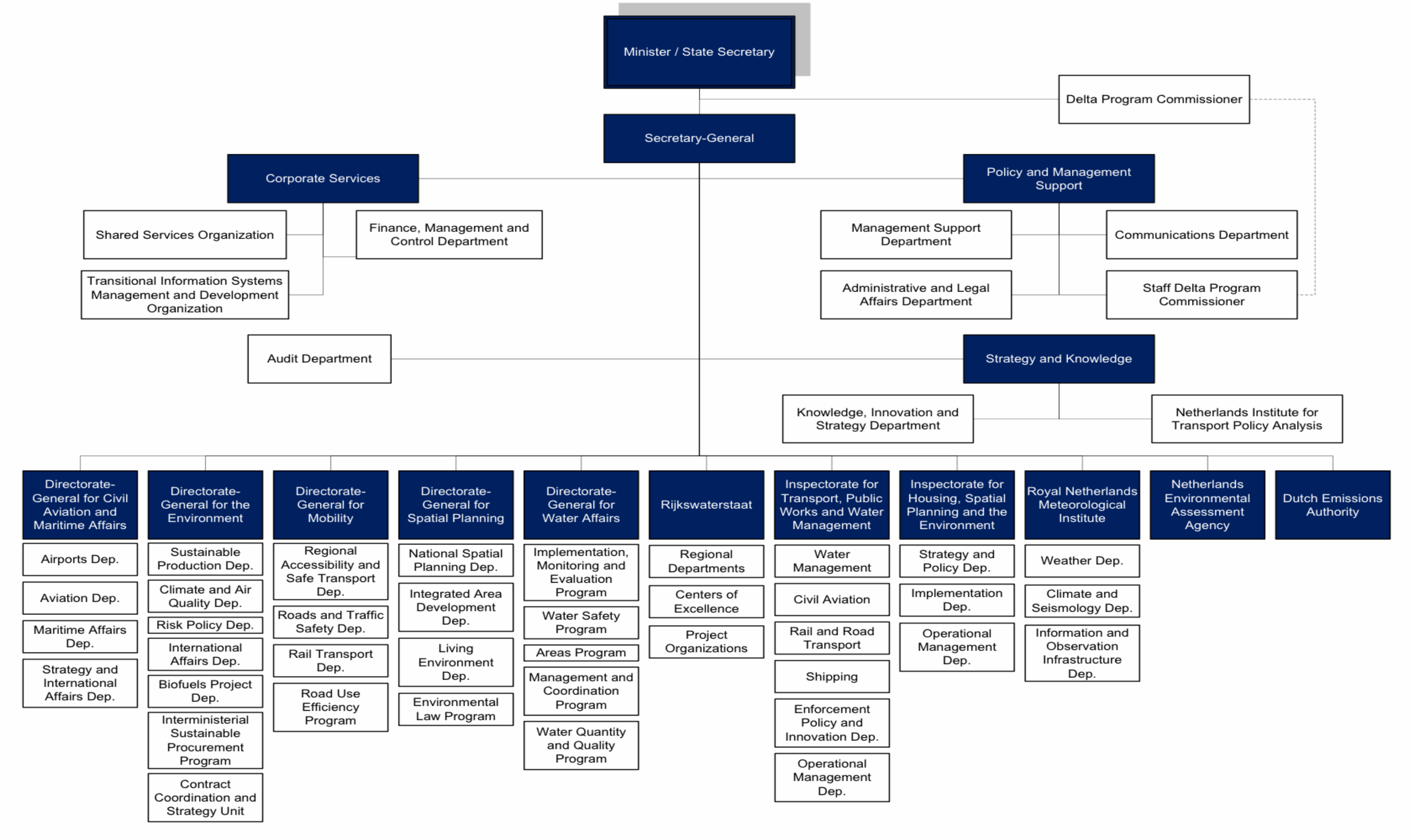
South Korea
Society of Korea Value Engineering (SKVE)
Website not available or in construction

Spain
Federación Española de Gestión del Valor (FEGEVA)
Website not available or in construction

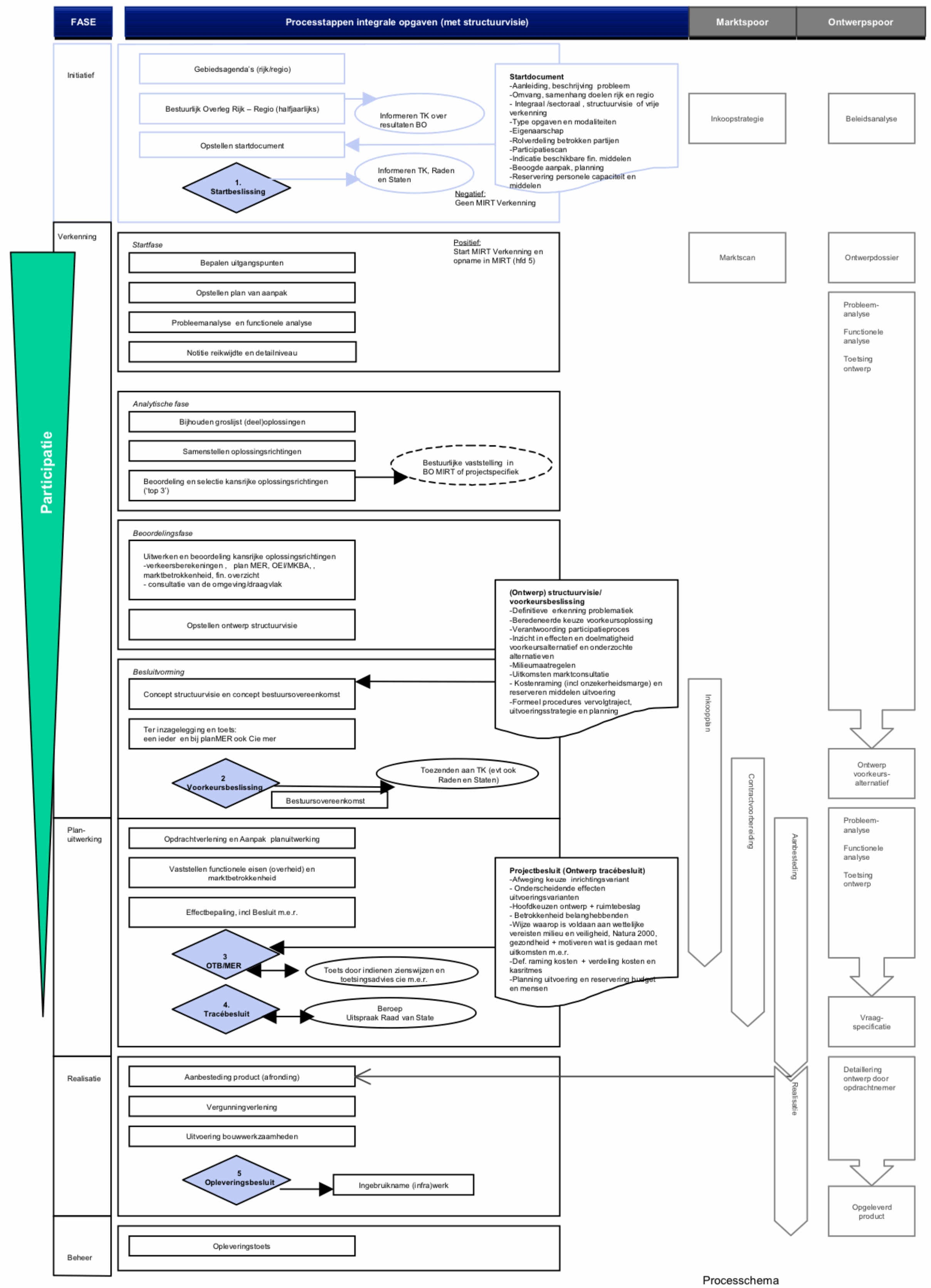
United Kingdom
Institute of Value Management (IVM)
http://www.ivm.org.uk/

United States of America
SAVE International
http://www.value-eng.org/

Appendix E – Organogram Dutch Ministry of Infrastructure and the Environment

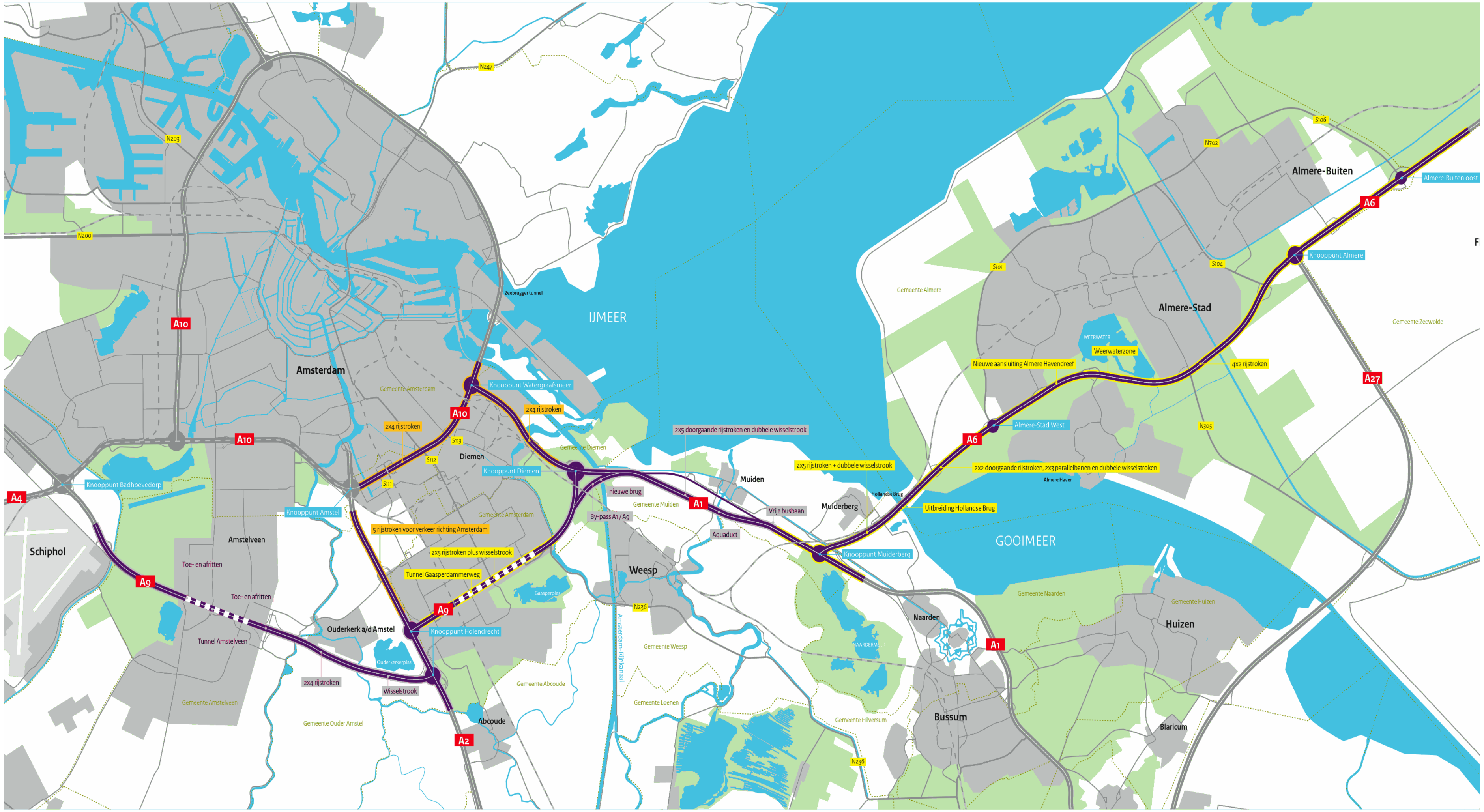


Appendix F – Sneller & Beter overview



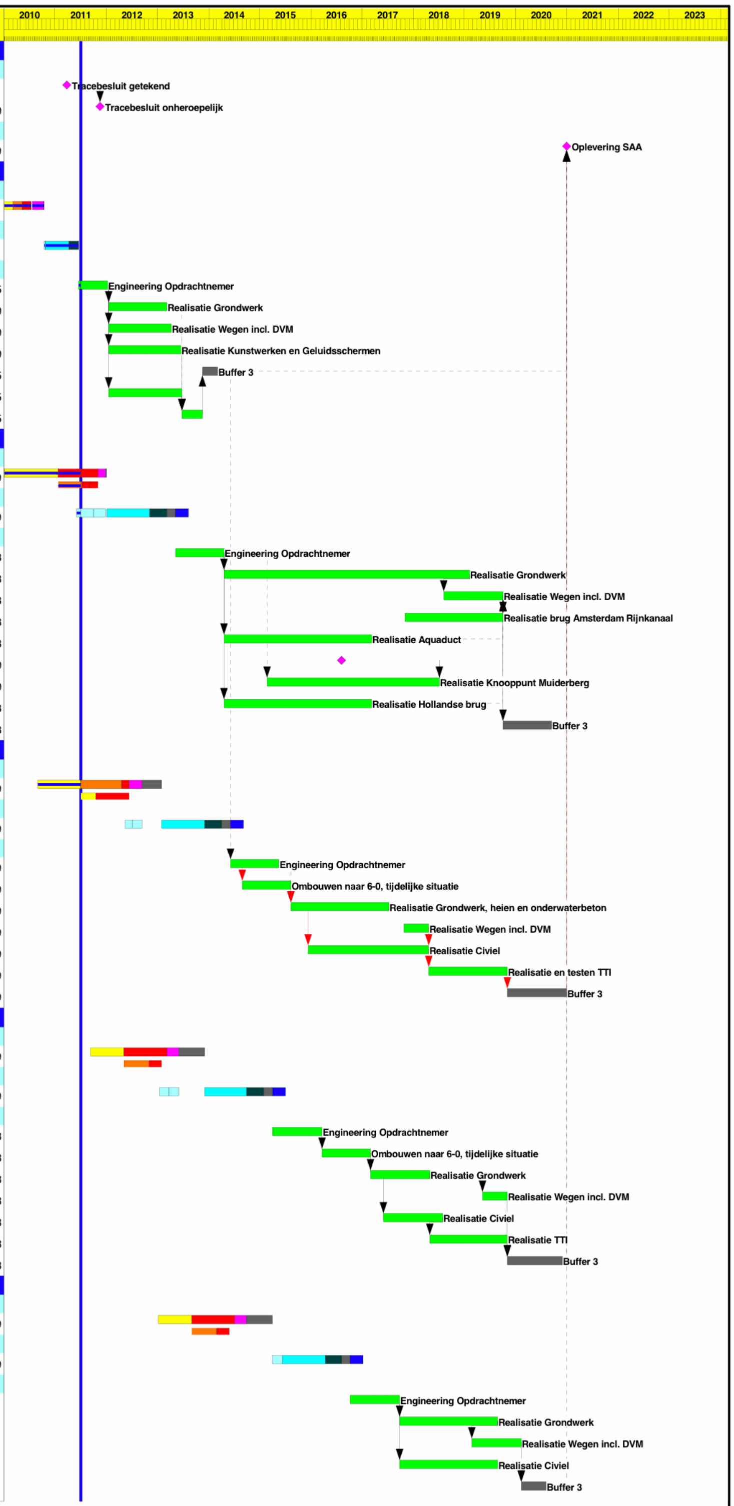
Processchema
Bijlage bij Procesontwerp Sneller&Beter II,
december 2009

Appendix G – SAA project overview plan



Appendix H – SAA project actual program

/OL(	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
Algemen activiteiten gehele project					
Contractfase					
01	Tracebesluit getekend	0		21-03-11A	
02	Tracebesluit onheroepelijk	0		14-11-11*	2,380
Realisatie					
01	Oplevering SAA	0		28-12-20	0
A10 Oost en A1 knp Watergraafsmeer - knp Diemen					
+ Contractfase					
		291	01-09-09A	12-10-10A	
+ Aanbesteding en gunning					
		175	13-10-10A	14-06-11A	
Realisatie					
12	Engineering Opdrachtnemer	153	15-06-11A	13-01-12	65
13	Binnenring A10	301	16-01-12	11-03-13	140
14	Buitenring A10	321	16-01-12	08-04-13	120
15	Zuidzijde A1	371	16-01-12	17-06-13	70
17	Buffer 3	75	19-11-13	03-03-14	65
	Noordzijde A1	376	16-01-12	24-06-13	65
	A1/A9 knp Diemen	105	25-06-13	18-11-13	65
A1/A6:Knp Diemen-Knp Muiderb.- Almere Havendreef					
+ Contractfase					
		523	03-01-10A	04-01-12	0
+ Aanbesteding en gunning					
		572	31-05-11A	07-08-13	0
Realisatie					
12	Engineering Opdrachtnemer	250	09-05-13	23-04-14	73
13	Realisatie Grondwerk	1,250	24-04-14	06-02-19	73
14	Realisatie Wegen incl. DVM	300	09-08-18	02-10-19	73
15	Realisatie brug Amsterdam Rijnkanaal	500	02-11-17	02-10-19	323
16	Realisatie Aquaduct	750	24-04-14	08-03-17	613
17	Prorail gereed met spoorviaduct	0		01-08-16*	270
18	Realisatie Knooppunt Muiderberg	875	24-02-15	02-07-18	270
19	Realisatie Hollandse brug	750	24-04-14	08-03-17	613
20	Buffer 3	250	03-10-19	16-09-20	73
A9: Gaasperdammerweg					
+ Contractfase					
		629	01-09-10A	28-01-13	0
+ Aanbesteding en gunning					
		604	09-05-12	01-09-14	0
Realisatie					
12	Engineering Opdrachtnemer	250	03-06-14	18-05-15	0
13	Ombouwen naar 6-0, tijdelijke situatie	250	26-08-14	10-08-15	0
14	Realisatie Grondwerk, heien en onderwaterbeton	500	11-08-15	10-07-17	0
15	Realisatie Wegen incl. DVM	130	24-10-17	23-04-18	0
16	Realisatie Civiel	620	08-12-15	23-04-18	0
17	Realisatie en testen TTI	400	24-04-18	04-11-19	0
18	Buffer 3	300	05-11-19	28-12-20	0
A9: knp Badhoevedorp - knp Holendrecht					
+ Contractfase					
		585	06-09-11	02-12-13	0
+ Aanbesteding en gunning					
		642	15-01-13	01-07-15	0
Realisatie					
12	Engineering Opdrachtnemer	250	02-04-15	16-03-16	18
13	Ombouwen naar 6-0, tijdelijke situatie	250	17-03-16	01-03-17	18
13	Realisatie Grondwerk	300	02-03-17	25-04-18	18
14	Realisatie Wegen incl. DVM	130	09-05-19	06-11-19	18
15	Realisatie Civiel	300	01-06-17	25-07-18	18
16	Realisatie TTI	400	26-04-18	06-11-19	18
17	Buffer 3	280	07-11-19	02-12-20	18
A6: Almere Havendreef - Almere Buiten Oost					
+ Contractfase					
		585	03-01-13	01-04-15	0
+ Aanbesteding en gunning					
		462	02-04-15	06-01-17	0
Realisatie					
12	Engineering Opdrachtnemer	250	10-10-16	22-09-17	101
13	Realisatie Grondwerk	500	25-09-17	23-08-19	101
14	Realisatie Wegen incl. DVM	250	25-02-19	07-02-20	101
15	Realisatie Civiel	500	25-09-17	23-08-19	221
17	Buffer 3	130	10-02-20	07-08-20	101



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Afdrukdatum: 30-06-11 15:15	Progress Bar	Schiphol - Amsterdam - Almere		
Layout: Opgerold	Critical Activity	Overallplanning juli 2011		
Filter: Vijf deelprojecten				
Opstellers: C Groffen / A. Peters				