Master Thesis

Better scope management during the initiative, design and construction phase of infrastructure projects

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Executive summary

Observation
Nine out of ten infrastructure projects fall victim to cost escalation (Flyvbjerg, 2004) and delays. This paper investigates the role of scope changes and the practice of scope management on project cost and planning.

Research design
The goal of the research is to provide recommendations for better scope management during the initiative, design and execution phase of infrastructure projects. To reach this goal the study is divided in three parts with different methodology; literature study, case study and survey study. The literature study provided a good grasp of the phenomena scope management resulting in the contruction of a theoretical framework. From this literature study specific questions were formulated to investigate the practice of scope management in a single case study. The case study resulted in some interesting findings and to verify the generalizabillity of these findings to other infrastructure project a survey study was held among project managers of 8 infrastructure projects in the Netherlands. By applying three methods of research accurate conclusions could be drawn about the current state of scope management and areas of improvement.

Literature study
The study showed that all project are bound by the quadruple constraints; scope, cost, time and quality. The premise of the quadruple constraint is that changing one constraint has consequences for at least one or more of the other constraints. The sum of these constraints determines the overall value of a project and the reason d'être for a project. Scope is defined as **Product scope** (features and functions that characterize a product or function) and **Project scope (**work that must be done to deliver a product with the specified features and functions).

A project takes place in a dynamic environment and even with a robust scope description, scope changes will occur. Scope changes can be related back to the following causes; new laws and regulations, requirements of the client change, risk take place, effects of other projects, new insights, technological breakthroughs, imposition by the State Council, incomplete scope definition, new economic situation and negotiations with stakeholders. Besides the cause and effects of a scope change the timing is also an important factor, the later the introduction the higher the effects.

Case study
The Betuweroute was chosen for an indepth case study, because of its size and the amount, availability and quality of the information. The Betuweroute showed that the client and stakeholders were the major causes of scope changes during the Project Life Cycle. In the scope definition phase there was an early fixation on a specific scope of the project, namely a west-east rail connection. This led to improper definition of the needed quality and functionalities for the project. Another major flaw in this phase was the neglect for stakeholders, especially local stakeholders. Because they were left out in the definition phase they strongly opposed to the project in the late stages of the design phase and in the execution phase. This led to many and large scope changes due to investing in the quality of the project (tunnels, deepened track, design, etc.) to meet stakeholder requirements. This ofcourse influenced the total value of the project in a negative way and the project became financially, economical and social economical infeasible.

Survey
To investigate if the problems regarding scope management with the Betuweroute were project specific, project managers of eight other infrastructure projects were interviewed through the use of a digital questionnaire. The results indicate that clients and stakeholders are major causes of scope changes, but also the influence of other projects. The effects of scope changes increase over time as was suggested in literature and have the most effect on the planning than the cost of the project, as was the case with the Betuweroute. The project managers indicated that the impact of local stakeholders is the highest in the design phase and higher than the impact of national and regional stakeholders in the design and execution phase. In comparison with the Betuweroute the managers indicate that there was no scope fixation and the development from functional to specific scope is more linear. The attention to the cost and planning is the highest when investigating a scope change, however the attention for the value increase/decrease is still underrepresented.

Conclusion and recommendations
The overall conclusion is that scope management in infrastructure projects can be much better. The practice of scope management can be divided into to streams "coming to the right scope" and "controlling the scope". The most gain can be reach by improving the scope definition in the initiative and the first half of the design phase.

A robust scope is important to reduce the amount of scope changes in the second half of the design phase and the execution phase. However scope changes will still ocur in these phases, so proper scope control is necaserry to ensure that only the right scope change request are implemented. In literature several methods and tools are available to better define the scope or better control the scope of a project.

Coming to the right scope

- Value management, a management style focused on the functionality of a project and thus creating the best value for all stakeholders.
- Stakeholder management, the continuing development of relationships with stakeholders for the purpose of achieving a successful project outcome.

Controlling the scope

- Decomposition, the division of a system in subsystems, can be used to; reduce complexity, optimise according to available specialization, save time because subsystems can work independently and parallel.
- Dynamic project organization is through the introduction of an aspect level better capable to cope with scope changes.
- Scope change procedure for requesting reviewing, approving, carrying out and controlling changes to the product and project scope.

1 Observation

1.1 Background

In the media there is a lot of attention for projects which run over budget and have serious delays. Research of Flyvbjerg et al. (2004) has indicated that nine out of ten infrastructure project fall victim to cost escalation; 45 % for rail projects, 34% for fixed links (like bridges and tunnels) and 20% for road projects. The cause is partly due to changes in scope. "*More than seventy percent of projects fail. When projects fail, it's rarely technical. Over eighty percent of those projects fail due to Project Management. Projects, like business, often fail because they are not properly managed. Scope Creep is a major aspect of project failure*[1]." Scope creep can be due to; poor change control, poorly described project objectives, weak Project Manager, bad communication, triggering of risks, etc.

And on the other hand there is also discussion concerning the utility of large infrastructure projects is the scope really necessary and is the right scope chosen to solve the problem? In 2003 the Dutch Parliament decided to conduct a research[2] to learn from large infrastructure projects. The projects scrutinized were HSL-zuid, Betuweroute, Westerscheldetunnel and the Maaswerken. In both the policy and execution phase scope changes were a large cause for the rise in cost.

Research of Hertogh et al. (2008) into large infrastructure project in Europe also conclude that cost control in the implementation phase is generally good. Problem however is optimistic levels of scope (no overall consent on scope, technical, environmental, and engineering requirements ill defined) in early phases which lead to cost and delivery underestimation. There is also a fine balance between control to prevent scope creep and constructive interaction to apply changes that potentially improve project outputs, reduce costs or speed up delivery.

All large scale infrastructure projects seem to have problems related to scope management. They all have in common that they have a lot of different stakeholders, each with varying ideas of what the scope should be and each with a different level of participation. Another aspect of large infrastructure projects is that the government is the client, so the determination of scope takes place in a political arena. These are just two important issues that make large infrastructure projects unique.

1.2 Problem definition

What is needed for project scope to be properly managed during the initiative, design and construction phase of many infrastructure projects in the Netherlands, so that we can suppress budget overruns and delivery delays caused by extra scope changes?

[1] www.projectperfect.com.au
[2] Leerervaringen Grote Projecten, August 2003

2 Research Design

2.1 Introduction

In the previous chapter we have identified that there is a problem in the manner in which scope is handled within infrastructure projects in the Netherlands. To solve this problem we want to do a research in the field of scope management both in literature and in practice. For a research it is important to determine what is to be achieved and how we are going to achieve this. This means that a clear objective and research question have to be set to guide the research. A research also has to be clearly bounded to prevent that one gets lost, this is done by setting your research boundaries. Because there are many types of research, each one with its advantages and disadvantages, an appropriate method has to be chosen that will have to most success in achieving the objective and answering the research questions. In the last section of this chapter the different methods and their relationship are set out in the research framework.

2.2 Objective

To provide recommendations for better scope management during the initiative, design and construction phase of infrastructure project.

2.3 Research question

Which experiences, methods and tools in scope management are useful for better scope management for large infrastructure projects?

To answer this broad research question it can be divided in several section; theory and practice.

Theory; these questions will be answered by the literature study:

- What is scope? (definitions, dynamics, dimensions, relations)
    - What definitions are available?
    - How does scope change over time?
    - What relationship does scope have with other project aspects (time, cost, quality and value)?
- What are scope changes? (causes, effects)
    - How can we identify a scope change?
    - What are the causes of scope changes?
    - What effect do scope changes have?
- What is scope management?
    - How can we determine scope?
    - How can we control scope?

Practice; these questions will be answered by the case study and the questionnaire as they are provided in chapters 5 and 6:

- How is scope determined in projects?
- What scope changes occurred in projects?
- What where the effects of scope changes in the project?
- How was the scope managed during the project?
- What was the role of stakeholders in scope definition and control?

2.3.1 Research boundaries

Boundaries have to be set before starting the research, it is essential that important information relevant in answering the research questions fall within the boundaries and on the other hand try to ignore all irrelevant information. For this research the following boundaries are set:

- A selection of literature on project and process management is used.
- The recommendations are applicable for the entire Project Life Cycle (period from beginning of the initiative phase till the completion of construction).
- The Betuweroute is chosen as a representative infrastructure project for a case study.
- A selection of team members (30-40) of infrastructure projects (5-10) are interviewed through a questionnaire, that give a good representation of the composition of a project team.
- Excel is used for qualitative analyses of the questionnaires.
- The focus of the research is on the relationship between the client and stakeholder on the scope of a project and not on the relationship between the client and the contractor.

2.4 Research framework

2.4.1 Explanation of chosen research method

Sekeran (2003; 119) explains in his book "Research methods for business" that the purpose of a study may be either exploratory in nature or descriptive, or may be conducted to test hypothesis. The purpose of this study is exploratory in nature, because it is undertaken to better comprehend the nature of the problem since no or very few studies have been conducted in the specific area of scope control and scope definition. Sekeran (2003; 120) states that:

Exploratory studies are important for obtaining a good grasp of the phenomena of interest and advancing knowledge through subsequent theory building and hypothesis testing.

In Figure 1 the research framework is presented, at this point in the paper the observation has been made and presented in the background section, from which the problem was defined. In the research framework section we have set or objective, research questions and boundaries. Now we are at the point of designing the research itself, how do we reach or objective and answer the research questions. The research itself is divided in three major parts; a literature study, a case study and a questionnaire.

The literature study is done to gain main knowledge about the theories on scope management and other management theories that are closely related to scope management. After conducting this research it will be possible to develop a theoretical framework with all the important factors and their relationships that are important for the research. The literature study will be the starting point from which tools and methods can be obtained that can be useful for better scope management. To get a better grasp of the phenomena, it is important not to only use theories but also experiences and preferences of the people in the field. So the next step is to investigate one project as a subject of a case study. At the end of the case study the result will be checked with the assumptions made in the theoretical framework, the verification. A case study alone will not be enough to understand the experiences and preferences. In this research this understanding is done by the application of a questionnaire. A questionnaire is applied to be able to extract information from a large test group (more reliability), and through the use of closed questions with scales statistical analyses can be performed to interpret the data. The results of the questionnaire are than checked with the results of the questionnaire and theoretical framework, the verification.

The end of the research will consist of the formulation of the overall conclusions that can be drawn from answering the research questions, the findings of the three research parts and the verifications between the these parts. Recommendations can be made that will reach the objective for better scope management and finally suggestions for further research can be given.

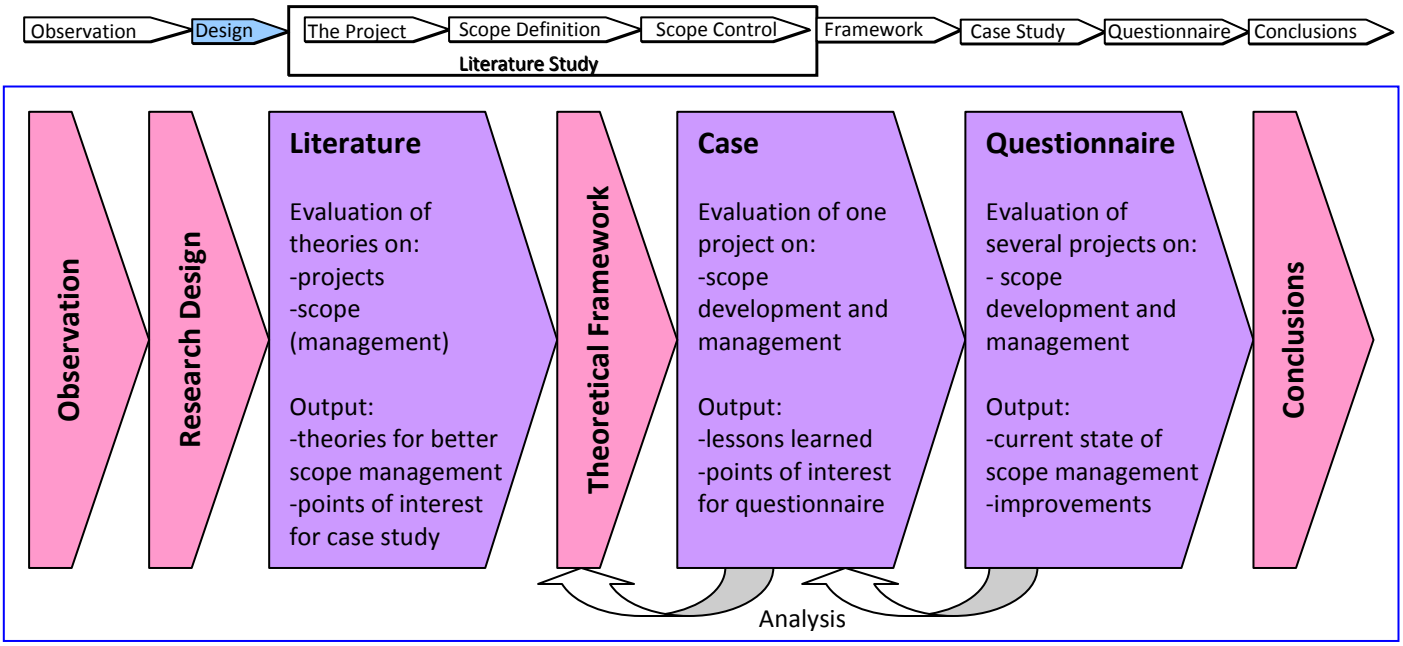


Figure 1, Research framework.

Because of the use of different types of research methods the outcome of the research will be more reliable (triangulation). Important for the convergence of evidence through triangulation, and therefore the reliability of the research. Two types of triangulation are used; methodological (variation of research methods) and data (variation of information sources) triangulation, which is illustrated in Figure 2.

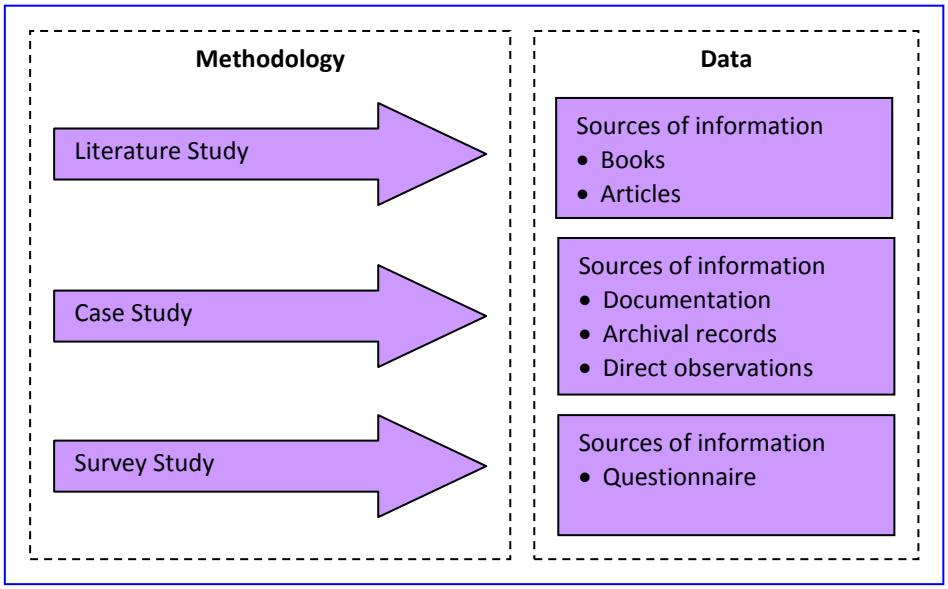


Figure 2, Two types of triangulation, methodological and data.

2.4.2 Literature research

According to Sekeran (2003; 63) the purpose of literature review is to ensure that no important variable that in the past been found repeatedly to have had an impact on the problem is ignored. Translating this argument to this paper it means that the purpose is to ensure that no important aspect of a project and project management are overlooked that are important for the scope of a project and scope management.

The literature research itself will be divided into three sequential theory parts; the project, scope development and scope control. First of all it is important to investigate the characteristics of a project and its dynamics. And what position does scope hold within a project. The outcome of this study will determine the focus point of the next theory parts. What characteristics are important when defining and controlling scope in an infrastructure project. The division of scope management into scope development and scope control is chosen because different methods and attitudes are required. Scope development (part 2) will focus on coming to the right scope and developing a robust scope that is better susceptible to changes. This process requires a soft approach because of the involvement of several actors trying to shape the project. Scope description is built on consensus building to come to the right scope. Part 3 of the literature research focuses on the controlling of

scope and is focused on a hard approach. Scope control requires an appropriate organization, strict procedure and scope changes need to be scrutinized on their effects. Proper scope control will prevent unnecessary scope changes to be carried out, because they are filtered out.

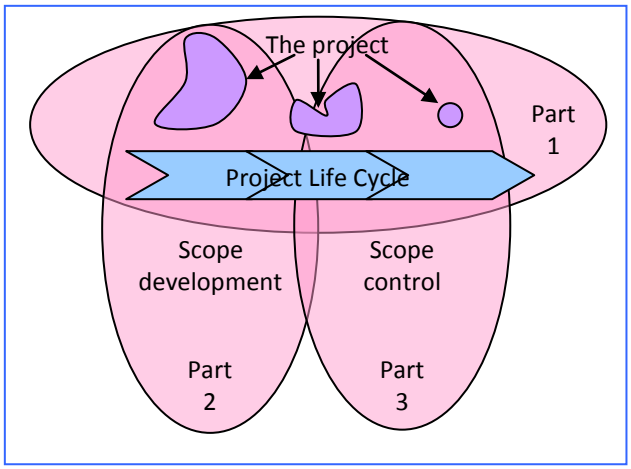


Figure 3, Construction of the literature study.

With the result of the literature research it will be possible to construct a theoretical framework which will guide the critical case study and questionnaire. It is possible to make connections between existing theories in process and project management that will benefit scope management. On the other hand the literature research will point out areas of interest when conducting the case study and questionnaire. What are the characteristics of scope in the literature and how does scope "behave" in existing infrastructure projects.

2.4.3 Theoretical framework

Sekeran (2003; 87) describes a theoretical framework as a conceptual model of how one theorizes or makes logical sense of the relationships among the several factors that have been identified as important to the problem. The theoretical framework discusses the interrelationships among the variables that are deemed to be integral to the dynamics of the situation being investigated. The theoretical framework summarizes the most important concepts discussed in the literature study and the theoretical framework will provide us with more specific research questions for the case study and questionnaire.

2.4.4 Critical case study

The research questions composed in the theoretical framework are used to investigate the project and the theoretical framework is tested on its viability. Areas of interest will be the development of scope (scope definition, scope changes and scope effects) and scope management during the Project Life Cycle. For this research the Betuweroute is chosen as a subject because it represents a large, completed and elaborately investigated infrastructure project in the Netherlands. Another important criterion was the amount of information and its accessibility. Because the Betuweroute was labelled a knowledge project, from which other infrastructure project can learn. Because of this status a lot of information and documentation were available on the website. The use of a case study is one of the research strategies in this research and is used for a first orientation of scope (management) in a large infrastructure project. A case study involves an in-depth, longitudinal examination of a single instance or event: a case.

The case study is a research approach, situated between concrete data taking techniques and methodological paradigms[3].

A decision had to made between a multiple or single case study. The advantage of a multiple case study is a better founded generalization of the findings in the cases. The advantage of an in-depth single case study is the thorough research of all information of the single case. Because in this research the case study is just one of the research methods and because of time constraint a critical single case study was chosen over a more superficial multiple case study.

[3] Lamnek, 2005

The result of the case study will be that certain mechanism described in the literature and in the theoretical frame work are coherent with the situations described in the case study. Others may need to be adjusted or rejected altogether for this project. The case study may point out problems in the scope and/or scope management in the Betuweroute project. Because these problems may be unique it is essential to check this with other projects and this is done through the application of a questionnaire. The lessons learned in the Betuweroute project may also be translated to other infrastructure projects.

2.4.5 Questionnaire

The research questions of the theoretical framework and the outcome of the case study are starting points in designing the questionnaire. The outcome of the questionnaire is used to validate the assumptions made in the theoretical frame work and to see if the Betuweroute has similarities with the projects used in the questionnaire. The use of a questionnaire is one of the many research methods a researcher can choose from, they are an inexpensive way to gather data from a potentially large number of respondents. When applying a questionnaire as a means of collecting data the following criteria are important to keep in mind (Sinclair, 1975);

- **Objectivity.** Extrinsic factors, associated both with the data gathering and more generally, can influence subjective judgement, and the actions to mitigate the effect of those factors can sometimes be very complex.
- **Quality of measurement.** This refers to the accuracy of measurements needed.
- **Validity.** Any measurement technique measures only what it is designed to measure, and that inferences and generalisations from the results obtained depend entirely on the relationships established between the methods and independent criteria.
- **Reliability.** Concerned with the internal consistency; successive repetitions of the method will yield similar results.
- **Resource availability.** Time and money available to conduct the research.

3 Literature Study

3.1 Part one, the project

3.1.1 Introduction

This part of the literature study will provide answers to the research questions mentioned in the research design, namely:

- What is scope? (definitions, dynamics, dimensions, relations)
  - What definitions are available?
  - How does scope change over time?
  - What relationship does scope have with other project aspects (time, cost, quality, risk, value, etc.)?

Besides dividing a project in a longitudinal direction to describe the dynamics it is also essential to divide a project in a cross sectional direction to describe the different elements that make up a project at one moment in time. The characteristics of a project will influence the manner in which scope is/should be managed and developed. This paper discusses a method to characterize projects by determining their goals and methods. This is a very crude method that categorizes projects in four different types. A more elaborate method in analyzing a project is by defining the hardness and softness of several project characteristics. The most important method in describing a project is in project constraints (scope, time, cost and quality). Fundamental in this approach is that all constraints are linked, meaning that a change in one constraint will influence another constraint. This is essential to investigate if cost overruns and delays can be traced back to scope changes.

In the last sections of the chapter two constraints will be further elaborated; scope and quality. The dynamics and definitions of scope and quality are discussed and their relationship and overlaps in the reviewed literature will be pointed out. The distributions of the constraints will determine the value of project and vice versa. A prospected increase in value will be the reason d'être for the project. So the value of a project should be the main factor in deciding to undertake the project or not.

3.1.2 Dynamics

During the Project Life Cycle the characteristics of the process can vary greatly through the project phases. Some characteristics changing over time are illustrated in Figure 4, and will be discussed in the following section.

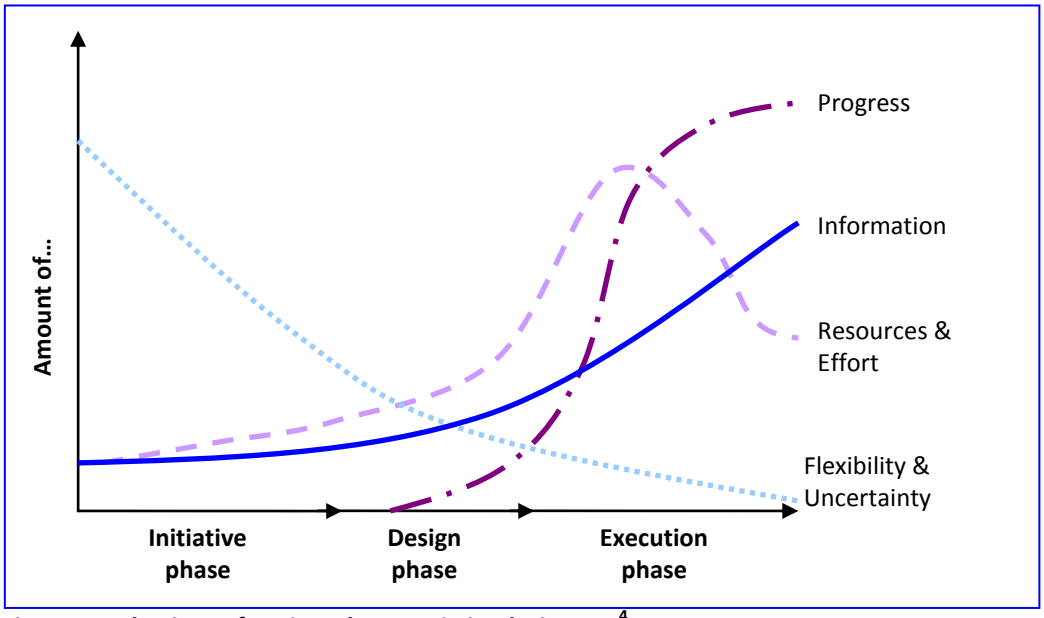


Figure 4, Behaviour of project characteristics during PLC[4].

[4] Based on Wideman (1989), Olson (2006) and Carrayannis et al ()

Progress related to Resources & Effort
Meredith and Mantel (2006:14-16) and Winch (2002:170-172) in their books on projects both describe the progress of a project as a rolling wave. The project starts out slow when the project team and initial resources are assembled. Than the construction phase starts and momentum builds up, until the final tasks where the different components of the project come together. Another explanation of the slow finish according to Meredith and Mantel (2006:14) is that project members deliberately slow down. The reasons not given by the authors could be the uncertainty of work on another project is the attachment to the project.

The amount of resources and effort are related with the progress of the project. In the beginning there will be effort from the initiator who wants a situation changed. When the direction is agreed upon, effort is put in the definition and design of the project. The execution phase by far the most resource intensive phase and in the middle of the phase most resources are placed. Nearing the overall end of the project subprojects are rounded of and resources are placed on other project and decreases.

Available information related to Flexibility and Uncertainty
During the PLC more information related to the project is known. This is closely link to the amount of uncertainty on the scope of the project, because in the initiative phase the scope can be very broad and in the end there will be a physical object. In the initiative phase information is needed from the client and other stakeholders what they want (goals and objectives). During the design phase this is translated in scope, quality, cost and planning. In de execution phase information on the realised scope, quality, cost and planning is gathered.

3.1.3 Project constraints

A project has constraints to which the success of a project can be measured, according to Dobson (2007) there are internal and external constraints. Turner (2009) identifies 5 internal project constraints; scope, quality, organisation, time and cost. These five constraints are connected to each other, so if you would change the premises of one constraint, this will have an effect on at least one other constraint. In all projects there will be a driven constraint, one constraint that is (slightly) more important than the rest. The driven constraint will for a large part determine the success of a project. Other constraints will change to meet the accomplishment of the driven constraint. An example of a project where time is the driven constraint is an Olympic stadium, the project has to be finished before the game starts even if that means that more cost have to be made, quality is less or the scope is simplified.

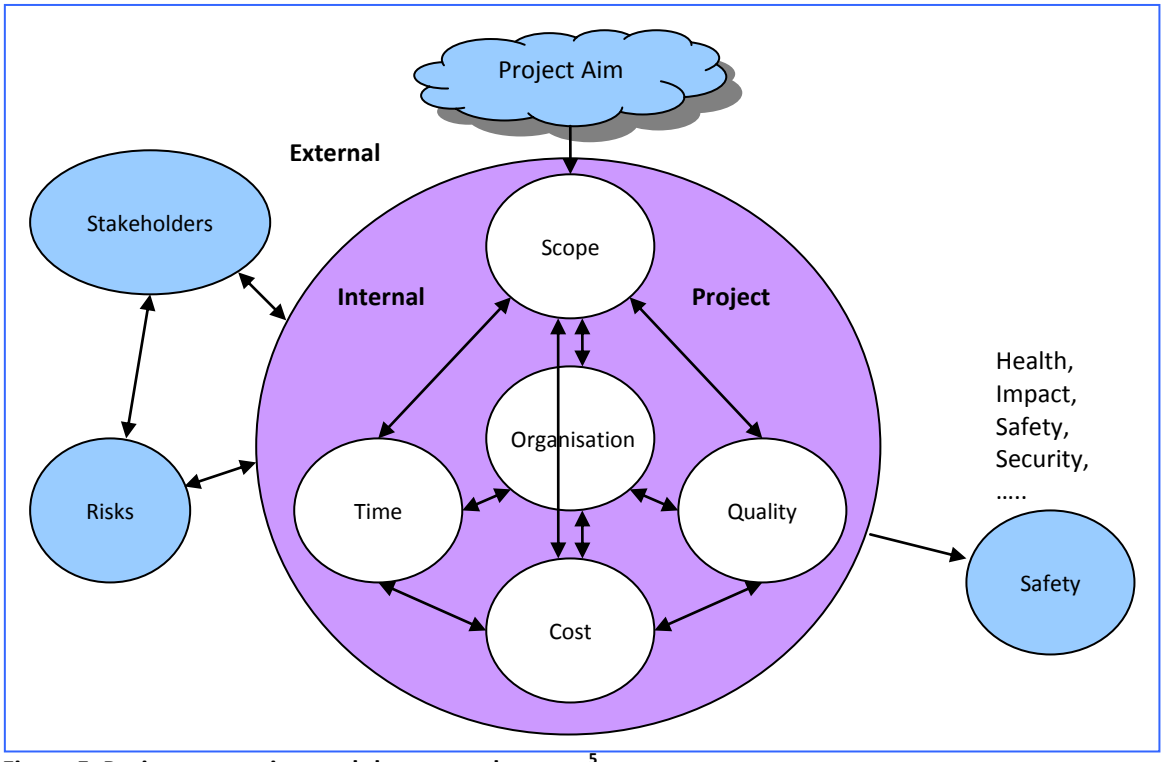


Figure 5, Project constraints and the external aspects[5].

[5] Sheet (November 2009) Project Management, A. Verbreack, based on Turner.

3.1.4 Scope

Winch (2002) states that scope identifies the core requirements of the service, and any additionally desirable services, together with any constraints upon service delivery such as latest date for availability, or regulatory requirements. This definition is more focused on the functional requirements of what a project must deliver and not on the actual object the project must deliver, so this definition is not complete. Also the constraint of latest date for availability is a time constraint rather than a scope constraint.

Other definitions found on a project management internet source[6] are:

- The sum of work content on a project[7]. This is only focused on the needed activities in the project, so the definition is not complete.
- The bounded set of verifiable end products, or outputs, which the project team undertakes to provide to the project sponsor. The required set of end results or products with specified physical or functional characteristics[8]. This definition stipulates the physical and functional aspect of the object as project scope, however the activities are left out which still leads to an incomplete definition.
- Scope is the way that we describe the boundaries of the project. It defines what the project will deliver and what it will not deliver[9]. This definition implies that there is room to manoeuvre within the scope, a margin. Instead of looking at scope as a fixed point it can be looked as a box representing a solution space for the eventual product/project. However it does not stipulate that during the PLC these margins diminish when the project sequentially enters the design and construction phase. To illustrate this development the manoeuvrability of the scope of the Betuweroute is presented in Figure 6. In the initiative phase there was the desire to strengthen the position of the Netherlands as a freight transportation hub for Europe by strengthening the West-East corridor. This could be done by investing in transportation by water, road or rail. The choice was made for the investment in rail, decreasing the manoeuvrability of the scope. Than the decision was made for a new freight rail connection trough the Betuwe. During the design the scope becomes clearer; the trace, the alignment, number of bridges, viaducts and tunnels, materials and construction methods.

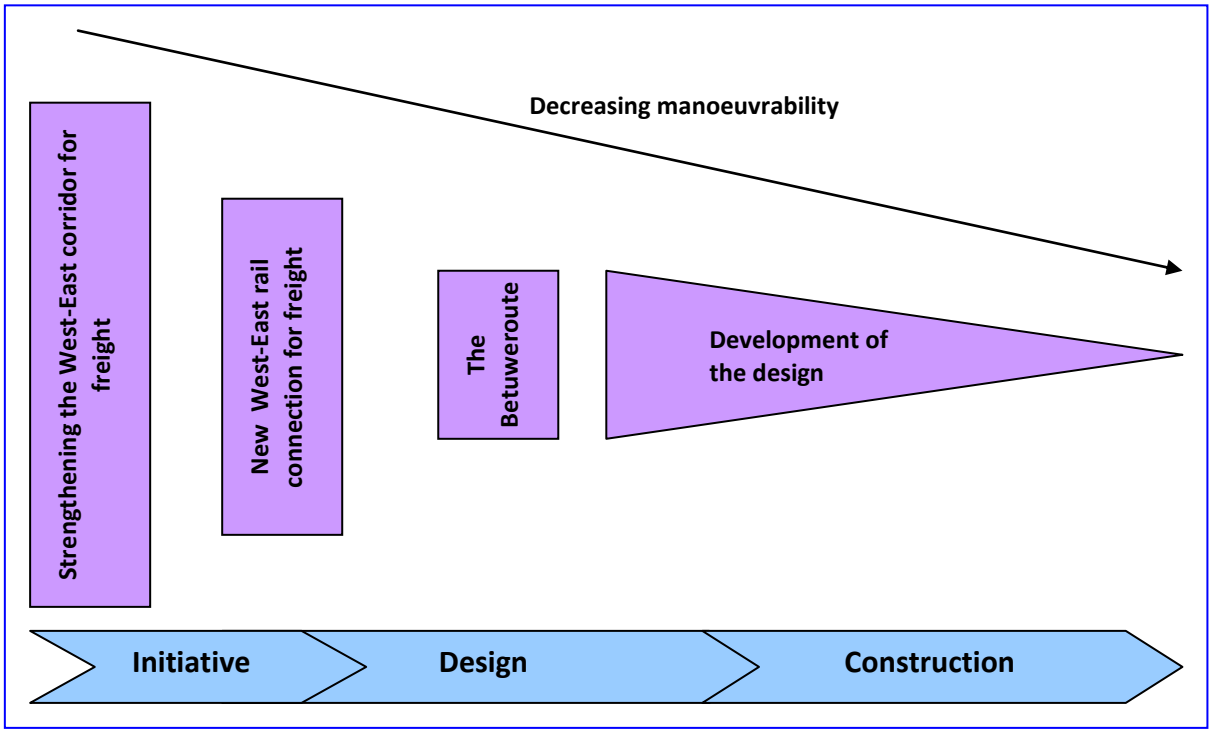


Figure 6, Decreasing manoeuvrability in the PLC of the Betuweroute (author).

[6] http://www.maxwideman.com/pmglossary
[7] Various original authors quoted in Welcom PM Glossary, Project Management Solutions, Internet: 1998
[8] Wideman, R. M. Framework Handbook, Project Management Institute, 1991
[9] Mochal T, the TenStep Project Management Process

The last two definitions describe scope as a solution space in which the project deliverables can manoeuvre. This paper however uses the definition that the scope itself changes/develops from a loose description in the early stages till a completed structure at the hand-over of the project. The difference between the two concepts is visually explained in Figure 7.

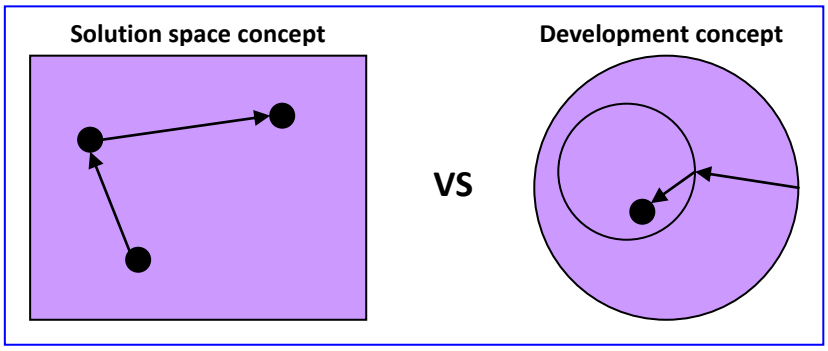


Figure 7, Different concepts of scope (author).

The most used definition of scope and fits best the concept of scope used in this paper, is that of The Project Management Body of Knowledge (2000:51), which distinguishes scope into two parts:

- **Product scope;** the features and functions that characterize a product or function.
- **Project scope;** the work that must be done to deliver a product with the specified features and functions.

This definition of scope combines the work content of the earlier mentioned definition in the project scope and the bounded set of verifiable end products of the other definition in the product scope.

In the figure below the development of a high speed rail connection between two cities is presented. In the initiative phase the description of the product scope will be functional and gradually during the PLC the product scope becomes more specific and the scope takes more shape. Parallel with the development of the scope, the required quality description becomes clearer.

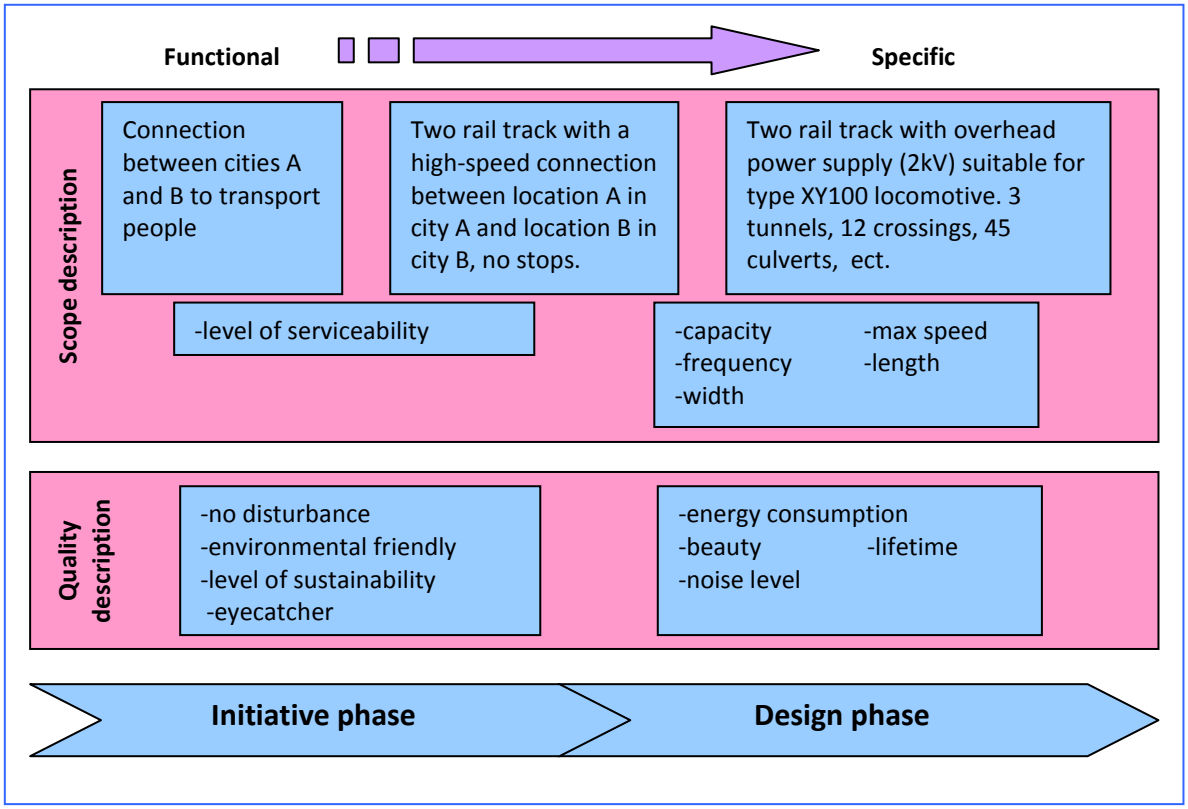


Figure 8, The development of the product scope from functional to specific (author).

In a project the work content can be represented in a Work Breakdown Structure (WBS) and the product in a Product Breakdown Structure (PBS). These breakdown structures are related to each other, every product element will have at least one connection with an activity on the same breakdown level (see Figure 9). The PBS is focused on the question what needs to be build and the WBS is focused on the question how it is build.

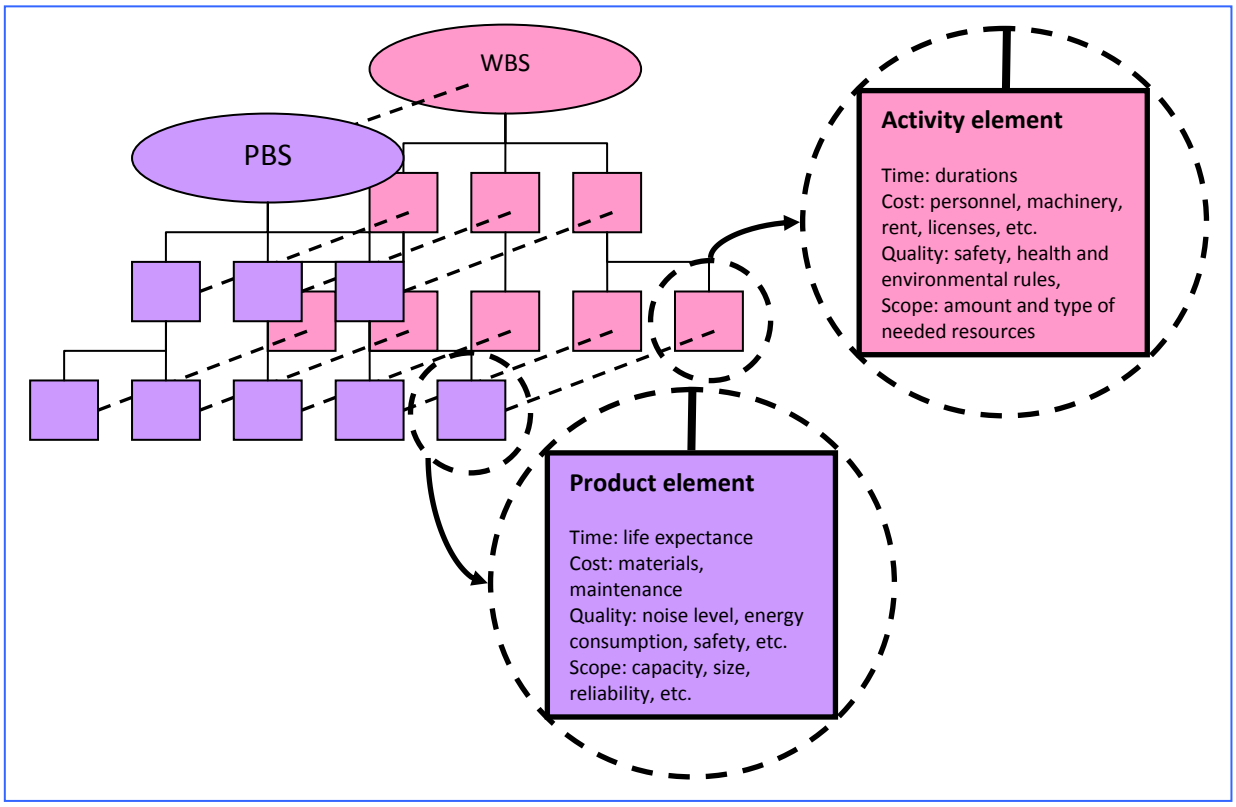


Figure 9, The relationship of the PBS and the WBS of a project (author).

In the figure below this process is illustrated with the different scope documents. The product scope definition can come in many forms, at the start the documents will have a high level of flexibility because of a low detail level. Towards construction of the project the documents are highly detailed and there is little room for unexpected changes, without causing problems. Ideally the dimension of scope will move from functional in the beginning to specific in the end.

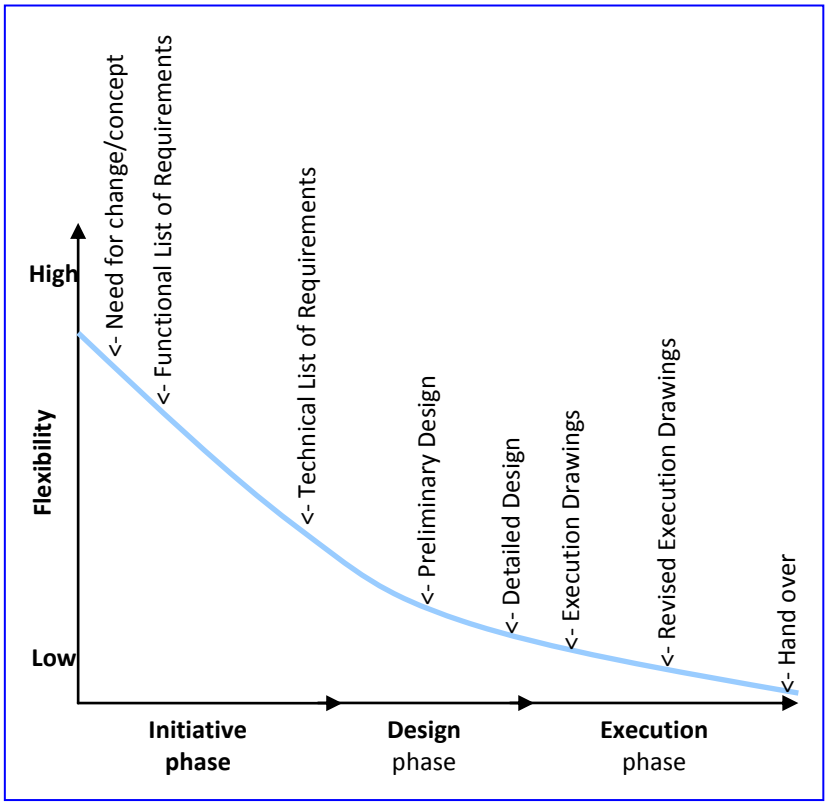


Figure 10, Change of the product scope documents during the PLC (author).

3.1.5 Quality

The Business Dictionary[10] provides the following definitions:

1. General: Measure of excellence or state of being free from defects, deficiencies, and significant variations. ISO 8402-1986 standard defines quality as "the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs."
2. Manufacturing: Strict and consistent adherence to measurable and verifiable standards to achieve uniformity of output that satisfies specific customer or user requirements.
3. Objective: Measurable and verifiable aspect of a thing or phenomenon, expressed in numbers or quantities, such as lightness or heaviness, thickness or thinness, softness or hardness.
4. Subjective: Attribute, characteristic, or property of a thing or phenomenon that can be observed and interpreted, and may be approximated (quantified) but cannot be measured, such as beauty, feel, flavour, taste.

The first two definitions relate quality to the compliance to earlier stated requirements and the last two stipulated the description of quality as the characteristics and aspects of a product or service. According to Turner (2009) the first two definitions describe the performance, the linkage between scope and quality. The first explanation can also be found in other sources, such as the Office for Quality Programs[11], which compiles the following definitions:

Joseph Juran & Frank Gryna
"Quality is fitness for use."
Robert Peach, The ISO 9000 Handbook
"...the totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs."
Armand Feigenbaum
"Quality is a customer determination based upon a customer's actual experience with a product or service, measured against his or her requirements -stated or unstated, conscious or merely sensed, technically operational or entirely subjective -and always representing a moving target in a competitive market."
American Society for Quality (ASQ)
"Quality denotes an excellence in goods and services, especially to the degree they conform to requirements and satisfy customers."

[10] http://www.businessdictionary.com/definition/quality.html
[11] http://web2.concordia.ca/Quality/definitions.html

Peter Senge et al, The Fifth Discipline Fieldbook
"Quality is a transformation in the way we think and work together, in what we value and reward, and in the way we measure success. All of us collaborate to design and operate a seamless value-adding system that incorporates quality control, customer service, process improvement, supplier relationships, and good relations with the communities we serve and in which we operate - all optimizing for a common purpose."

These definitions all describe quality as the level of compliance to earlier requirements or expectations, which again according to Turner (2009) describe the performance. This paper uses the latter definition and defines quality as the aspects, attributes and characteristics of project and product scope. As provided in the definition of the Business Dictionary they can be objective (good to measure) or subjective (difficult to measure). Subjective quality is most difficult in a project, first it is hard to quantify and second there is can be a great difference of experience of subjective quality between client and other stakeholders.

Yasamis et al. (2002) provide us with the best definition and divide quality into the quality of (i) the end product or service (product scope), (ii) all the transformation processes (project scope), and (iii) the inputs used to provide the final goods and services (product scope). This is translated in a scheme (Figure 11), in this paper the focus is on quality on project level. In the dimension squares we can distinguish the objective and more subjective characteristics of both product and project (service in scheme) scope. However certain characteristics are (by the definition of this paper) not attributed to quality, such as performance (match quality and scope), time and timeliness (part of constraint time). Conformance and completeness according to this paper should not be part of quality as a project constraint, but rather a measurement of difference between the designed quality level and the constructed quality level.

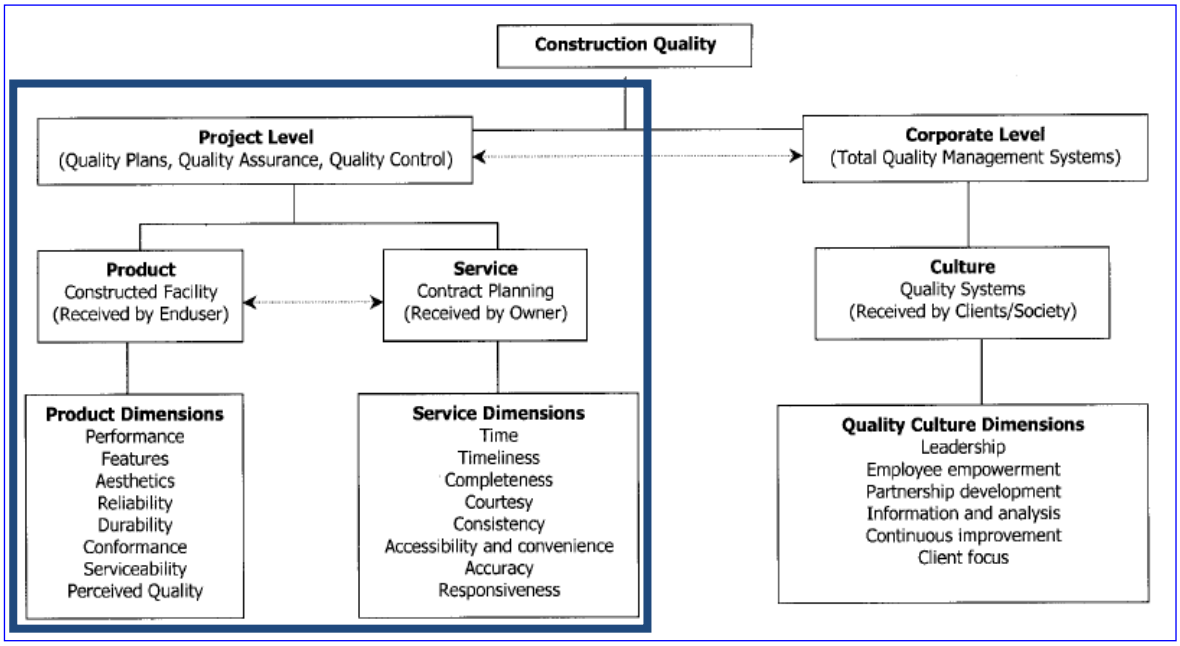


Figure 11, Framework for construction quality (Yasamis et al. 2002;213).

The product and service dimensions describe the required level of quality which the client expects of the project. The needed level of the dimensions should be set out before moving into the design phase where it is translated into a specific scope definition. Just as scope, these dimensions are also subject to change in all project pahses. In this research quality will be defined as the underlying or secondairy functions, both objective and subjective, of project and product scope. Quality will alsways be described in intangible aspects and not in objects, objects fall under the scope of a project.

3.1.6 Quality and Scope

As was shown in the two previous sections, there are different definitions for scope and quality. Some do not cover the entire concept and some definitions of scope and quality overlap, especially when describing the functions and characteristics of a project. This leaves us with the question what function of a project is scope and what is quality? Scope is related to the main function of a project and quality is more related to secondairy functions and characteristics of a project.

To illustrate, let us look at a new road connection between city A and B. The functional product scope is; increasing vehicle capacity between two cities, reducing travel time between two cities, dissolving congestion on existing road. The specific product scope is; the new road, including tunnels, viaducts, traffic lights, ramps and exits, etc. The project scope is; constructing the road, including expropriation, preparing the land, laying the foundations, the asphalt, making the tunnels, viaducts, ect. The quality of the new road are; eastethics of the road design, safety for roadusers and residents, noise reduction, pollution, ect . The improvement of the capacity and travel time will benefit the higher order quality aspect such as the local economy by improving the overall attractiveness for companies and citizens to settle in the city.

3.1.7 Quality and scope in contracts

Traditionally the government as a client would design the infrastructure projects and then go to the market to find a contractor who would build it. In this role the government as a client would specifically define the scope of a project in detail in terms of what must be build. The contractor could only influence the project scope, how he could build it. However because the product scope was fixed, the project scope was also more or less fixed. Today more and more responsibilities are transferred to the contractor in DB (design and build), DBM (design, build and maintain) or even DBMF (design, build, maintain and finance) contracts. The client in these contracts should be more focused on the functional scope and quality requirements of the project rather than the specific scope requirements. This leads to more flexibility for the contractor for the product scope and thus project scope. The idea of the DB type contracts is that the contractor can work more innovative and cost effective, which will benefit both parties. Because the contractor is involved in the design of the project he is earlier involved in the PLC (see Figure 12). For the DB contracts to be successful the client has to be able to specify its needed quality and functional scope and that is easier said than done. Because people are still visually minded they tend to think in object rather than functions. To overcome this problem value management methods can be applied, which will be discussed in chapter 3.2. In a DB contract the client is responsible for a clear quality and functional scope definition and the contractor is responsible for a good translation into a specific scope definition; the transformation process.

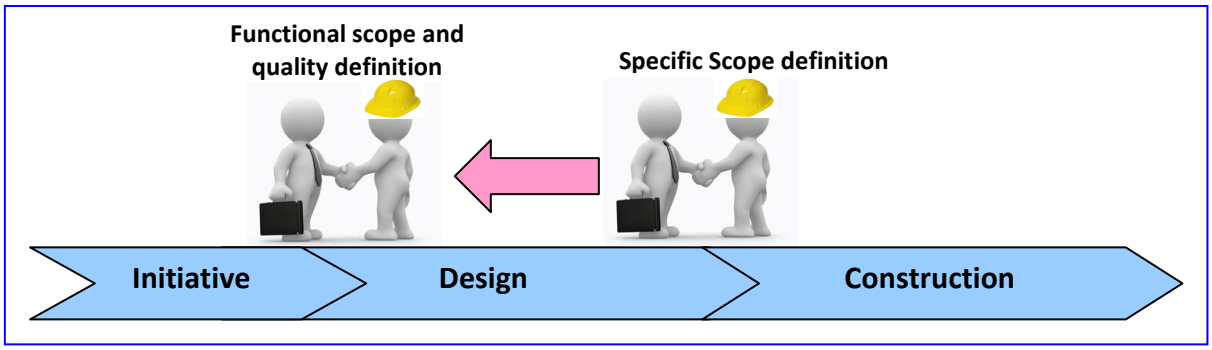


Figure 12, Involving the contractor earlier in the PLC (author).

3.1.8 Value

Stewart (2005:43), in his book Fundamentals of Value Methodology, explains that the evolution of the concept of value has been a long one. Formulas have been developed to provide a more tangible visualisation of the concept. Stewart (2005:46) uses the following definition of value;

A qualitative or quantitative expression of the relationship between the performance of a function, and the cost of acquiring it. Hence the term "best value" refers to the most cost effective means to reliably accomplish a function that will meet the performance expectations of the customer.

Stewart (2005:46) describes performance as being the sum of scope and time, in contrast with Turner (2009) who described it as a relationship between scope and quality. The visualisation and equation used by Stewart is illustrated in Figure 13, value can be increased by changing one or more of the constraints. However the quality of a project also has an influence on the value of a project, so it must be included in Figure 13.

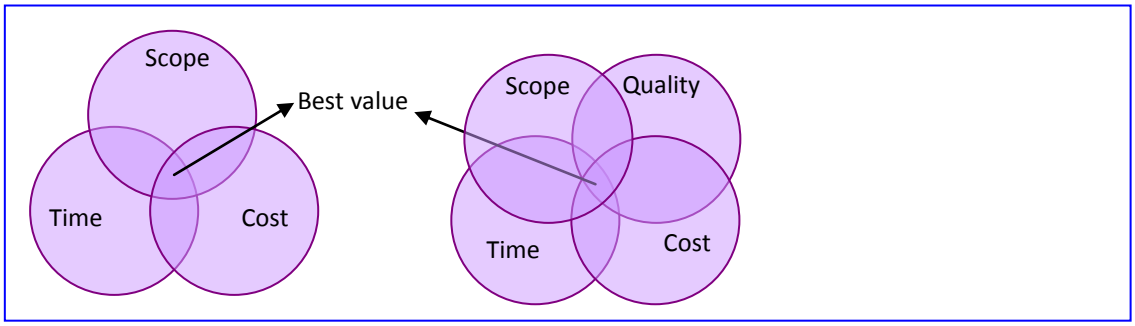


Figure 13, The composition of value (Stewart, 2005:42) on the left and revised on the right.

Stewart (2005:42) also focuses on the economic value of a project that can be separated in; cost (of labour, material and overhead), exchange (trade value), esteem (attractiveness of ownership) and use (properties or qualities of that accomplish the work).

De Ridder (2007:374), in his booklet of the living building concept, states the following on value:
"The aim of construction is to produce an acceptable difference between value on the one side and cost on the other side."

Value for a client can be described in different ways, De Ridder and Vrijhoef (2007:2) separate it in psychic (like aesthetics and luxury), functional (capacities) and technical (climate, energy consumption and safety) value. But the value for a client can also be divided in different levels. For a firm the micro economic value (profit/loss) will play an important role. A nation will make a decision not only on the profit or loss of project but will also take into account growth, employment and inflation which make up the macro economic value. And today the environmental, health and culture values of a project are also important and describes the political value.

The three different break downs of are compared in Figure 14. The description of value in Figure 14 is focused on the economic view of value in broad terms. Stewart (2005) separates this economical view in more tangible properties of value. The description of value of De Ridder (2007) focuses more on the quality aspect of value as it is used in this paper.

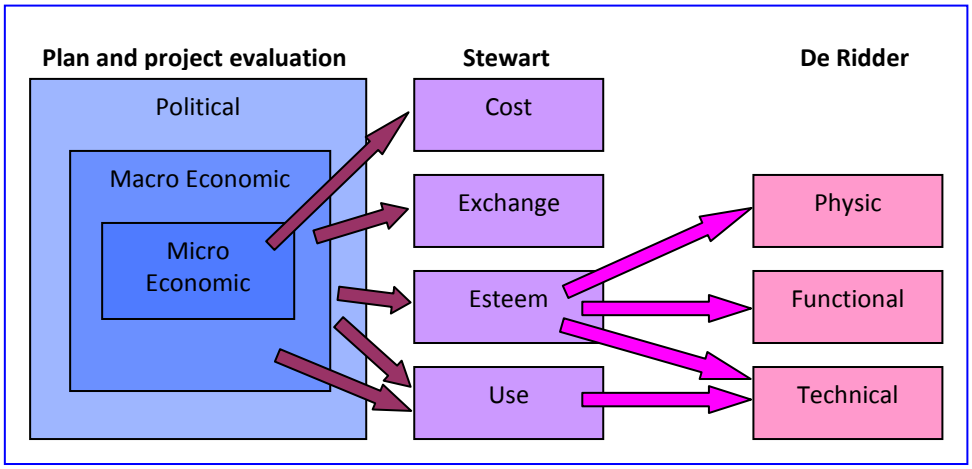


Figure 14, Relations between different interpretations of value.

During the PLC there are also different levels of uncertainty about the eventual value of the project. In the initiative phase the different levels of value are determined by the client (and in co-operation with stakeholders). These values will be translated in a list of requirements that will eventually result in a design. Only when the project is finished and fully operational we know for certain the amount of value. Some aspects of value however are difficult to quantify, for instance aesthetics. Because of uncertainty you should just as you would do with cost apply a probability distribution which changes over time. In Figure 15 the development of value during the PLC is presented. In the initiative phase the needed value will be determined (List of Requirements) for the project. In the design phase these requirements will be translated into a design, the design will have uncertainty about the level of value it will produce. During construction more certainty about the eventual value will be gained, so the probability distribution is more peak shaped. When the product is fully operational the value it produces will be certain.

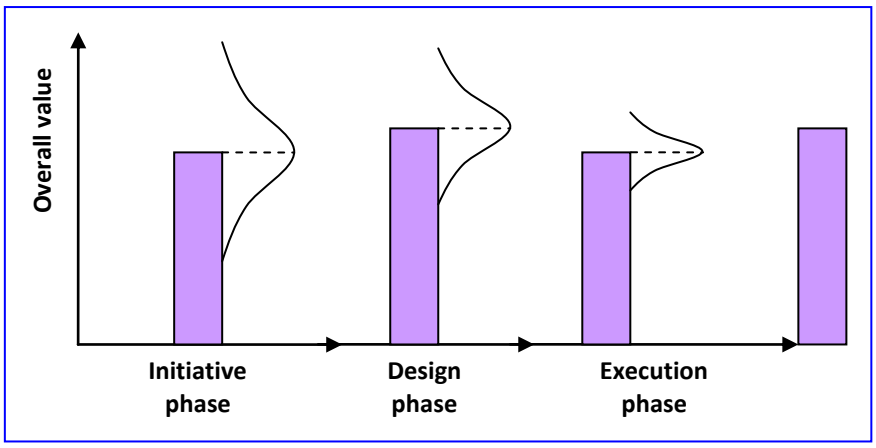


Figure 15, Development of value during PLC (author).

3.1.9 Summary part one

This part highlighted the characteristics of a project. The PLC is introduced to discuss the dynamics of a project, the development of the characteristics of a project are parallel to that of the PLC. The project starts in the initiative phase, where the need/desire for change leads to the functional specifications of a project. The following phase is the design phase where the wishes of the client are translated into a design which is ready for implementation. The construction phase is the implementation phase of the design. In this phase the most resources and effort are required, and the project takes shape in a physical sense.

All projects are bound by the project constraints; scope, time, cost, quality and organisation. The success of a project is determined by these constraints and for a large part by the driven constraint. The constraints are linked, so changing one constraint will have an effect on at least one other constraint. Extra attention was paid to explain the definitions of scope and quality and their relationship, because in literature the subject was under lighted or opinions varied. In this paper scope is divided in product and project scope and the description develops gradually in a project from broad specification towards a completed construction. The definitions of quality in literature vary greatly and are broad. In this research quality is defined as the underlying or secondairy functions, both objective and subjective, of project and product scope. The relation between scope and quality is closely linked to the PLC. In the initiative phase the needed quality is agreed upon and in the design phase these underlying and secondairy functions are translated in a design. In the end the manner in which the end product (scope) fulfils the wanted quality is a measure for its performance.

Projects create value for the client and are the reason for the initiation of the project. Value can be described as the sum of scope, quality, time and cost. The wanted value agreed upon in the initiation phase between all relevant parties will determine the scope of the project that must generate this value in the end.

3.2 Part two, Scope development

3.2.1 Introduction

This part is devoted to scope management as part of scope development which is important in the first half of the PLC. This chapter will provide answers a part of the research questions mentioned in the research design, namely:

- What is scope management?
    - How can we define scope?
- What relationship does scope have with stakeholders?

Three management methods are introduced to guide the process of scope definition; stakeholder, value and flexibility management. In Figure 16 the methods are placed in the PLC. Stakeholder management is important during the entire PLC, however the most benefits can be reaped in the beginning of the PLC (illustrated by the difference in tint). The first part of stakeholder management is to indentify stakeholders, develop strategies of approach and get a clear view of the problem area. The next step is to translate the problem description into needed quality and this is done trough value management. Stakeholder management remains an fundamental part because stakeholder opinions may change and strategies have to be changed and during the entire PLC stakeholders need to be informed or involved.

Value management focuses on the needed functions to create be best value rather than developing scope to early. This is essential part of scope management as argued in this paper. First the needed functions should be clarified before entering the design phase. Value management delivers a structured hierarchical network of functions, which will form the basis for the actual scope description. In the design phase the tangible scope of the project takes shape, and in this phase it is important to anticipate on future scope changes.

Even though the previous efforts created a most complete scope, the scope will change during the PLC. The practice of flexibility management sets out to create a product scope that is better in accommodating scope changes. Modularity is applied on the scope to diminish relations between scope components. Scope changes in one component have no or little effect on other components, which of course benefits the entire scope of the project. Modularity will also benefit the product when certain components become outdated and need to accommodate other or more functionalities.

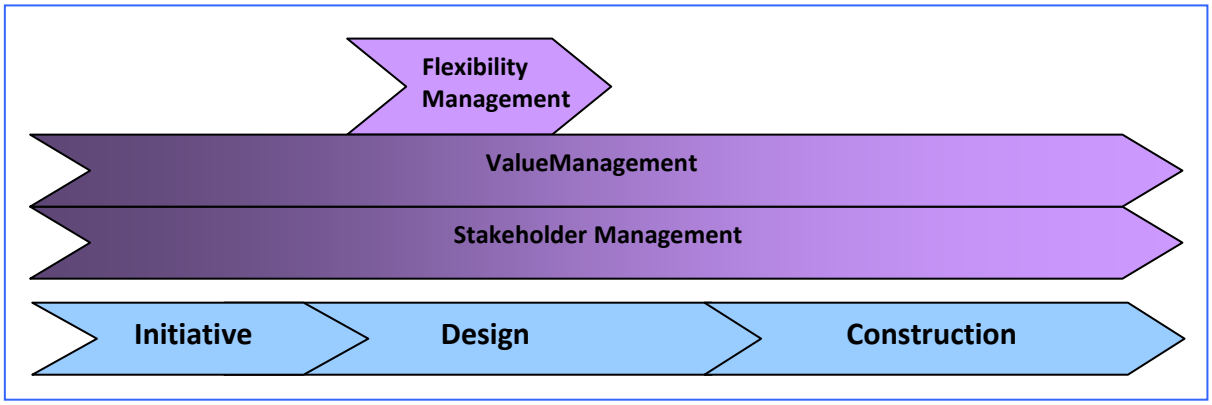


Figure 16, Management methods and their place in the PLC.

3.2.2 *Importance of scope definition*

In the initiative and design phase it is important to a clear and complete scope of the project, so that all necessary changes in scope are located and processed at an early stage. Because when scope changes occur in a project the effect it has on the other project constraints is highly dependable on the moment in time it occurs. . The later a scope change is introduced, the more effect it has on the other project constraints (see **Figure 17**). To reduce unnecessary scope change and create a clear and complete scope several theories can by found in process management literature that will be discussed in this chapter. Or the purpose of this paper these collection of theories contribute to a clear and complete scope definition.

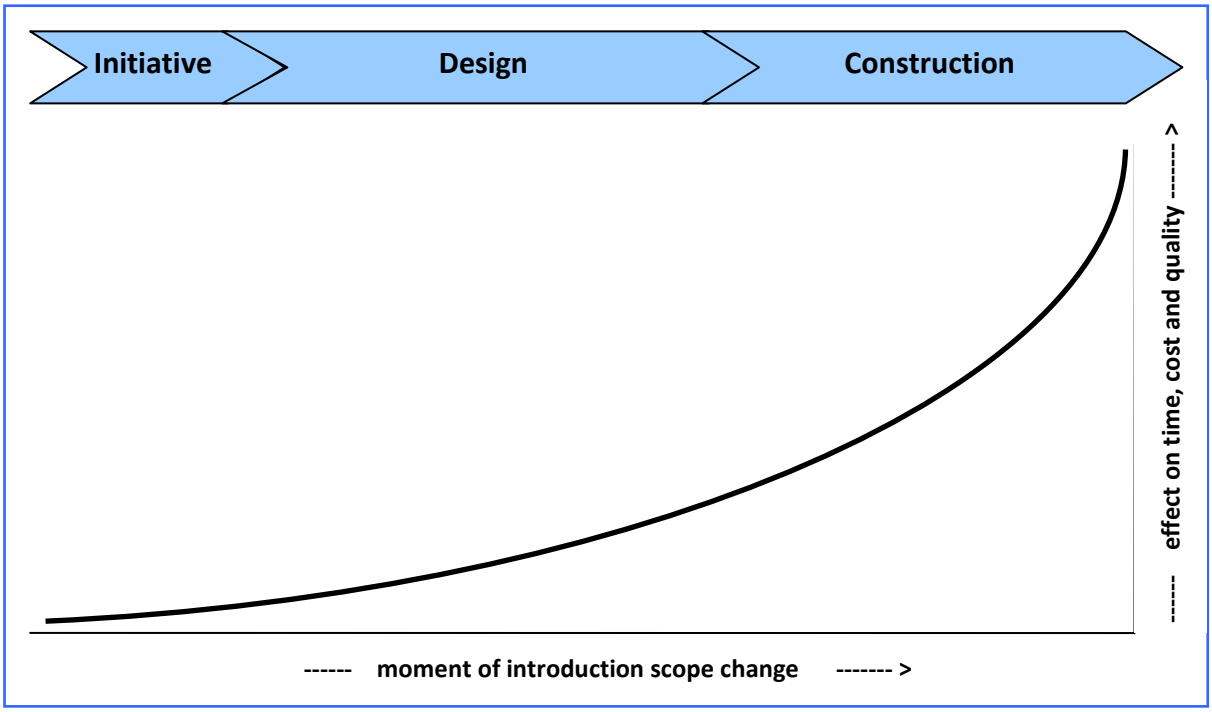


Figure 17, The effect of the moment of scope change implementation on project constraints (author).

3.2.3 Stakeholder management

Because the client is not the only person that will influence the scope it is essential to also include stakeholders in defining the scope of the project. Turner (2009:757) stipulates that besides the project constraints, the success of a project is determined by the level of stakeholder satisfaction. The satisfaction of stakeholders depends on hard factors (created value for stakeholder) of the project and the soft aspects of the process (involvement, approach). In this paper the value for the stakeholder is important, because scope generates value. Thus stakeholders will influence the scope of a project and stakeholder management is needed to guide this process.

Stakeholders

Two definitions of stakeholders used in Turner (2007:759) are:

"A person or group of people who have a vested interest or role in the success of an organization and the environment within which the organization operates (BS 6079-2:2000 Guide to Project Management)"

"Stakeholders are all those with an interest or role in the project or who are impacted by the project (PMBOK 5th edition)"

Because these definitions of stakeholders results in a exhaustive list of potential stakeholders it is important to make a division. Winch (2007:70) divides stakeholders in:

- **Project stakeholders**, those actors which will incur a direct benefit or loss as a result of the project.
- **Internal stakeholders**, stakeholders that are in legal contract with the client (demand and supply side).
- **External stakeholders, s**takeholders that have a direct interest in the project (public and private actors).

Project and external stakeholders will have the most influence on the project because they have an interest in the project. For large infrastructure projects it is important to divide these groups even further. First category is their focus of attention (national, regional and local), which will influence the moment of their involvement in the PLC. Second category is the type of organisation (public or private) which will for a large part determine their power.

Because the level of their attention is different their level of involvement changes over time when the project scope becomes more specific. In the initiative phase a problem is recognised and a stakeholder (most of the time future client) steps forward to solve the problem, national stakeholders get involved who have an interest in solving the problem. In the design phase functional requirements are translated into physical scope and it becomes clear where the project is going to be build and what the consequences are. In this phase regional and local stakeholders become involved to make sure their interests are heard. These dynamics of involvement are illustrated in Figure 18. Besides that the involvement of the different stakeholders change over time, their attitude and power also are susceptible to time.

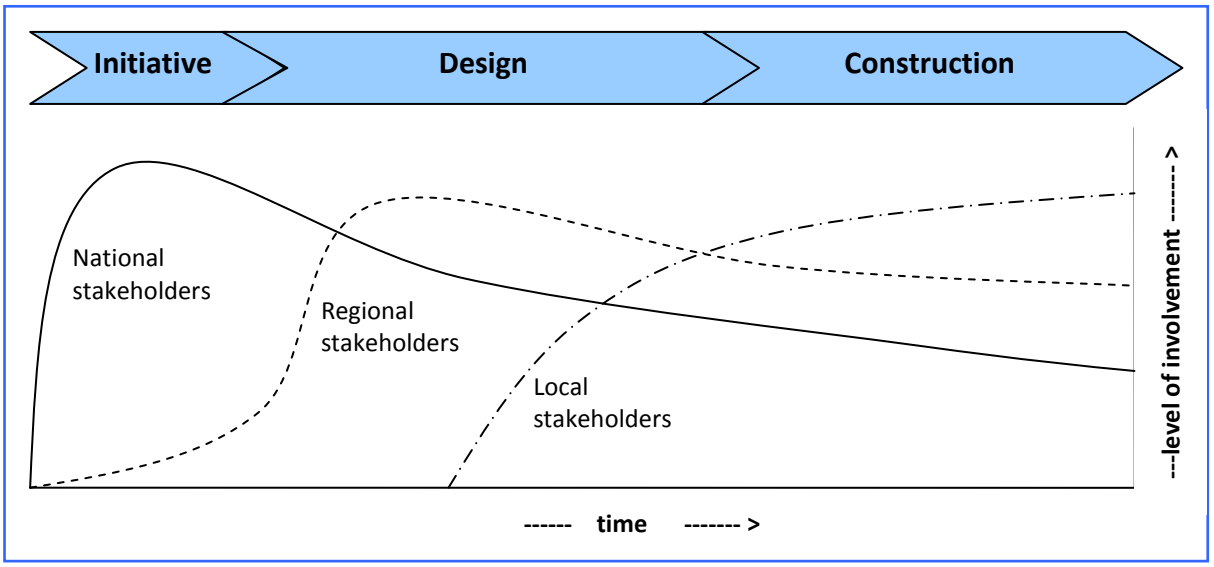


Figure 18, Involvement of different stakeholders over time (author).

The dynamics of the impact of stakeholders leads to the following stakeholder dilemma:

Involving stakeholders early in the project life cycle will lead to more scope changes however the effects on the other project constraints will be less. Not involving stakeholders will lead to (less) stakeholders being involved in a later stage with possible fewer scope changes but higher effects on other project constraints.

The outcome of this dilemma will be that involving stakeholders will be more beneficial because of the exponential character of the effects on the project constraints. This is also being recognised by the Dutch government in a recent article[12] in the Cobouw. To stimulate the economy in difficult weather a new Tracé Law that is designed to cut the procedural time of infrastructure projects in halve (from 14 years to 7 years) and thus earlier deliverance of projects. In the article the State Council questions the time benefits, because although local and regional governments have less opportunity to appeal by the short cutting of procedures, they do still have the opportunity to follow a civil procedure. The government tries to prevent this, by involving stakeholders more in the early phases of the project. The used argumentation is backwards; we want to save time so we must involve stakeholders earlier, rather than we must involve stakeholders earlier and this will also have a time benefit. So governments do indirectly notice the benefit of early stakeholder involvement for saving time, which is a good first step. Maybe in the future they will also understand that early stakeholder involvement will also lead to better scope and best value for all parties.

Stakeholder management

Two definitions of stakeholder management in Turner (2007:760) are:
Stakeholder management is systematic identification, analysis and planning of actions to communicate with, negotiate with and influence stakeholders (BS 6079-2:2000 Guide to Project Management)

Stakeholder management is the continuing development of relationships with stakeholders for the purpose of achieving a successful project outcome (PMBOK 5th edition)

Bryson (2004) discusses various stakeholder analysis methods, each stakeholder analysis highlights a particular feature of the stakeholders. Main reason for the use of stakeholder analysis methods is that the model simplifies the complex reality, which makes it easier to choose the right strategy. Some methods will be briefly described:

- **Stakeholder survey**, an overview of all major features of the stakeholders; general interest, problem perception, specific goals and means herein stated. The survey is the basis for all other analysis methods.
- **Critical actors**, based on dependence and substitutability of resources is determined a stakeholder is critical or not.
- **Power versus interest grid**, power and interests of each stakeholder in the project are plotted in a 2x2 matrix to determine the strategy of approach.
- **Problem frame stakeholder map**, supporters and opponents of a project are plotted in this 2x2 matrix also taking into account their power. This method is used to find winning coalitions.
- **Stakeholder-issue inter-relationship diagram**, a schematic representation of all stakeholders in their mutual relations and issues.

In appendix 9.5,9.6,9.7 and 9.8 examples are given of a those methods for the Betuweroute

According to Turner(2007:757-776) stakeholder management is important for the success of the client, because not involving them will result in higher cost for the client. Winch (2007:66-81) takes a more holistic approach and discusses the importance of stakeholder management for the overall value improvement for the project by including more interests. Winch (2007) in contrast to Turner (2007) does not see stakeholder management as a necessary evil, but as a improvement. For the purpose of this paper it is important that stakeholders influence scope and that these influences should be taken into account to create a complete scope as possible before the design phase starts.

[12] "Tijdwinst nieuwe Tracéwet 'onzeker'" (in english: "Time savings new Tracé Law 'uncertain'"), Cobouw, 11-5-2010/nr 88.

Important steps in stakeholder management (Turner, 2007:761-776) are:

1. **Identification of project success criteria**, what are the criteria for the client in terms of scope, time, cost and quality.
2. **Identification of resource requirements**, all tangible and intangible resources to indentify the resources for which the client is dependable on stakeholders.
3. **Identification of stakeholder groups and interest levels**, different stakeholders will have different success criteria. These will determine if they are beneficiary, loss or regulatory stakeholders
4. **Conduct stakeholder analysis**, to determine their attitude (oppose, support or no commitment), level of involvement, level of power.
5. **Develop strategy for each stakeholder**, the output from the previous step is used to develop strategies (ignore, inform, involve).
6. **Monitor and review**, stakeholder opinions changes, which will influence the stakeholder satisfaction.

Winch (2007:70) states that;
An important part of stakeholder management is to find ways of changing opponents to supporters by offering appropriate changes to the project mission, and preventing possible supporters defecting to the opponent camp by offering to accommodate more explicitly their proposed problem solutions.

This statement has severe consequences for the scope of the project, because a change of the project mission will lead to a change in scope. But the upside is that the stakeholder is satisfied and the likelihood that he will oppose to the project in a latter stage and change the scope is low, because due to the change he is committed to the project.

Problem structuring: Alexander's synthesis
The previous methods are focused on indentifying stakeholders and stakeholder issues and developing strategies for stakeholder approach. However the most important element is how do we handle the different perspectives of stakeholders on a problem. Joham et al (2009) present an approach that structures these differences by encouraging the problem solver to flip from 'zooming in' to 'zooming out' on the problem area. Especially zooming out is important because people tend to zoom in to get a better grip on the problem. Zooming in to early will lead to an incomplete description of the problem and thus eventually an incomplete scope with all its negative consequences.

The method contains several steps (Joham, 2009:789):

- The process involves first giving each stakeholder an opportunity to describe what they understand is the purpose of the project, and then to state their concerns. This often subdivides the stakeholders into contrasting groups. Their differences can be used to improve the reasoning of the other.
- Next, each stakeholder is encouraged to make conditional statements about what the project is. These are recorded and in the third stage presented sequentially for all those present to debate.
- The debate is intended to edit the wording of the statements until there is a clear majority agreement on the statement. However it is done, numerous statements need to be collected and connected (synthesized). This involves deciding which statements are strongly related (linked or connected).
- Once this is done (and moving back to analysis) statement numbers and the connections between the numbered statements can be recorded in an Interaction Matrix. In this Interaction Matrix the strength of the connection can for example be quantified on a 5 point scale. This is then ready to be input into Network Analysis software, which in turn will produce a network graph with the statement numbers as nodes and the strength of the connection by the length of a line (the stronger the connection, the shorter the line). Statements with a strong connection will be grouped together, an example for the Betuweroute is given in the figure below. The issues in the stakeholder-issue relationship diagram in appendix 9.8 are used for the statements.

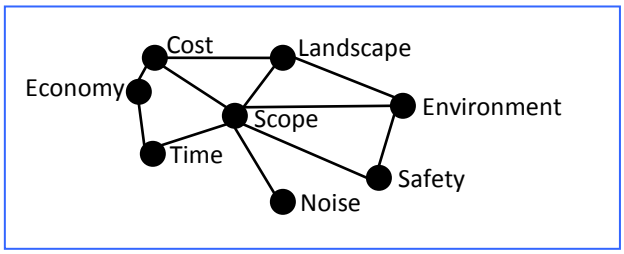


Figure 19, Network graph of the Betuweroute.

The network graph can be very useful starting point when developing the needed qualities of a project and eventually the needed scope. The next step in the scope definition is the application of value management to identify the needed functionality (or quality) of the project, this will be discussed in the following section.

3.2.4 Value management

In the previous section it was stipulated that we needed to involve stakeholders (who, how, when). What was not discussed is how we get the wanted scope from the client and stakeholder, value management can be used here. Value management builds on a strong involvement of stakeholders. Stewart (2005) in his book on value management states that the gathering of information in value management is not a one-way street and a thorough understanding of the project will only occur through a strong dialogue with stakeholders. So stakeholder management is an integrate part of value management practices. Green (1999) in his article notes that the purpose of value management is the maximization of the functional value of a project by managing its development from concept to occupancy through the audit of all decisions against a value system determined by the client. This however does not include the involvement of stakeholders in the process. Leung and Liu (2003) do indicate the importance of stakeholders by stating the following;

A primary purpose of value management, is to specify the client's and participants' values and goals explicitly through decision-making process. The determination of value and goal specificity for the project and the management of conflict among participants are fundamental in value management in order to determine the 'best' value by consensus/compromise.

Joham et al (2009) in there article on pragmatic methods for project conceptualization discuss the Alaxander's synthesis method that makes these differences visual to create understanding.

The process involves first giving each stakeholder an opportunity to describe what they understand is the purpose of the project, and then to state their concerns. This often subdivides the stakeholders into contrasting groups. Their differences can be used to improve the reasoning of the other. Next, each stakeholder is encouraged to make conditional statements about what the project is. These are recorded and in the third stage presented sequentially for all those present to debate. The debate is intended to edit the wording of the statements until there is a clear majority agreement on the statement. However it is done, numerous statements need to be collected and connected (synthesized). This involves deciding which statements are strongly related (linked or connected).
Once this is done (and moving back to analysis) statement numbers and the connections between the numbered statements can be recorded in an Interaction Matrix. This is then ready to be input into Network Analysis software, which in turn will produce a network graph with the statement numbers as nodes.

Stewart (2005:72-82) uses a job plan for the application of value management which is divided in eight steps:

- **Preparation**, conducting a pre-study to plan for the value study which will identify goals, objectives, assumptions and constraints.
- **Information**, all relevant information must be gathered from documents and stakeholders.
- **Function**, use function analysis to define, classify and evaluate functions to indentify functions that are not providing good value or are unnecessary.
- **Speculation**, creative process to develop ways of performing the functions and to improve the performance of the function.
- **Evaluation**, ideas of the previous phase are evaluated and a selection is made which ideas are further being developed.
- **Development**, develop concepts into specific value alternatives that have been technically validated.
- **Presentation**, to inform the owner, project team, stakeholders and the customer or user of the value team's findings.
- **Implementation**, the value team will be present to provide clarifications and assistance to the decision makers.

In the next section the most relevant phase for scope definition is discussed; the function phase, because in this phase the foundation is laid for the scope definition.

Function phase
The most important phase is the function phase, because here participants have to learn to think in functions rather than objects. To often clients focus to early on specific objects for filling in their projects. By doing this the solution space is drastically narrowed and the client runs the risk of realising a project that does not create

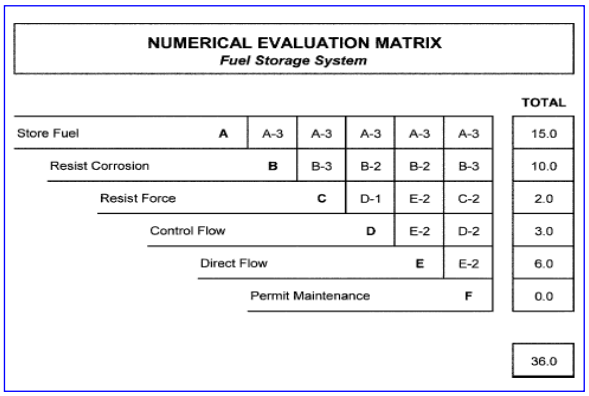
the best value. Subsequent phases (Stewart, 2005:163-173) in the function phase are; defining, classifying and evaluating functions.

Defining functions
Important in defining functions is to use only two words, a verb and a noun. The verb answers the question; "What does it do?" and the noun; "What does it do it to?". Instead of for instance the object noise barrier the function would be reduce noise. However other objects do also have this function, like a tunnel or a deepened alignment. So by thinking in functions, your solution space remains wider.

Classifying functions
To determine the relative importance of the produced functions it is important to classify the functions in:

- **Basic functions**, "What must it do?".
- **Secondary functions**, "What else does it do?".
- **Higher order functions**, identifies overall need related to a projects need and purpose. Establish connection (between city A and B (project)) can be a basic function, and a higher order function may be to improve the network (of all connected cities).
- **Assumed functions**, functions that lie beyond the scope of the study.

Evaluating functions
Stewart (2005:173-203) gives two methods; numerical evaluation matrix and FAST (Function Analysis System Technique) diagram. The numerical evaluation matrix determines the relative importance of the functions using a paired comparison method (see X).



NUMERICAL EVALUATION MATRIX
Fuel Storage System

							TOTAL
Store Fuel	A	A-3	A-3	A-3	A-3	A-3	15.0
Resist Corrosion	B		B-3	B-2	B-2	B-3	10.0
Resist Force	C			D-1	E-2	C-2	2.0
Control Flow	D				E-2	D-2	3.0
Direct Flow	E					E-2	6.0
Permit Maintenance	F						0.0
							36.0

Figure 20, Numerical Evaluation matrix, Stewart (2005:175).

A more sophisticated method which also investigates the relation between the functions is the FAST diagram. Important in establishing a FAST diagram are the questions; "Why?" and "How?", which determines the relation between functions. In Figure 21 the layout of a FAST diagram is illustrated, where we can see that the focus is on the hierarchy of functionality of the project. In appendix 9.1 the FAST diagram for a road improvement project is given. On the left are the higher-order functions (relieve congestion, improve safety, enhance aesthetics and improve utilities) that imply the needed quality of the project and describe the why. Going to the right in the how direction describes how the quality will be produced, and gradually turns into the project scope (repair pavement and create roundabout) as part of the WBS, and into product scope (repair pavement and create roundabout) as part of the PBS. So FAST diagramming is a useful method to force clients and stakeholders first to indentify the higher-order function, thus quality, and gradually arrive in sequential steps to the needed scope that satisfies the needed quality.

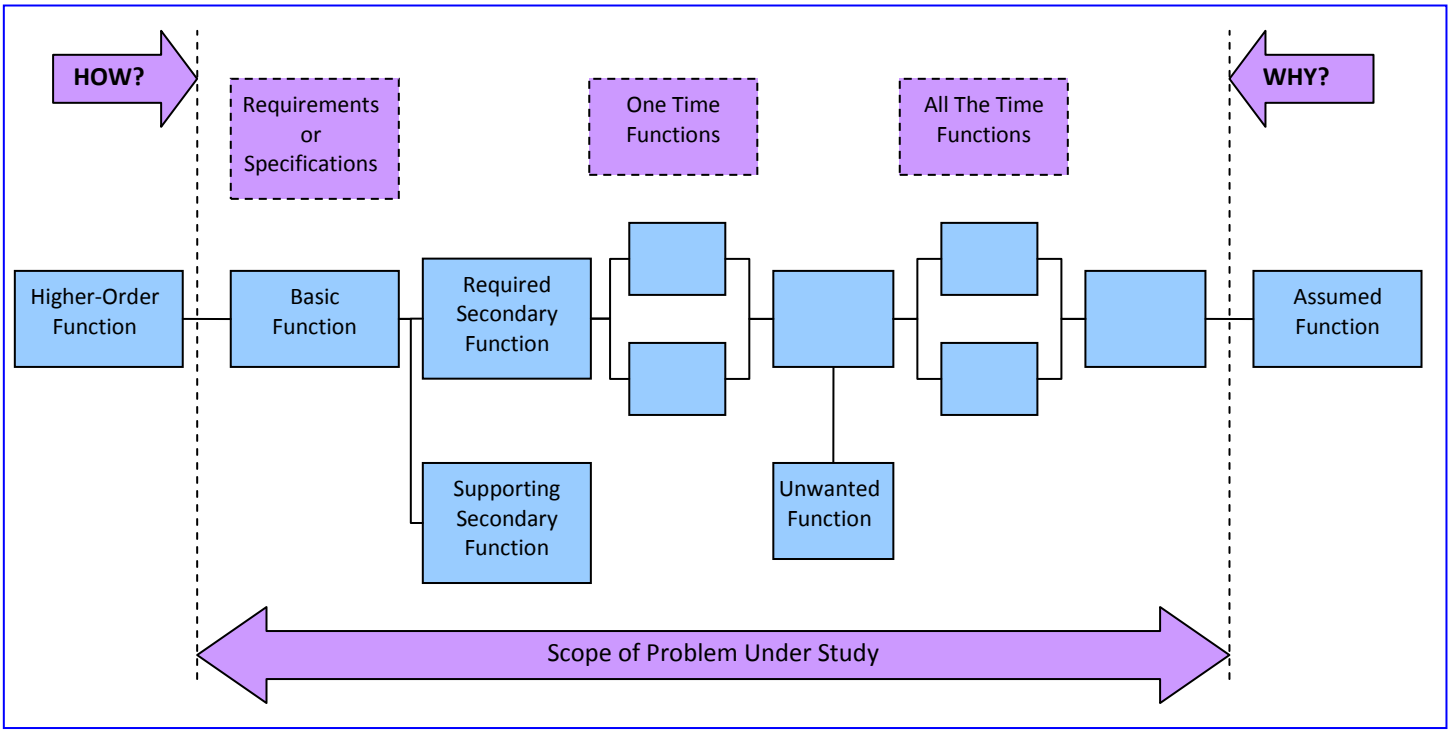


Figure 21, Structure of a Basic FAST Diagram, Stewart (2005:183).

The application of a FAST diagram will lead to a better development of ideas, because options are kept open. The end result will be that the eventual scope of the project has a better change of creating the "best value". Leung and Liu (2003) that the goal specificity is influenced by the value specificity, and that final outcome of the project (satisfaction) is associated with goal specificity and conflict resolution. So not only the value methodology is important but also the interaction between stakeholders.

3.2.5 Flexibility management

Stakeholder management and value management methods are helpful in creating a complete scope definition by including all relevant stakeholders. However that does not mean that the scope definition after this is not susceptible to scope changes. Besides the need for completeness of scope definition there is also a need for the flexibility of the scope definition. Olsson (2005) makes us aware of the tension between the need for flexibility and the need for a clear project definition. Due to fast changing environment there is the need for organizations to adapt to changes, on the other hand studies show that a clear project definition is a critical success factor for projects. Flexibility is related to the room to manoeuvre, a decision is within the room for manoeuvring if it does not violate the consequences of previous decisions. A way to increase this room for manoeuvring is generality. Generality is the ability of the building to meet shifting demands without physical changes. In this terminology, flexibility is the possibility for construction and technical changes with minimum cost and disturbance (Olson, 2005).

To accommodate flexibility in a project it should be made more modular. Modularity can enable projects to cope with uncertainty because individual components do not have a critical role. Modularity has advantages in the short term in the PLC, adjustments on scope can easily be made and the consequences on the other project constraints are limited. On the long term, for the lifespan of an object, it also has it advantages because the object can be changed easily in a fast changing environment. This fast changing environment is due to the dynamics of value as discussed in paragraph 3.1.8. When a particular module has dropped in value below the acceptance line it can be changed without majorly influencing other modules that still meet the acceptance level. So in the end a consideration has to be made between on the one hand the possible extra costs of making a project modular on the short term, and on the other hand the possible extra benefits of flexibility on the long term. Possible is used in both ways because the cost may be the same or even less and the flexibility may not be used in the future (design phase, construction phase and use phase).

3.2.6 Summary part two

The goal of the initiative phase of the PLC on the subject of scope is to come to the right scope. Because in the end it is more important to do the right things than to do things right. This means that it is more important to select the right project than to do the project effectively. The project must not be approached as a standalone project but must be approach in a manner that is best for the network that it is part of. Large infrastructure projects affect a lot of stakeholders, so it is important to involve them in the scope shaping process to come to a complete scope. This is important because adjustment in latter phases have bigger consequences for the other project constraints.

Because most people are visually minded they tend to come to an explicit project to early in the PLC, without a clear analysis of the underlying functionalities that are needed. Value management provides us with a method to force us to identify the needed functionalities and place them in hierarchical order. By first looking at the function instead of going too fast to a specific project, you will in the end have a scope that is more robust and complete.

At the beginning of the PLC there is also a lot of uncertainty and ambiguity. Uncertainty of information, through for example value analysis and risk analysis you gain more certainty about existing information and you gain information not known before. Ambiguity is the existence of multiple interpretations of stakeholders, through sense making and conversations you can move towards one interpretation. If there is ambiguity it is important to find out early, because this affects the scope of the project.

Because changes in scope will occur during the latter stages of the PLC, even if the scope is robust. To minimise the effects of a change the product scope can be made more flexible in the initiative and design phase. Modularity of the project can make the product scope more flexible, because individual components do not have a critical role. So changing one component, without majorly influencing other components of the project..

In literature there are several management approaches that will contribute to a better scope in the first half of the PLC. The definition of the scope will only be successful when the approaches are applied together. Value analysis with only the client will not result in the complete list of functionalities. Involving other key stakeholders for such analysis are important.

3.3 Part three, scope control

3.3.1 Introduction

Ones the scope definition is completed in the initiative phase and is translated in a design, the emphasis of scope management shift to the efficient and effective implementation of scope changes. This chapter will provide answers a part of the research questions mentioned in the research design, namely:

- What are scope changes? (causes, effects)
  - How can we identify a scope change?
  - What are the causes of scope changes?
  - What effect do scope changes have?
- What is scope management?
  - How can we control scope?

Important in controlling scope changes is understanding what causes a scope change, so we can anticipate them. The causes and scenarios of scope changes will be discussed in the first section of the chapter. As mentioned in chapter scope is connected with the other project constraints; cost, time and quality. To better cope with scope changes (scope control) and reduce the effects on the other project constraints the scope can be decomposed. In the previous chapter modularity was introduced to make the scope more flexible. Decomposition unlike modularity has the focus on making a large complex project more manageable by dividing it in subprojects. These subprojects have very few relationships, so they can be managed independently on the short run. This big advantage of decomposition will make it easier to manage the project and its scope.

The decomposition of the project will determine the organization; the number of subprojects will determine the number of branches of the organizational structure. The dynamic project organization is introduced in this chapter as a suitable organization to manage a project and its scope. The main feature of this type of organization is the use of aspect manager, who have information available of the whole project per aspect. This paper suggest to at least use the project constraints as an aspect, so the project scope can be better managed because effects of scope changes can be better determined.

The scope change procedure is the procedure that handles scope changes in a project. Every scope change should be investigated on its effect on the project constraints and other important aspects of the project (such as risks or stakeholder opinions) so that a clear consideration can be made whether to implement, change or not implement the suggested change. It must not be the case that every suggested change is automatically implemented, because this will easily lead to large cost overruns and delays. To accommodate and organize the scope change procedure the decomposition of the scope and the organizational structure play an important role. The decomposition of the scope will determine the depth of the investigation of every scope change and the organizational structure will determine the efficiency of the scope change procedure.

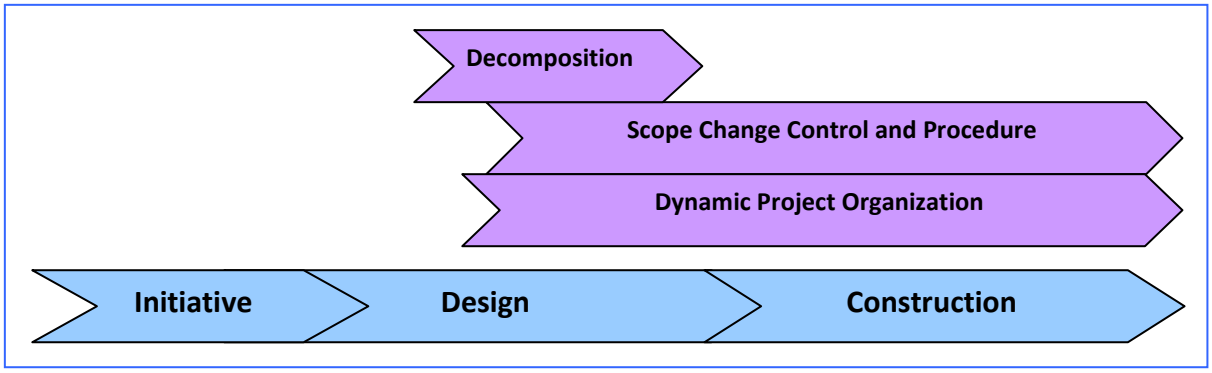


Figure 22, Scope control methods and their place in the PLC.

3.3.2 Scope Change

A change in scope can either be a change in the product scope and/or project scope. In most cases a change in product scope will also mean a change in project scope. For example, changing a part of a product scope from a bridge to a tunnel will also lead in a different construction method (project scope. In this section the significance of scope creep is discussed on project success, the causes of scope changes and the scope change scenario's that may occur.

3.3.3 Scope Creep

If uncontrolled, mostly small scope changes in the scope of a project are undertaken, it is referred to as scope creep. This phenomenon occurs when scope is poorly defined, documented and/or controlled. The risk of scope creep is that a project drifts further away from its initial goal and generates higher costs and delays.

Causes of scope creep can be:

- **Poor process management**. For example, not involving key stakeholders in the initiation and design phase, so changes have to be made at a late stage. Poor communication between stakeholders can also be a cause of scope creep.
- **Poor project management**. Project goals are not fully defined, the result is scope additions are needed for important non-defined goals.
- **Deliberate actions of the client**. Deliberately vagueness of the scope of the project to ease the acceptance of the project. Later in the process scope additions are necessary to meet project goals.

3.3.4 Causes of Scope Changes

There are several causes why a scope change can occur:

1. *New laws and regulations*. Unavoidable external demands on which no control can be exercised. Think of new legislation on safety and environment.
2. *Requirements of the client change*. Strategies of a client change over time, this may effect project scope.
3. *Risks taking place*. There is always the possibility that risks will take place causing scope changes to be needed to complete the project successfully.
4. *Effects of other projects*. Other projects may affect the project, which can result in scope changes.
5. *New insights*. During the process, information becoming available, for example soil composition, which can lead to scope changes.
6. *Technological breakthroughs*. New technologies come on the market that can be applied on a project.
7. *Imposition by the State Council*. One can think of individuals or groups (stakeholders) object against (a part) of the project and either receive compensation awarded by court. Think of the placement of additional noise barriers or a forced cancelation of a certain part of the project.
8. *Scope definition is not complete*. During the development there is scope missing for a successful completion.
9. *New economic situation*. New economic situations influence the financial feasibility of a project. Scope changes can then necessary to overcome these negative effects.
10. *Negotiations with stakeholders*. Instead of the intervening of the State Council it is also possible to negotiate proactive with stakeholders to come to a solution.

The causes of a scope change also have relations with each other and a certain overlap, for example:

- An unfavourable outcome of a soil examination (5), may have already been incorporated in the risk register (3).
- A significant change in the steel price (9) can lead to different requirements of the client (2).

This overlap is visualised in Figure 23,where the causes a scope change are proportionally represented in different sizes.

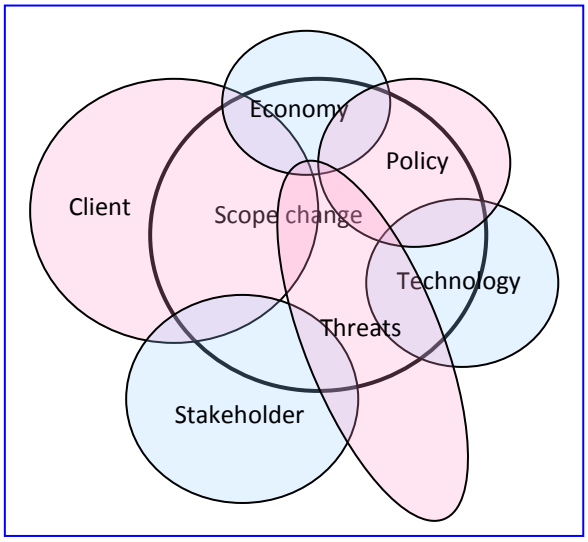


Figure 23, Causes of scope change and their proportional contribution.

Most causes of scope change will most likely be a change in the requirements of the client. Certain causes may have been incorporated in the risk register and identified as the know knows, this is the overlapped area of threats with the other causes. The theoretical framework of the scope change causes leads to the next questionnaire objective.

Scope change scenario's

The relationship between the constraints budget, time and scope can be visualised by Figure 24. For a certain scope you need an amount of budget and time to complete the scope. There are several configurations available to complete the scope, however you always need certain amount of budget and time. A famous statement in project management is that you cannot deliver one baby in one month with nine women.

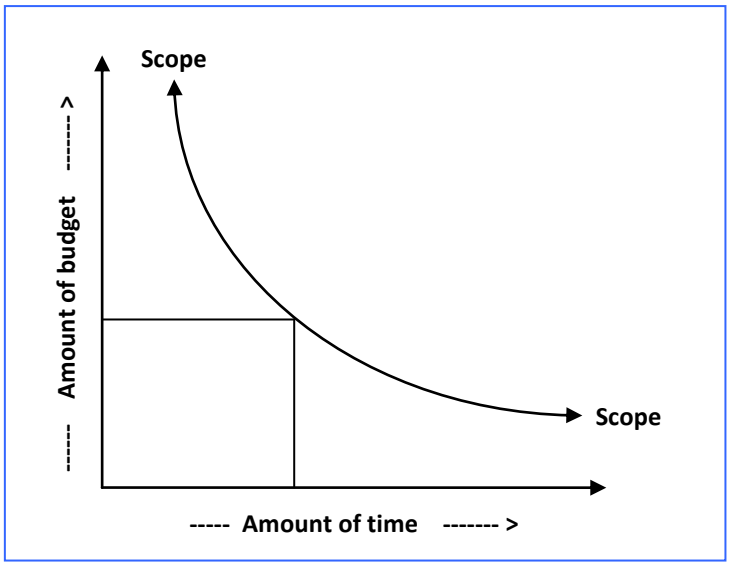


Figure 24, The relationship between the triple constraints (Putman, 2003)

Over time the triple constraints change due to different causes, which due to the relationship has consequences for the other constraints. In figure 3 several scenario's can be thought of due to an increase in scope:

1. Budget has to be increased to cope with the scope increase and to hold on to the delivery date.
2. Both an increase in budget and a delivery delay are chosen to cope with the scope increase.
3. The delivery date is postponed to cope with the scope increase.

The scenario chosen is highly dependent on the driven constraint, if the driven constraint is budget a postponement of the delivery date will be chosen over a budget increase.

There are also scenario's possible were scope decrease to:

4. Pull the delivery date forward.
5. Decrease budget/costs.

Objective 3: what scenario's occurred during the project and to what extend.

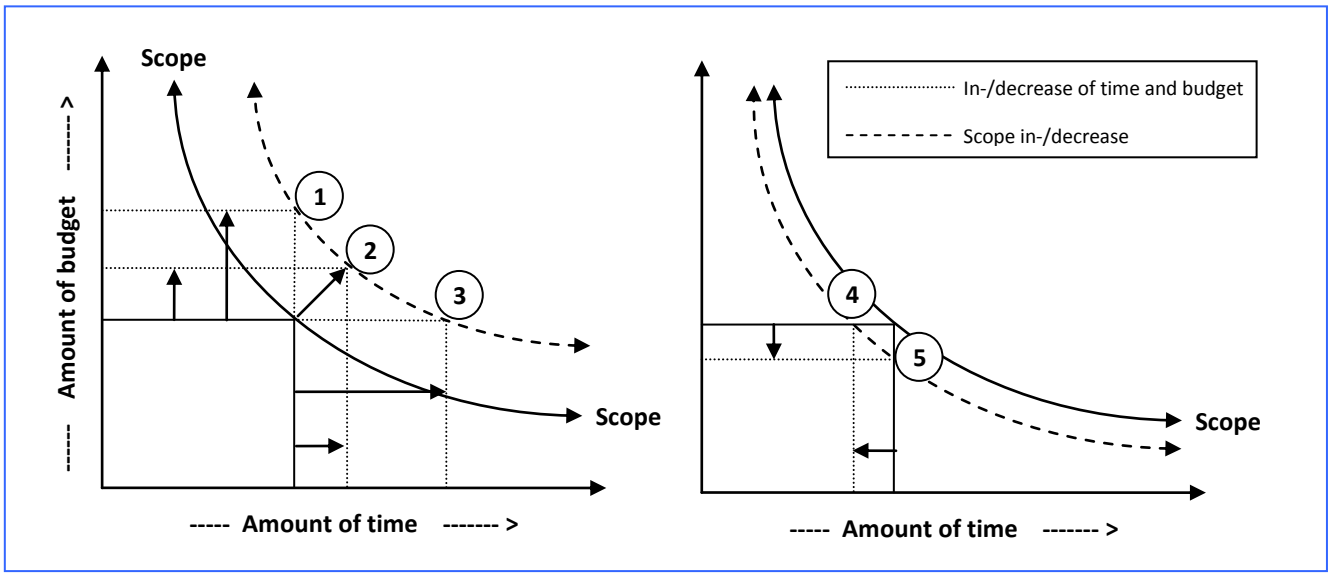


Figure 25, Several scenario's when a change in one constraint occurs.

3.3.5 Decomposition

Decomposition can be applied on the product and/or project scope to make a large project more manageable and thus better accommodate scope changes. In the previous chapter modularity is important to make the scope more flexible to changes. Closely related to modularity is decomposition where it is also key to minimize relations and create subsystems that can be managed independently. Decomposition (De Ridder, 2008, P5.1-5.26) is a method to make the complexity of a system more manageable by dividing it into subsystems that can operate independently in short period of time. In general, decomposition is used to:

- Reduce complexity
- Optimise according to available specializations
- Save time because subsystems can work independently and parallel

3.3.6 Interface Management

There are also relationships that are outside the clusters, these relationships will be governed. This leads to the nearly decomposition rule of Simon[13], "Short-term behaviour of subsystems of the system is determined by the internal consistency of the considered subsystem (intra-relations), while the long-term behaviour is determined by the coherence between the subsystems (interrelationships). De Ridder (2009) suggests that these inter-relationships are to be governed by aspect managers, which will be explained in the next paragraph on dynamic organizations. An example of decomposition for the Measlantkering is provided in appendix 9.2.

3.3.7 Dynamic Project Organization

Literature review of Van Donk and Molloy (2008) in project structures, identify projects as temporary organizations, the basis of this theory is constructed from four concepts, the project aspects (time, money, team and transition) and four phased concepts, the phases of the PLC (lobbying, specification of tasks, planned isolation and institutionalised termination). From this theory are five different types of project structures, simple, bureaucratic, divorced, professional and adhocracy

[13] De Ridder H.A.J. (2009) collegesheet Dynamic control of projects September 22nd. Technische Universiteit Delft, Faculteit Civiele Techniek en Geowetenschappen, Sectie bouwprocessen.

According to Van Donk and Molloy (2008) structural and civil engineering projects fall within the bureaucratic structure project. This project structure is characterized in that it is sensitive to changes in the initial plan. One pitfall might be that in the technocratic structure (preparing and monitoring project) the use of standardization of work is applied to such an extent so that the adaptability of the project is limited. The dynamic project organization of De Ridder (2009) is capable of processing changes because they can be monitored and controlled by the introduction of an aspect level in the organization structure. De Ridder (2007, p8.1-8.8) gives an explicit organizational structure for project as shown in Figure 19. Different levels in a project can be distinguished:

- *The system;* entire object required for the overall objective. Example, a subway connection between A and B.
- *The aspect system*, a subset of the relationships within a system. For example cost, planning or scope.
- *The subsystem*, which is a subset of elements within a system. Example, stations in a metro project.
- *The element*, which are the basic components of the system. A viaduct in a metro project.
- *The discipline*, which provides the knowledge necessary for some elements of the system. The discipline of tunnelling in a metro project (drilled or sunk).

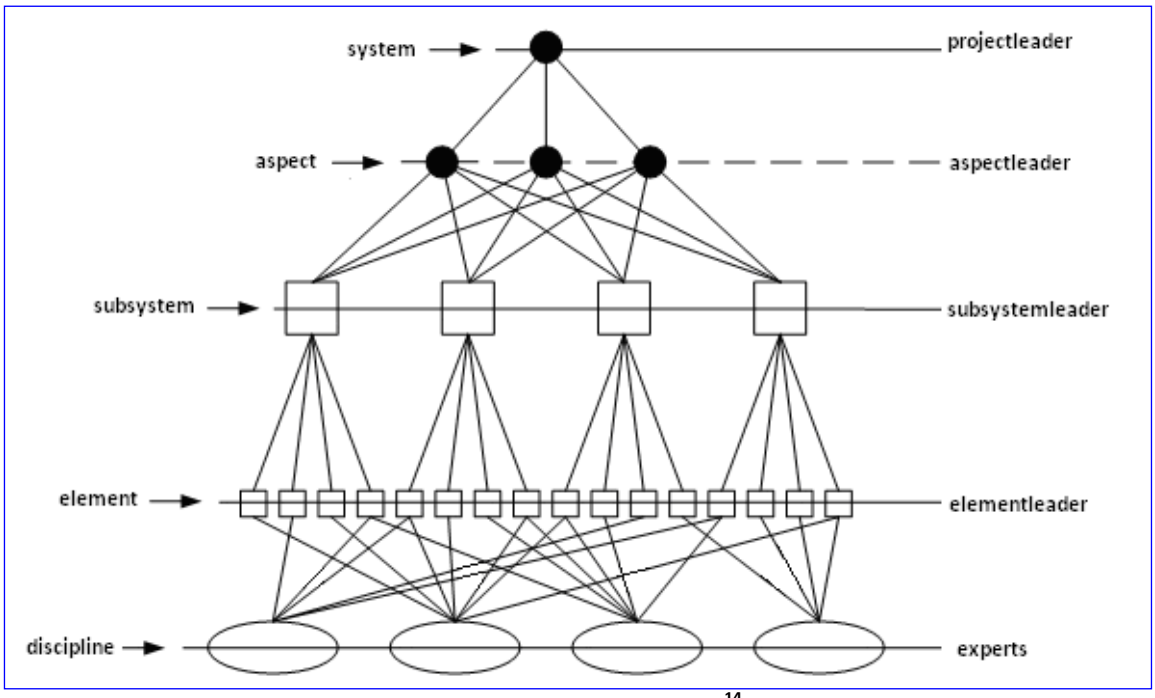


Figure 26, Dynamic Project Organization, multilevel meta control [14].

3.3.8 Strength of decomposition with dynamic project organization

Dynamic project organization leads to shorter communication lines and a better grip on the aspects of the project through the use of aspect manager. Together with the use of decomposition which will form the subsystems a complex project can be divided into smaller manageable subsystems. The relations that fell outside the decomposed area's can be controlled by the aspect managers, because they have all the information and knowledge per aspect. It is also possible to apply an interface manager as an aspect leader who controls all interfaces in the project. So product and project scope can be better managed because of simplification (decomposition) and clearer project control (dynamic project organization).

[14] De Ridder H.A.J. (2009) collegesheet Dynamic control of projects. Technische Universiteit Delft, Faculteit Civiele Techniek en Geowetenschappen, Sectie bouwprocessen.

3.3.9 Scope change control

Because the control of a project is subject to a mix of feelings and facts, of human and technical aspects, of cause-effect and randomness, it must be approached in an orderly manner (Meredith and Mantel, 2006, p543). In practice, according to Meredith and Mantel (2006, p574) it is still common for project managers to avoid approaches which have characteristics of bureaucracy. Instead a more informal approach is used to treat requests for changes. This kind of approach lead to misunderstandings and ultimately the project manager will experience that the changes are "attached" to the project "and should be executed, even if this results in budget overruns and delays. The main purpose of scope change control would be that one thinks about the scope change and does not accept every suggested scope change. This paper suggests cybernetic control for large infrastructure projects to avoid undesirable budget overruns and delays.

In the implementation of scope changes, decisions should be taken gradually if the proposed scope change is actually to be implemented. In the control mechanism a difference have to be made between avoidable and unavoidable scope changes. In Figure 27 an example of a decision tree is given for scope change control for avoidable and unavoidable scope changes. Important is that for each major scope change the effects are investigated which will form the basis for decision making. The procedure will reduce the number of scope changes because unnecessary scope changes will be identified and rejected. Once it has been decided that the steps should be undertaken to implement a proposed scope change, this will have an impact on the existing contract between the client and the contractor. The implications depend on the type of contract and the type and size of a scope change. Do the changes fall within the boundaries of the contract?, is the scope change due to the firing of a risk allocated to the contractor or client? Is the proposed scope change introduced by the contractor or the client? These are all questions that fall outside the boundaries of this paper, defined by the dashed line in the decision tree. Whether or not a scope change is avoidable will decide the balance of power in the negotiations, if a scope change is unavoidable the contractor is more likely to get a good price for the implementation.

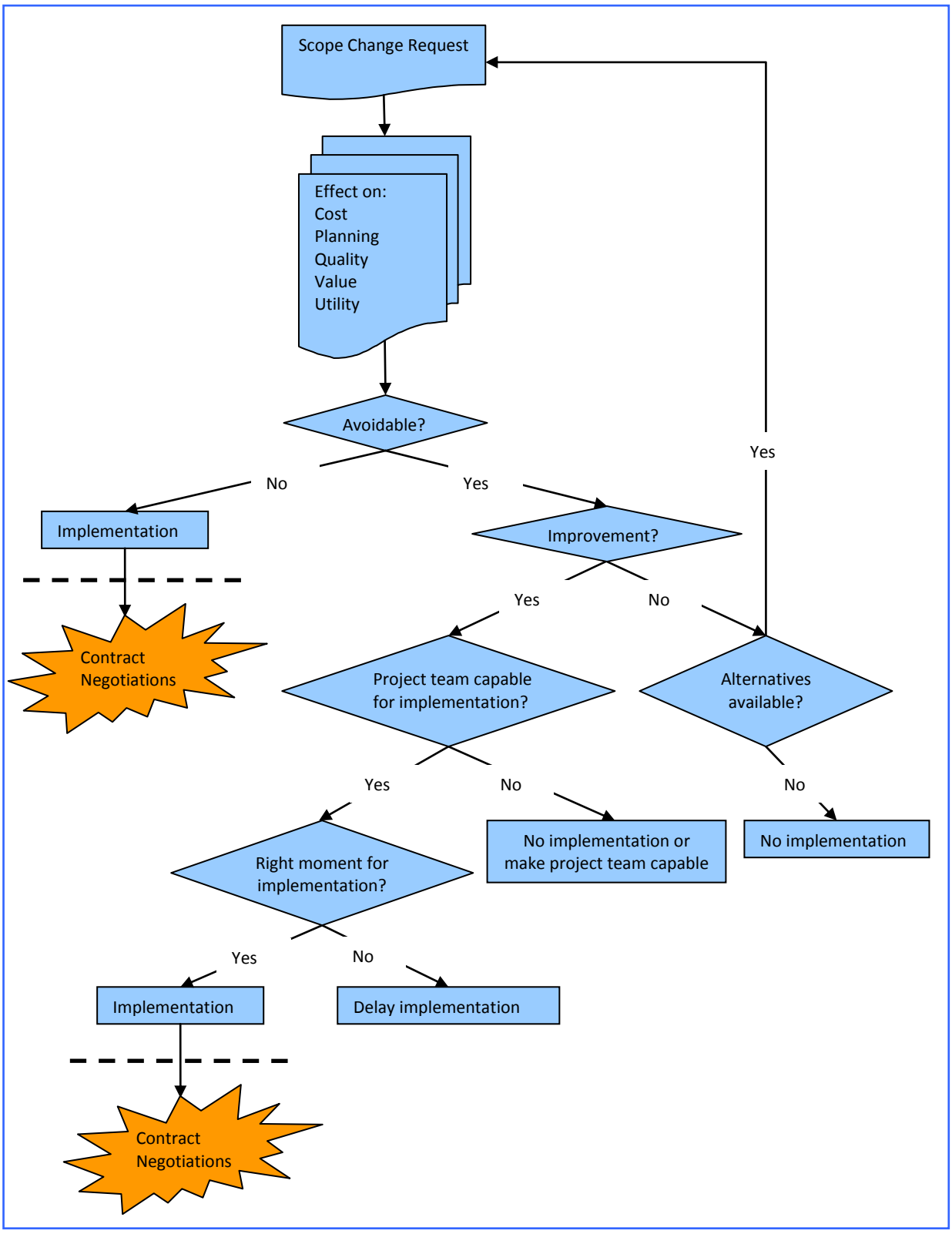


Figure 27, Decision tree for scope change control (author).

3.3.10 Scope Change Procedure

To make sure that scope changes are processed properly, the organization has to be well structured to accommodate a scope change procedure during the design and construction phase. Turner describes managing scope as the process of:

"*Ensuring enough, but only enough, work is undertaken to deliver the project's purpose successfully*".

This contains three elements:

1. a sufficient amount of work is done
2. unnecessary work is not done
3. we achieve the stated purpose of the project

To realize these conditions, have to be judged on feasibility, necessity and utility by investigating:

- necessity of scope change (does a highly unfavourable/dangerous situation occur when not implementing?)
- cost of scope change
- effect on planning of scope change
- risk associated with scope change, risk of implementing and not implementing
- extra benefits (lower exploitation costs, longer lifespan, higher incomes, etc.) of scope change
- value change of scope change
- availability of other more favourable scope changes

This investigation stretches out over several different specialisations and needs to be well structured throughout the organization. A manager may be appointed to steer this process with sufficient mandate to review, reject and implement a scope change. Because the investigation of a scope change also takes time and costs money a several thresholds and have to be established to determine to which rigor the suggested scope change has to be investigate.

In Figure 28 an example of a scope change procedure is presented to handle scope change requests. In structured phases (activities), where is clear who (actor) is responsible for what action and what documents (output) they must provide. Important note is that the submission of requests for scope changes are not subject to milestones and intervals, the procedure for scope changes is a reactive process.

Scope change requests should be processed through the following phases:

1. **Application.** To avoid confusion about who is responsible for the scope change, the submission is formally done by the project director (management staff). This happens using a standard form "Proposal to change", the scope manager checks for completeness and accuracy. If the form is incomplete or filled out properly it is rejected until it does meet the standards.
2. **Verification**. At this stage in the risk register is check to see whether the scope change request was caused by the firing of a foreseen risk. If this is the case then the actions described in the risk register will be implemented, if still applicable. Any effect on the risk register are also included in the risk register if the situation is changed.
3. **Estimation.** The effects of the implementation of the scope change are determined what leads to change in; cost, planning, quality level, risks, resource allocation, contracts, etc.
4. **Classification.** Classification of scope changes is determined by the impact of the consequences and formulated in a classification form. A classification could be, additional cost <10,000 (3), 10.000 <extra cost <100,000 (2) and additional costs> 100,000 (1) or delay <Week (3) week <delay <month (2) and delay> month (1). These classifications can than be used to determine the overall classification by attaching weighing factors to each classification .
5. **Authorization.** In this stage the scope change request is either rejected or accepted on the on the premises of the classifications of the preceding stage. The overall classification determines the authorization level needed.
6. **Contract negotiations.** As mentioned earlier the contract negotiations are not included in this paper. The matter on the process of contract negotiations is large and complex enough for several research papers. However it is important to include it in the scope change procedure, because it will effect the decision to implement.
7. **Preparation and Implementation.** The activities are prepared, planning is adjusted, budget is adjusted, resources are allocated and the scope change is implemented.
8. **Evaluation.** The process is evaluated, learning moments are documented changes in the process are made.

Importance of dynamic organization and decomposition in scope change procedure
Because communication lines in a dynamic organization are short, and general information is available on important aspects of the project on request, it will benefit the scope change procedure. The runtime of the scope change procedure is an important feature, because certain scope changes will have a high level of urgency. In those cases it is essential to have all relevant information available on request. It will also be beneficial for the contract negotiations because there will be more time available to manoeuvre in the contract negotiations and not to make hasty decisions that will a negative effect on the eventual value of the project (too high a price, poor quality due to haste, delays due to criticality of scope change in planning, ect.).

The use of decomposition will also lower the runtime of smaller scope changes that will only effect one component, because only the effects on that component have to be investigated.

Timing of introduction
In the figure below it can be noticed that a lot of actors will play a part in the scope change procedure. Because scope changes will occur during the PLC it is important to agree upon the procedure as early as possible in the design phase when the scope of the project for a main part is established. Implementing the procedure too early will result in a sluggish development and smother creativity which is essential in the early phases. Implementing the procedure too late on the other hand and most damage will already have happened (scope creep). So the tipping point has to be allocated in the design phase where the need for creativity becomes less than the need for strictness. Before this moment a scope change procedure has to be agreed upon and the responsibilities have to be clear to everyone so that it is ready to be implemented when needed.

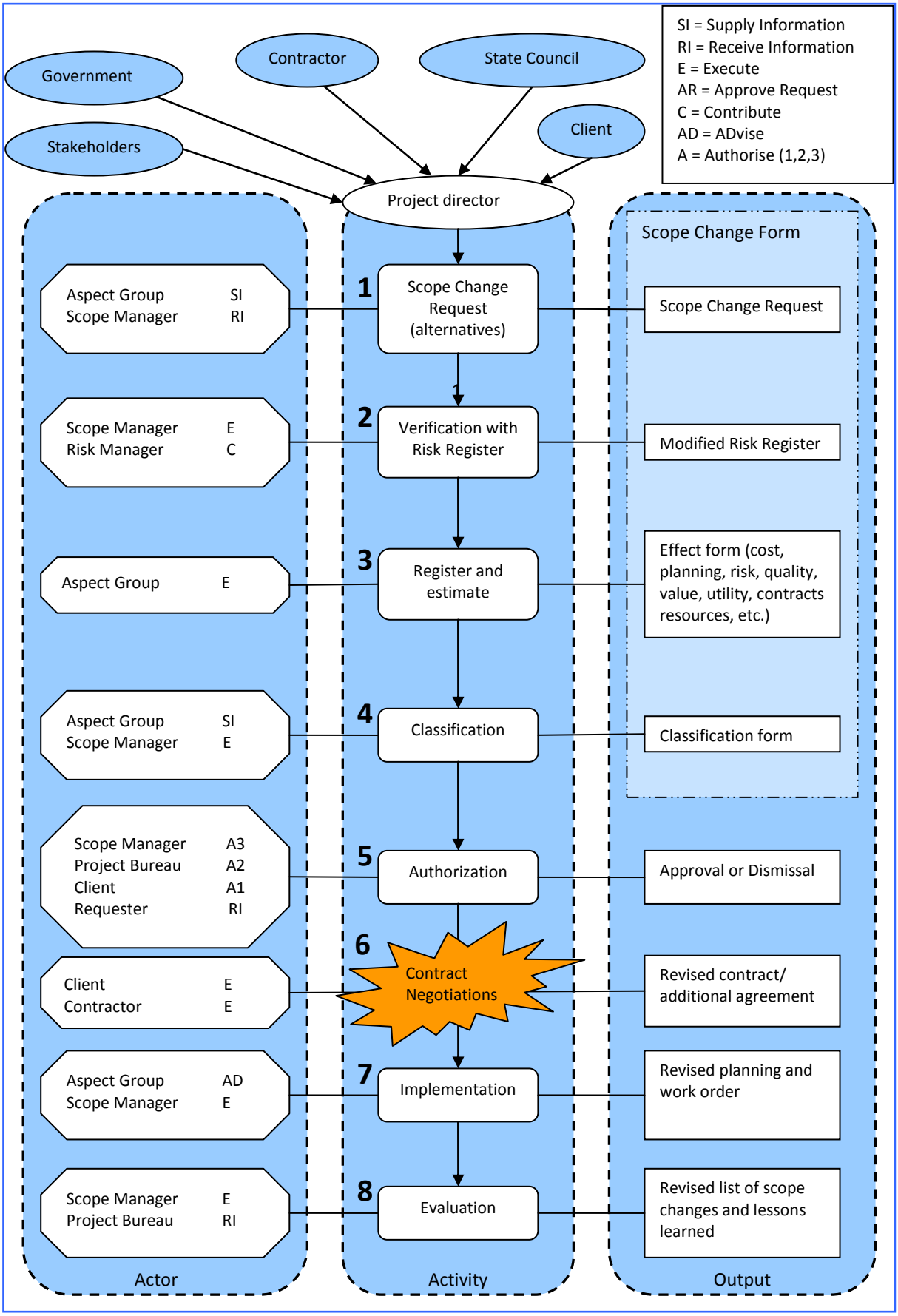


Figure 28, Scope Change Procedure (based on procedure of Shell (BBS procedure 02.05.1053)) .

3.3.11 Summary part three

This part focused on the control of scope changes during the design and construction phase of large infrastructure projects. When trying to control scope changes it is first important to investigate what causes scope changes. Causes of scope changes are; new laws and regulations, requirements of the client change, risks taking place, effects of other projects, new insights, technological breakthroughs, imposition by the State Council, scope definition is not complete, new economic situation and negotiations with stakeholders. For the case study and questionnaire it is interesting to investigate the impact and frequency of these causes to estimate their relative importance on scope. These causes do not always stand alone but can be overlapped or have a causal relation. Besides understanding the causes of scope changes it is also essential to estimate the effects it has on the other project constraints and several scenarios can occur.

The second part of the chapter focuses on methods to better manage the scope changes. First the decomposition method was introduced which divides a large complex project in several manageable subsystems that can operate independently from each other for a short term. Scope changes that only affect one subsystem can much easier be estimated. The decomposition into subsystems needs an organization that fits the subsystem structure and that manages the long term relations between the subsystems. The dynamic project organization fits these criteria through the introduction of an aspect level above the subsystem. All the essential information on the entire project is divided into specific aspect and are the responsibility of an aspect manager. So per aspect there is always current information essential for the determination of the effects of a scope change and communication lines are shorter.

To prevent that all suggested scope changes are implemented they must be properly assessed by applying a decision tree. When assessing a scope one must ask the following questions; what are the effects (on cost, planning, quality, value, utility, etc)? Is it avoidable? Is it an improvement? Are there better alternatives available? Can we implement it? Is this the right time for implementation? Answering these questions will result in the acceptance, rejection or postponement of scope changes and will assure that unnecasary scope changes are not implemented.

The scope change procedure provides us with a standardised mechanism to assure that requests for scope changes are assessed, classified and evaluated. Standardization is important for roles and responsibilities, documents and runtimes in the scope change process. The aspect managers in the dynamic control organization play an important part in the procedure for the assessment of a scope change request. A separate aspect manager for the aspect scope has the main responsibility for the procedure. For the case study and questionnaire it is relevant to investigate the current scope change procedure and allocate the problems.

4 Theoretical Framework

4.1 Introduction

After the literature survey on the subject, one is ready to construct a theoretical framework. According to Sekaran (2003) a theoretical framework is a conceptual model of how one theorizes or makes logical sense of the relationships among the several factors that have been identified as important to the problem. The theoretical framework discusses the relationships that are deemed to be integral to the dynamics of the situation being investigated. A theoretical framework is none other than identifying the network and relationships among the variables considered important to the study of any given problem situation. In the preceding chapters the most relevant variables have been explained and their relationship and the dynamics of their relationships have been discussed. Different definitions of those variables in literature were presented and the most suitable ones were chosen for this research. The assumptions of the theoretical framework will be tested by the application of a case study and a questionnaire on their legality and accuracy. In the following sections the framework of a project, scope changes, scope development, stakeholder impact and scope management methods are discussed. For every subject a set of more specific research questions for the case study and questionnaire can be formulated and will be presented at the end of the sections.

4.2 The Project

The infrastructure project represents a network of variables (see Figure 29). The variables that make up a project are the quadruple constraints; scope, time, cost and quality. These variables are dependent and are influenced by the independent variables; new insights, economy, technology, policy, client, other projects and stakeholders. These independent variables will constantly try to shape the constraints and thus the outcome of a project (see Figure 30). Changing one constraint will also cause a change in at least another constraint, extra scope is not created out of thin air. Changing one constraint will also lead in a change in value because value is a measure of quality plus time divided by cost. In every project there will be one constraint that will be more important than the others, the driven constraint. Changes in the project constraints will be made according to there importance.

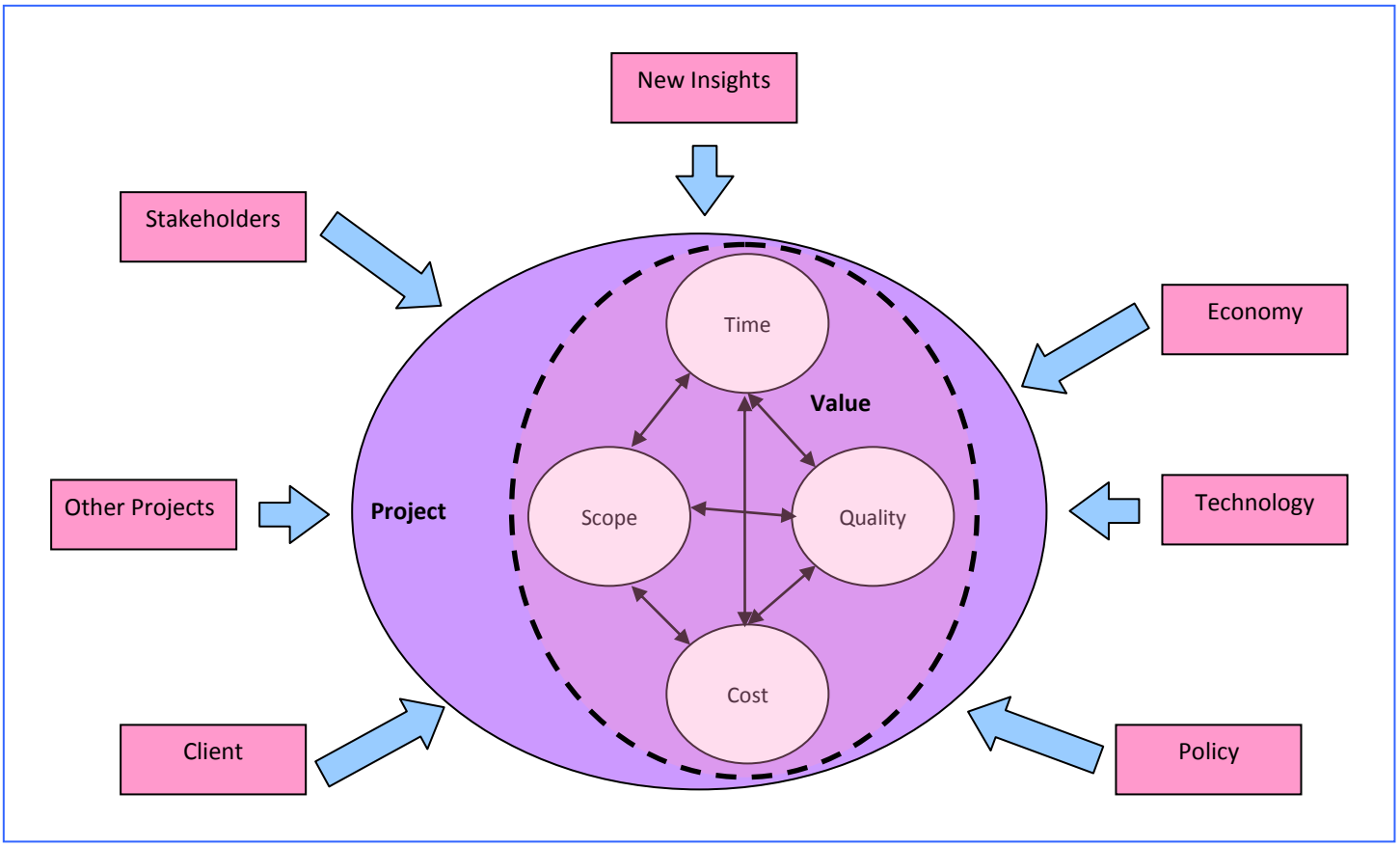


Figure 29, Network of variables of a project.

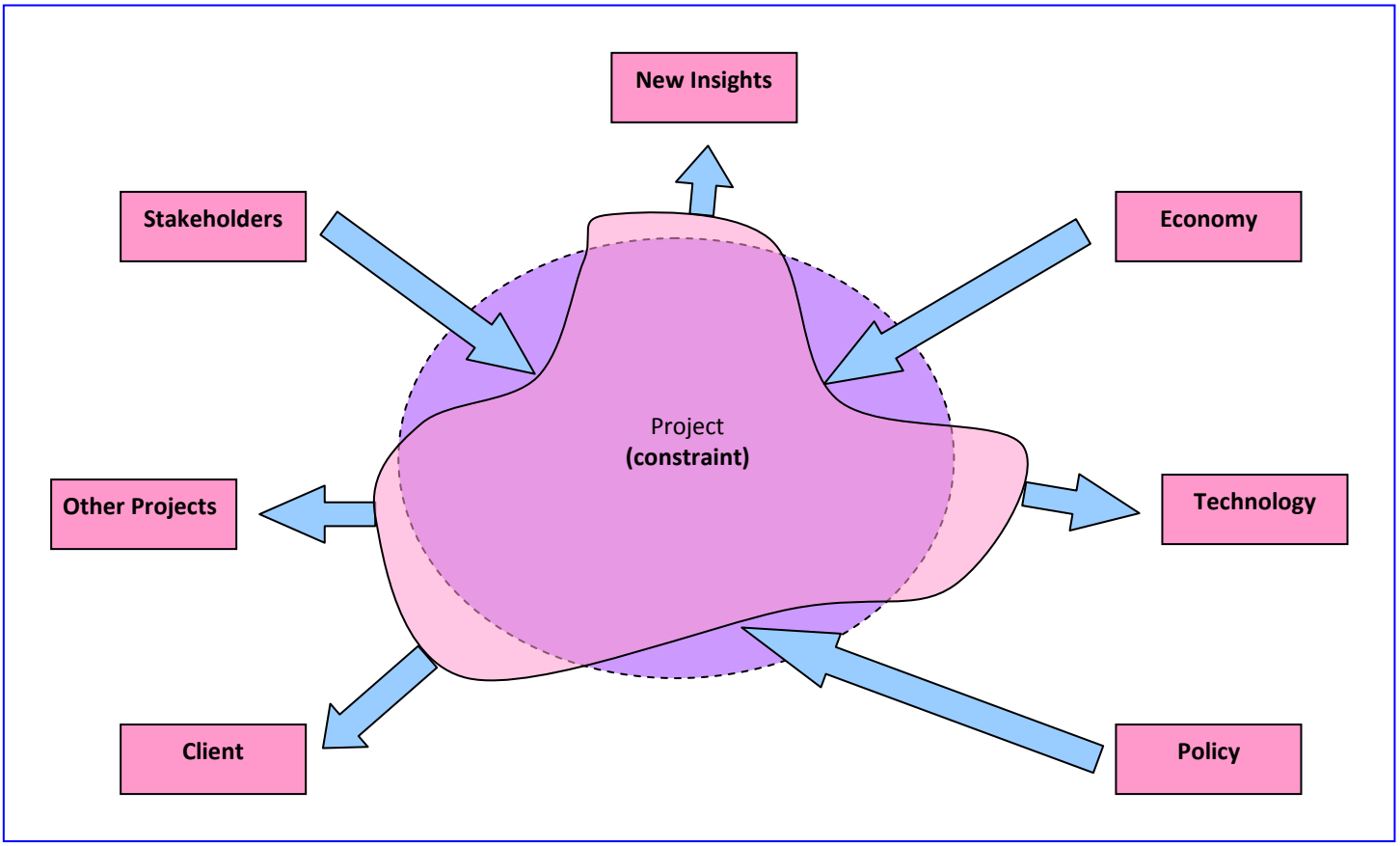


Figure 30, Constant changing of a project.

For this subject the research questions for case study and questionnaire will be:

- Is there a clear relationship between the project constraints and external influences?
- Is there a clear relationship between the project constraints? Does a change in scope lead to a change in one or more project constraints?
- Is there a clear ranking in the project constraints and do they change during the PLC?

4.3 Scope changes

4.3.1 Scope change causes

Behind every scope change there is a cause that can be related back to the external influences. The causes of scope changes were given in paragraph 4.3.1 and are:

1. New laws and regulations.
2. Requirements of the client change
3. Effects of other projects.
4. Technological breakthroughs.
5. Imposition by the State Council.
6. Scope definition is not complete.
7. New economic situation.
8. Negotiations with stakeholders.

For this subject the research questions for case study and questionnaire will be:

- What were the causes for the scope changes that occurred?
- What was the impact and frequency of those scope change causes?

4.3.2 Scope scenario's

As was illustrated in the figures above the project has several independent variables that influence the project and thus the scope. A change in scope can be either direct or through an intervening variable. In the figure below several potential scenario's are illustrated.

1. Due to opportunistic cost estimations in the early phases of the PLC the client now phases high costs. In order to stay within budget he wants to lower the cost by changing the scope of the project (expl.

instead of designer street lights standard ones). But by doing so the client in the end also changes the quality of the project (lower aesthetic quality).

2. Due to a delay in another project, the contractor does not have the availability on certain essential resources and faces a potential delay. To prevent a delay he chooses to apply a different work method (different scope) that requires other resources.
3. Environmental groups apply pressure on the client because the intended design of the infrastructure has to great of impact on the environment (quality). To compensate the environment the creation of new nature is included in the project (extra scope), which will take time and money.
4. The cost of a certain material have increased so much that an alternative becomes more favourable to use. The scope of the project is changed by using the other material.
5. A new building technique (different work method) becomes available which is faster and cheaper and has the same qualities as the old technique.
6. Soil research indicates that the soil is contaminated and the soil first has to be cleaned or measures have to be taken to retain the contamination. This extra scope will cost time and money.
7. The estimations for the amount of time needed for the project prove to be opportunistic. In order to realize the project in time the scope is reduced. This reduction of scope leads to a decrease in quality.
8. The policy on noise pollution becomes stricter which has an effect on the project. Extra noise screens have to be placed to fall within these stricter rules. And the extra screens of course cost time and money.

These were just some examples of scenarios that can occur where scope is either an intervening or dependent variable in the project.

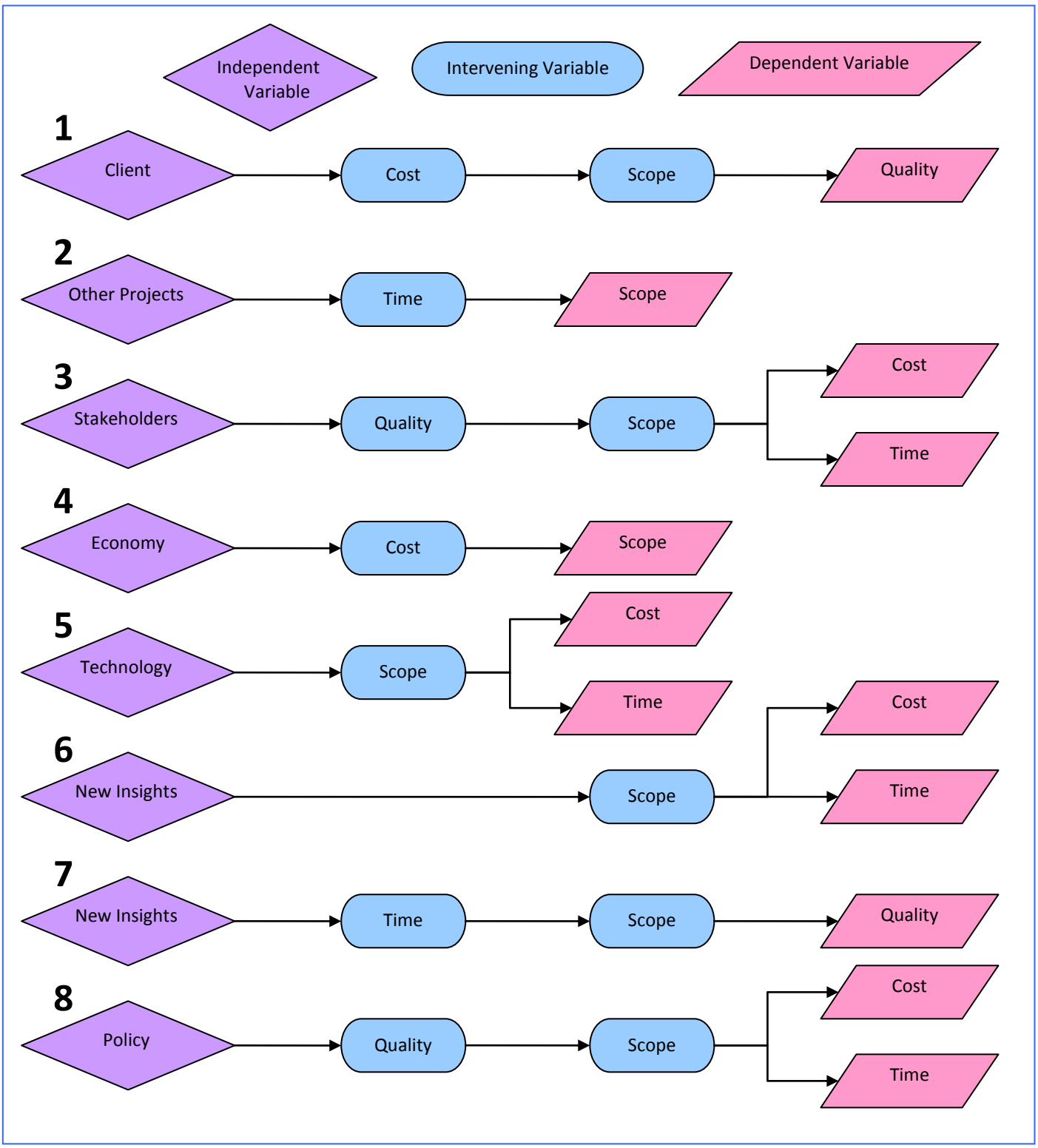


Figure 31, Different scenario's for different influences from outside the project (author).

For this subject the research questions for case study and questionnaire will be:

- What scope change scenarios occurred during the PLC?
- What was the effect of scope changes on the other constraints?

4.4 Scope Development

In section 3.1.6 and 3.1.7 the difference between quality and scope was elaborated. Because quality is related to the why of a project it will be defined in the initiative phase of a project. After the quality definition the scope is defined that will service these qualities, and is related to the what and how of a project (see figure below). Also with the rise in number of Design and Build type contracts clients have to focus on a clear definition of the quality rather than focusing on the scope, which should be left to the contractor.

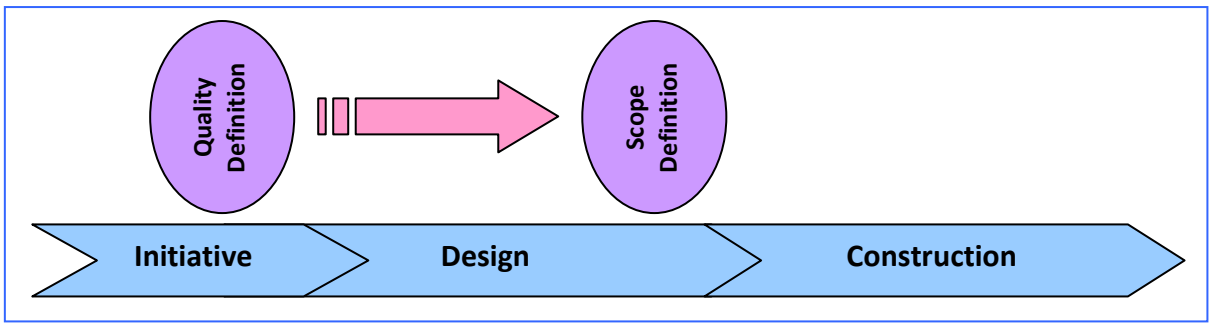


Figure 32, Developmant of quality toward scope description (author).

The importance of a robust and complete scope as early as possible was stipulated by the assumption that scope changes later in the PLC will have larger effects on the other project constraints. It is also assumed that this increase is rather exponential than linear, because it becomes harder and harder to implement changes. In the latter stages of the project more and more people and other resources are involved and flexibility of the project decreases as it nears completion.

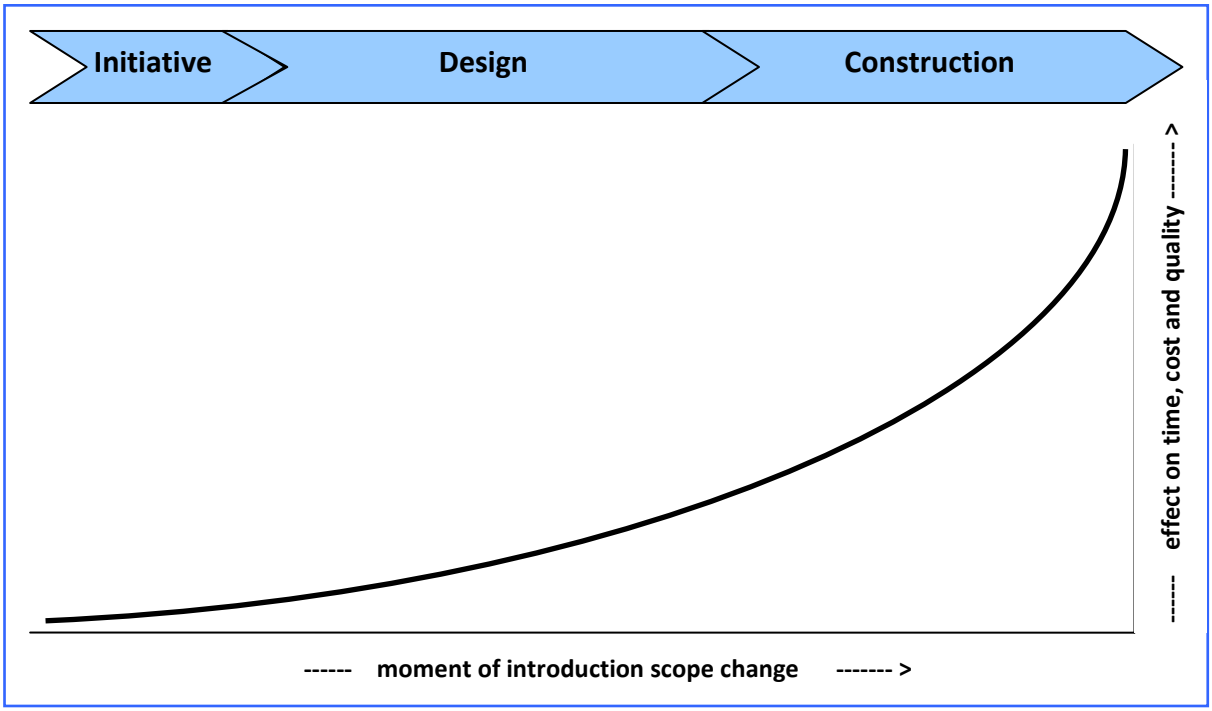


Figure 33, The effect of the moment of scope change implementation on project constraints (author).

For this subject the research questions for case study and questionnaire will be:

- How did the scope develop during the PLC?
- Does the moment of scope change introduction resemble the function of Figure 33?

4.5 Stakeholder Impact

Stakeholders can have a great influence on the scope of a project, so an important part of scope management is stakeholder management. The number of stakeholder also plays an important factor because of the longitudinal character of most infrastructure projects. Keeping in mind the exponential effects of scope changes during the PLC, it is important to involve stakeholders as early as possible in the project. Because of the character of projects going from quality definition to a scope definition it gradually becomes clear which groups and persons are affected by the project.

In this paper it is suggested that stakeholders can be divided by their geographical area of interest, from national to regional to local, and that there level of involvement will be related to this area of interest (see figure below). The dynamics of the impact of stakeholders leads to the following stakeholder dilemma:

Involving stakeholders early in the project life cycle will lead to more scope changes however the effects on the other project constraints will be less. Not involving stakeholders will lead to (less) stakeholders being involved in a later stage with possible fewer scope changes but higher effects on other project constraints.

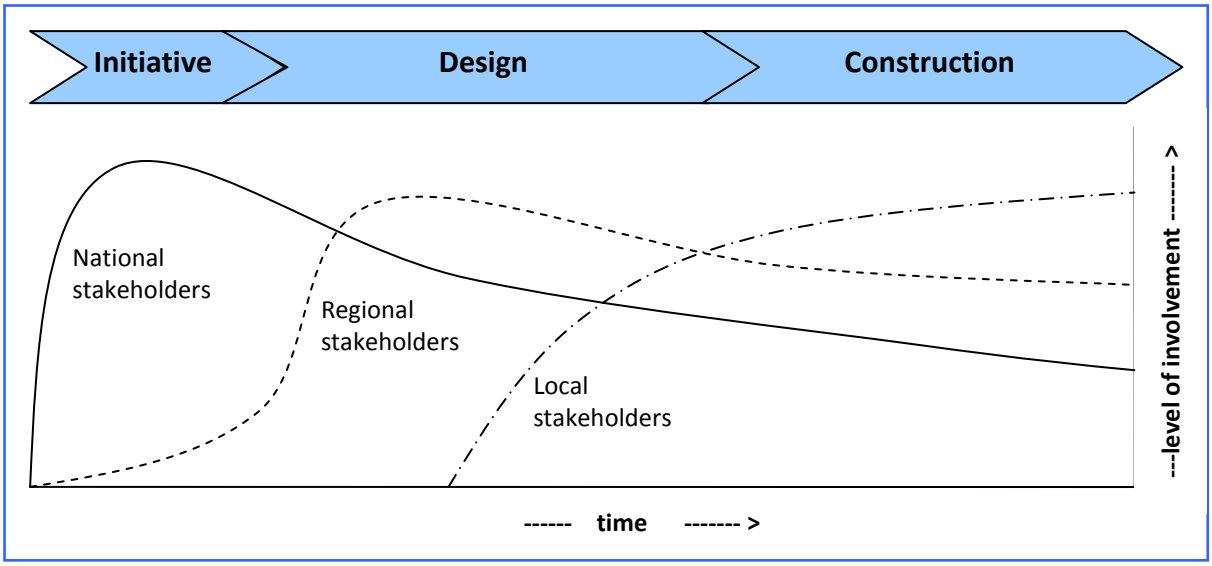


Figure 34, Involvement of different stakeholders over time (author).

For this subject the research questions for case study and questionnaire will be:

- What was the impact of stakeholders on the scope of the project?
- Does the level of impact of the stakeholders suggested in Figure 34 represent the reality?
- Could the effect of the impact of the stakeholders on the scope of the project be reduced by involving them earlier in the project?

4.6 Scope Management

In the chapters on scope definition and scope control several management methods were introduced that play an important part in the when thinking of scope management. In the figure below these methods are placed in their suggested moment in the PLC where they are most beneficial. There position in the PLC is linked with the type of definition, quality or scope.

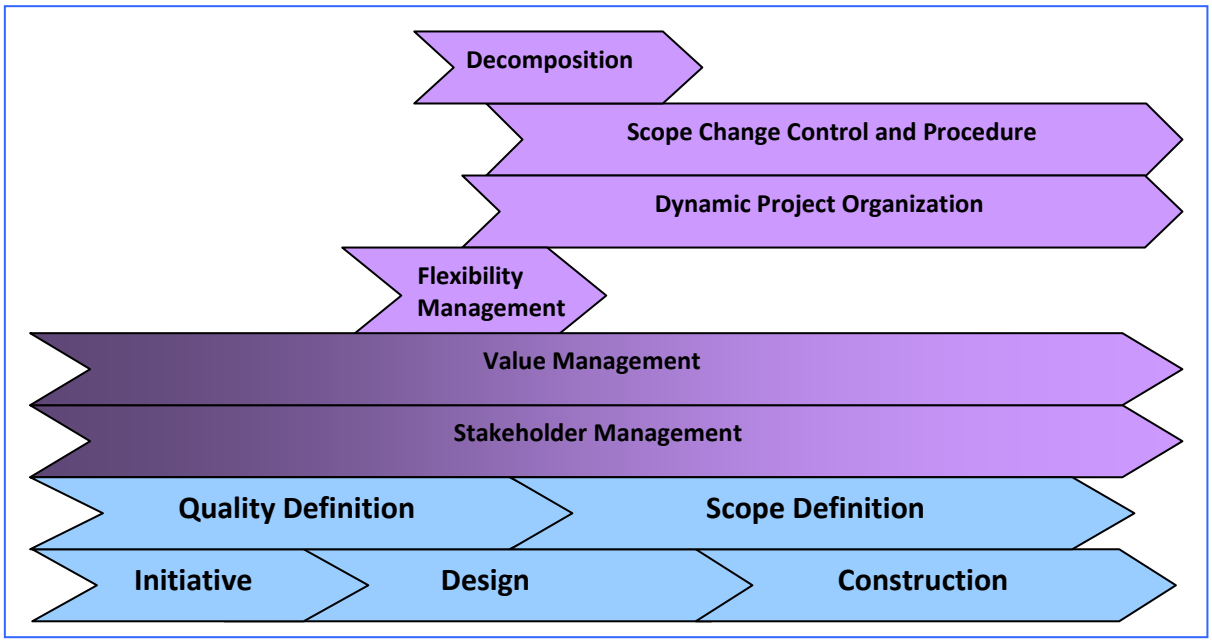


Figure 35, Scope management methods and their place in the PLC (author).

For this subject the research questions for case study and questionnaire will be:

- Could any of the suggested scope management methods in Figure 35 have prevented problems related to scope or could they have benefited the project?
- How did the scope change procedure function during the PLC?

4.7 Summary

In this chapter the framework for this study was set out that will be verified by the case study and questionnaire. The variables and their relationships and their dynamics in the PLC will be tested on validity and accuracy. The theoretical framework has led to the following research questions for the case study and the questionnaire:

- Is there a clear relationship between the project constraints and external influences?
- Is there a clear relationship between the project constraints? Does a change in scope lead to a change in one or more project constraints?
- Is there a clear ranking in the project constraints and do they change during the PLC?
- What were the causes for the scope changes that occurred?
- What was the impact and frequency of those scope change causes?
- What scope change scenarios occurred during the PLC?
- What was the effect of scope changes on the other constraints?
- How did the scope develop during the PLC?
- Does the moment of scope change introduction resemble the function of Figure 33?
- What was the impact of stakeholders on the scope of the project?
- Does the level of impact of the stakeholders suggested in Figure 34 represent the reality?
- Could the effect of the impact of the stakeholders on the scope of the project be reduced by involving them earlier in the project?
- Could any of the suggested scope management methods in Figure 35 have prevented problems related to scope or could they have benefited the project?
- How did the scope change procedure function during the PLC?

5 Betuweroute, a critical case study

5.1 Introduction

A case study is done to explore the current state of scope management in an infrastructure project, the Betuweroute. The theoretical framework of the previous chapter is tested in how it holds up against what happens in practice. The research questions set in the theoretical framework will be answered in section 5.11.

In this chapter the method of case study will be elaborated and explained why the Betuweroute is chosen as subject of the case study. After these elaborations the Betuweroute itself will be discussed, first a short introduction of the Betuweroute. After the introduction the PLC is provided as a reconstruction of the timeline of the project. From this timeline events can be recognised related to the development of the project constraints; scope, quality, time and cost. The structure of the theoretical framework is used to discuss the different topics; the project, scope changes, scope development, stakeholder impact and scope management.

5.2 Case study method selection

After the decision for a case study, an appropriate case study selection has to be made to best fit the purpose of the research. In Table 1 the different types of selection are presented with their purpose. The amount of large infrastructure projects in the Netherlands is limited, information oriented selection is chosen over random selection. Within the information oriented selection the selection of a critical case is chosen that represent a large infrastructure project in the Netherlands as to make logical deductions.

Type of Selection	Purpose
A. Random selection	To avoid systematic biases in the sample. The sample's size is decisive for generalization.
1. Random sample	To achieve a representative sample that allows for generalization for the entire population.
2. Stratified sample	To generalize for specially selected subgroups within the population.
B. Information oriented selection	To maximize the utility of information from small samples and single cases. Cases are selected on the basis of expectations about their information content.
1. Extreme/deviant cases	To obtain information on unusual cases, which can be especially problematic or especially good in a more closely defined sense.
2. Maximum variation cases	To obtain information about the significance of various circumstances for case process and outcome (e.g., three to four cases that are very different on one dimension: size, form of organization, location, budget).
3. Critical cases	To achieve information that permits logical deductions of the type, "If this is (not) valid for this case, then it applies to all (no) cases."
4. Paradigmatic cases	To develop a metaphor or establish a school for the domain that the case concerns.

Table 1, Strategies for the selection of samples and cases[15].

5.3 Case selection

Besides the criteria that the project has to be a representative large infrastructure project in the Netherlands, there were several other criteria that were important in the selection of the Betuweroute as critical case;

- *Amount of information.* To maintain the knowledge gained with the Betuweroute, a website (kennis.betuweroute.nl) was aired to spread this gained knowledge. Important information like:
  - *Researches.* Because of the scale, (economic) impact and complexity of the project several researches have been undertaken.
  - *Parliamentary Research.* Because of problems in the decision-making, design and implementation phase a Parliamentary Research by the Commission Duivesteijn has been undertaken.
  - *Progress Reports.* Every six months of the project a progress report is presented to Parliament and are available on the website.

[15] B. flyvbjerg (2006), Five Misunderstandings About Case-Study Research.

- *Access to information*. Via this website it is easy to access all relevant documentation about the Betuweroute.
- *Quality of information*.
  - *Researches*. Several studies about the feasibility of the Betuweroute have been presented and on some points there are differences of opinion in chosen future values which influence the feasibility of the Betuweroute. Because of these different viewpoints a discussion is started about the quality of researches. These discussions lead to a more accurate assumptions (quality) about future values and thus feasibility. Different researches lead to more unbiased opinion forming.
  - *Parliamentary Research.* An extensive and thorough research about the Betuweroute and their responsible actors has led to a qualitative evaluation. The general findings of the commission were accepted by the responsible actors.
  - *Progress Reports.* Progress reports contained information about among other things; scope development, planning, cost development, surroundings, etc. In latter progress reports an accountant report was included to examine the quality of the report according to predetermined norms.
- *Completion of project.* Because we want to gain more understanding through the stages of initiative, design and implementation it is essential for the project to be completed.
- *Project of Arcadis.* For latter stages of the research (questionnaire and interviews) it was important to select a project with involvement of Arcadis.

5.4 Introduction Betuweroute

The Betuweroute is a double tracked railway from the harbour of Rotterdam to Zevenaar and the border with Germany (Figure 36) solely devoted to freight transport. The Betuweroute has a total length of 160km new track with 5 tunnels (total length 18km) and 130 viaducts and bridges (no level crossings). The betuweroute will be part of the TERFs (Trans European Railways for Freight) en TENs (Trans European Network), in which other countries are also investing. Project Betuweroute is separated in two parts, the A15 track and the Havenspoorlijn.

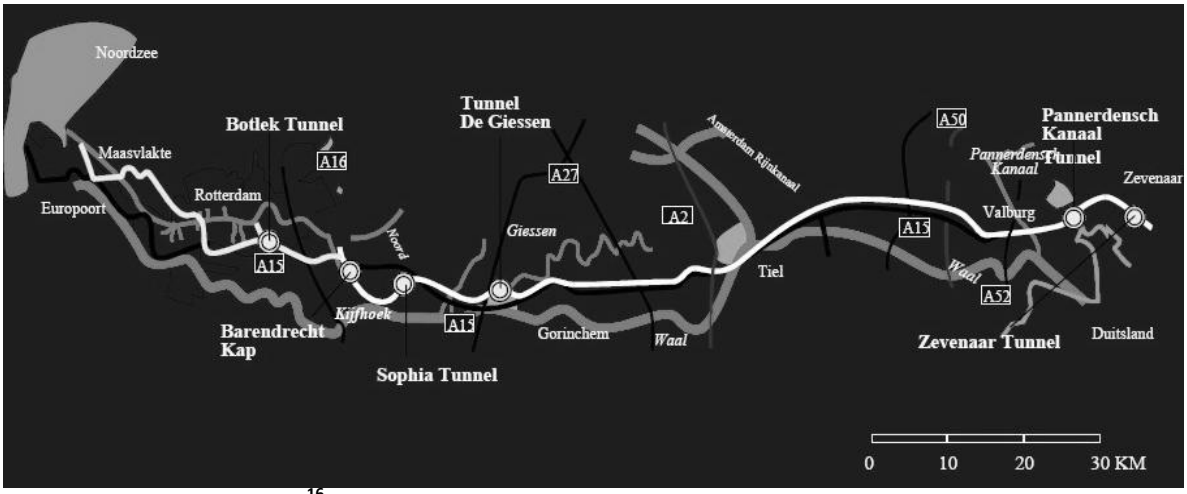


Figure 36, The Betuweroute[16].

5.5 Timeline

In the following sections a summary is given about important stages in the Project Life Cycle as discussed in the report of the Commission Duivesteijn (December 2004).

5.5.1 Agenda setting (1988-1990)

In the agenda setting phase from July 1990 till the decision of parliament to include the Betuwelijn (an existing east west rail connection that could be upgraded for freight transportation) in the SVV2, four elements play an important role, which can be translated in the stream model of Kingdon (see Figure 37):

16 P.E.M. Buck, presentation De Betuweroute; een bijzonder project.

1. *Changing context.* A policy shift from 1989 (from defending weak regions to strengthening strong regions), more investment from the government and the need for a Trans European Network was the breeding ground for the Betuweroute.

2. *Momentum for the Betuweroute.* Increasing prohibitions in road transportation in Germany and Alpine countries in the seventies woke up actors in the Rotterdam Harbour to promote a better rail connection with the Hinterland. These actors bundled their powers in the organisation Nederland Distributieland to get the interests on the agenda.

3. *Commission Van der Plas.* This commission had the assignment to develop a vision for freight by rail. Attending the commission included actors from the industry and transport sector, Rotterdam Harbour, the NS and two high officials from the Ministry of Transport, Public Works and Water Management. In a short period without much deliberation a strong plea is made for a expansion of the "East-West corridor", for which the Betuwelijn can be derived. First it can be noticed is the homogeneous composition of the commission what suggests a biased opinion for the favoured vision. Second of all is that the beneficial stakeholders developing the vision are not committed to any investment in the vision.

4. *Standpoint of the Cabinet, SVV2* . The report of the Commission Van der Plas is the basis for including the Betuwelijn in the SVV2 (Tweede Structuurschema Verkeer en Vervoer) with a indicative budget of 2-2,5 million guilders and without any balancing of utility and necessity.

The figure below shows that for a potential project to be born three streams play an important role. First the political arena has to be fertile for the subject of interest, in the case of the Betuweroute it was the need to strengthen the strong regions. Second there has to be a problem, in this case the weak west east connection with Germany. And last there has to be a solution to the problem and the political willingness to take action. All these three streams came together in the SVV2 the foundation was laid for the Betuweroute.

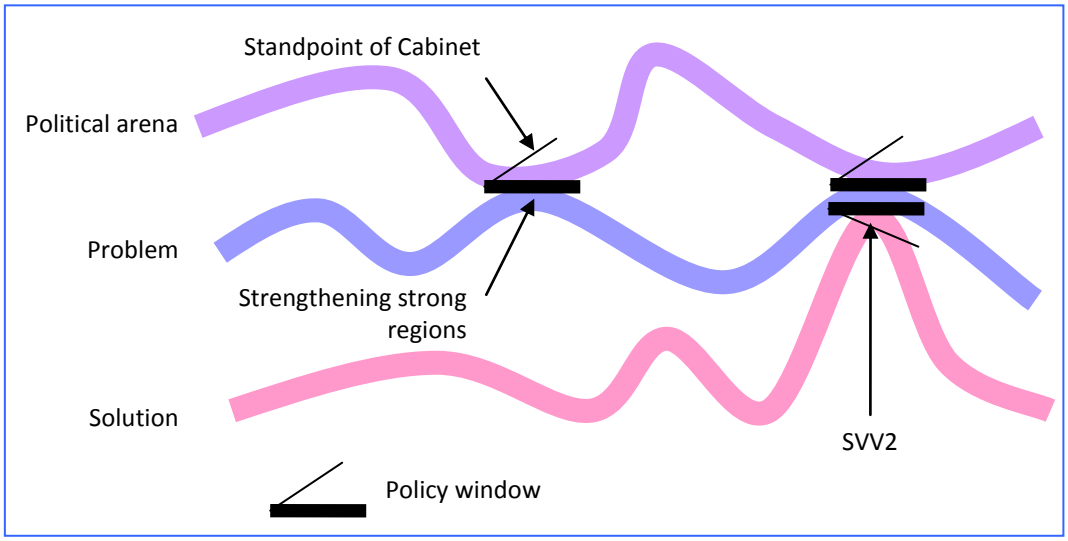


Figure 37, Stream model of Kingdon (Bruil et al. 2004) applied on the Betuweroute.

5.5.2 False start of decision-making (1990-1992)

In the 1990s the NS releases its proposal Betuweroute and in the spring of 1992 the cabinet publicises the PKB1 for participation, consultation and advise. Three themes play an important role;

1. *The project study, the neglect of the balancing of utility and necessity.* Instead of an integral study in alternatives, effects and a calculation of economic costs and benefits, the NS delivered a project note more focused on the development of a global design of the Betuweroute.

2. *Design and integration, the NS continues.* As NS continues to design and develop the Betuweroute, local governments slowly realize the potential impact of the Betuweroute has on the natural and residential environment. Local authorities unit in Gebundeld Bestuurlijk Overleg (Bundled Administrative Counsel) and civilians form several action groups united in Vereniging Landelijk Overleg Betuweroute (National Union Consultation Betuweroute). Ministry of Transport, Public Works and Water Management has no reaction on this development.

3. *PKB part one.* In the spring of 1992 the Project Note of the NS is finished and according the Trace Law a PKB procedure is started. ICES judges there is to few information to make a fair decision on content, there is a lack in insight in alternatives, economic effects and the cost have significantly increased in comparison with the estimate of the SSV2. As a result the cabinet only decide to conduct additional research, but the balancing of utility and necessity is again postponed. Measures for better integration in the environment do not have the anticipated effect on stakeholders, and reactions are mostly negative and emotional.

5.5.3 Decision of the cabinet (1992-1993)

This period start in the summer of 1992 when the Covenant of Warnemünde is made between the Dutch and German governments till May 1993 when the cabinet sent their standpoint on the matter to parliament.

1. *Covenant of Warnemünde.* Agreements are made between the two governments about actions to be taken for the connection of the Dutch rail and the German rail, and are very detailed. Now the cabinet is more committed to the realization of the Betuweroute even though a decision about the Betuweroute is still to be made in Holland.

2. *Additional research: Knight Wendling, McKinsey and CPB.* To support the PKB1 the cabinet first gives Knight Wendling the assignment to calculate the economic effects of an increase of freight by rail of 65 million ton in 2010 (no broad macro economic calculation). This situation is compared to a situation when no action is undertaken, and the result is positive. The CPB is approached for a second opinion and investigates two economic scenario's and also is positive about the construction of the Betuweroute. McKinsey investigates the business economic profitability with a best future cost scenario (with a optimal conditions). The results of this scenario are highly dependable on the likeliness of this scenario to happen. The report does not give any clarity on this subject. The cabinet prevails the positive results of the studies and the risks, uncertainties and assumptions are not mentioned clearly.

5.5.4 Decision-making in Parliament (1993)

This period covers a halve year, from May 1993 when the view of the cabinet is presented till December 1993 when a debate takes place in parliament.

1. *Request for external test by Parliament.* The report presented by Twynstra en Gudde contains some critical findings about project definition, used future scenario's for transport and the economic foundation. But in the conclusion of the report these findings are toned down with the conclusion that vision and will play an important role very fast.

2. *Review in Parliament.* The report again raises the question about the utility and necessity of the Betuweroute, and again this discussion is not settled. The discussion is aimed at the local integration, in the period of decision-making costs have risen with two billion guilders without more clarity about utility and necessity.

5.5.5 Reconsideration (1994-1995)

With the formation of a new cabinet, the Betuweroute is an important point on the agenda.

1. *Decision to reconsider: appointing commission Hermans.* In the governmental agreement the appointment of an independent commission is included that must give a decisive answer to the questions of utility and necessity of the Betuweroute.

2. *Capacity existing rail.* In only three months the commission has to give a Solomon's decision about the Betuweroute. Essential information for this decision is the existing capacity of the rail and this information has to come from RailNed. McKinsey has to answer the following three questions:
    a. *What are the future freight volumes by rail?*
    b. How many train paths are necessary to accommodate these volumes?
    c. Where are the bottlenecks in the current rail network and which options are there to resolve those bottlenecks?

For the answering of these questions McKinsey is dependable from information from RailNed, who is contractual obliged to do so. RailNed however does not deliver certain information or delivers it too late. Commission Hermans needs the answers provided by McKinsey to come to a conclusion, the minister however urges the commission to come to a conclusion soon. An attempt by the commission Hermans to resolve the problems between McKinsey and RailNed fail. The concept report of McKinsey causes a difference of opinion within the commission, but in the end the recommendation is made to implement the Betuweroute in full.

3. *A phased implementation revisited.* Besides the recommendation of the commission Hermans discussion is raised for a phased implementation, and the lack of a macro economic analysis of the Betuweroute. Cabinet asks CPB (Central Planning Bureau) to do this analysis, and the recommendation is to reconsider phased planning. This recommendation is rejected by parliament.

4. *Yes, unless…*. The advise of the commission Hermans is that the implementation of the Betuweroute is recommended, only if a policy is introduced which discourages freight by road and encourages freight by water and rail. Cabinet takes over the green light of the commission, but the recommended taxes are not taken into account for the short term. Also 820 million guilders is set aside to resolve bottlenecks, without any consideration.

5.5.6 Implementation and control (1995-2004)

In the fall of 1995, when the reconsideration of the decision-making is concluded, implementation of the Betuweroute is started.

1. *Project steering and control (1995-1998).* NS Railinfrabeheer leads the implementation of the project, the minister of Transport, Public Works and Water Management has end responsibility. A clear description of the relationship between NS Railinfrabeheer and the Ministry of Transport, Public Works and Water Management is lacking and the audit function is not working properly.

   Project steering and control (1998-2002). The audit function is working better, but there are new problems, the steering and coordination of large projects within the Ministry is not optimal. The relation between project board and NS Railinfrabeheer remains problematic.

2. *Tension between cost estimate and budget.* In some cases the budget is raised accordingly in other cases the tension remains. The project is cost-driven and reduction in scope are made (without considering parliament) to balance cost estimate and budget (Malle Jan agreement). The minister also improperly uses a part a the budget reserved for unforeseen to cover holes in the budget.

3. *Progress control by Parliament.* After the Malle Jan agreement the minister informs parliament that cost estimate and budget are again in balance and that the project will be realised within scope, planning and budget, even when this is clearly not the case. Parliament fails to interrogate the minister on certain topics and finally agrees on the proposed revisions.

4. *The accountant service.* In the first period of implementation (1994-2000) there are no accountant reports included with the progress reports. Even when they are included in one case changes are made after instructions of the minister. A subjective review of the progress report is not possible because of the hierarchical relation between the minister and the controller.

5. *Risk reservation.* In 2002 a risk reservation of 985 million euro's is introduced for the Betuweroute and the HSL Zuid to cover a combination of scope changes (major part), setbacks and risks.

6. *Budget development.* Since the PKB part 1 the budget has been doubled, 2,5 billion euro's more is needed. One third is due to regular price adjustments and more than halve is due to scope changes. The cost development in the implementation phase shows a positive development. A broad interpretation of (inevitable) scope changes is used by the minister.

7. *Steering on social objectives.* When in the fall of 1998 there is an urge from scientists for a reconsideration of the Betuweroute, the cabinet reacts irritated. The cabinet stipulates there are no new facts to justify a reconsideration and that the urgency of the Betuweroute is even bigger, followed with a list of partly questionable arguments.

5.6 The project

Over time a project changes and so does the project constraints, in this section the development of cost and time are presented. In the initiative phase time was a driven factor, the cabinet realised that the window of opportunity as can be seen in the stream model is limited. The project was forces through and any suggestions for reconsideration were labelled as superfluous, because not constructing the Betuweroute would harm the economy greatly. When the project had the green light, money became the driven constraint. Because the cost rose when the design progressed due to large adaptations it was essential to stay within budget. So there was a clear ranking between the project constraints and this changed during the PLC.

5.6.1 Cost development

The difference between the PKB1 (2.335 million €) and PKB3 (3.368 million €) differ greatly (+1.033 million €). If we look at the cost development during the implementation phase, as represented in Figure 38, we see that in the beginning of the implementation phase the budget increases faster than the inflation rate.

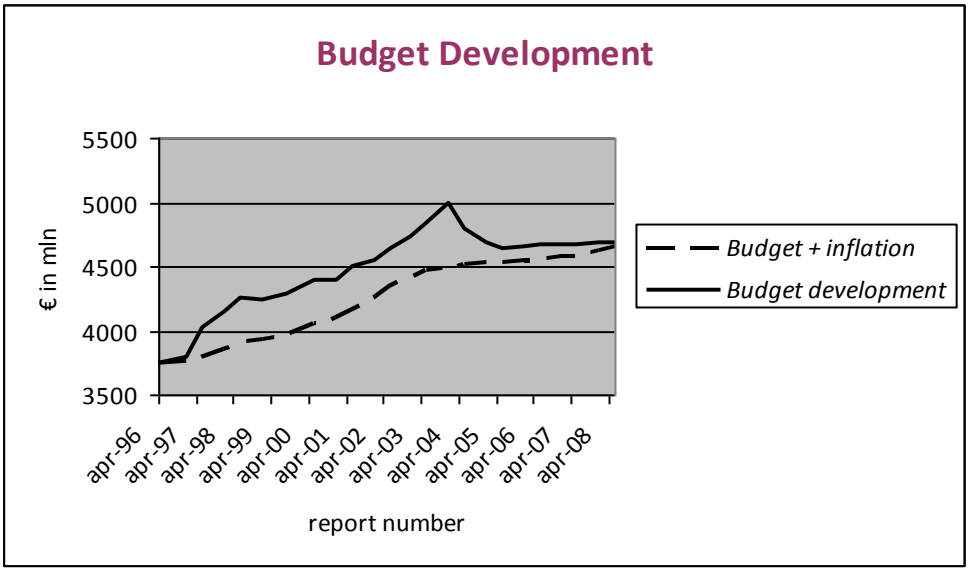


Figure 38, budget development during Construction.

Because of certain simplifications and windfalls in procurements in the project the tension between cost estimates and budget is relieved and at the end of the implementation phase the budget development aligns with the budget plus inflation rate. This policy to reduce the tension indicates that the project is cost driven.

Subject	Cost in million € (price level 1995)
PKB1	2.335
PKB3	3.368
Scope changes during implementation	258
Simplifications during implementation	94
Changes minus simplification	164

Table 2, Cost information Betuweroute.

Budget unforeseen

The report of the commission Duivesteijn also concludes that the budget reservation for unforeseen circumstances is misused by the minister to finance scope changes. In a proper scenario, each scope change raises project budget and would lead to more resistance of the Parliament for the project. Commission Duivesteijn also criticizes the manner broad interpretation of the minister of the phenomena of (inevitable) scope mutations. The total budget unforeseen used for the Betuweroute is 259 million € (price level 2008).

Risk reservation

At a certain point in time top officials of the Ministry of Transport, Public Works and Water Management realise that steering on budget has its limits and a risk reservation of 985 million € is set aside for the Betuweroute and the High Speed Rail South. For the Betuweroute the risk reservation is not only used for risks but also for a mix of scope changes, set backs and risks. For the following items the risk reservation is used:

- Sprinkler installations, 104 million € (price level 2002).
- EAT (Engineering Apparaat Toezicht), 37 million € (price level 2005).
- Migration Havenspoorlijn, 14 million € (price level 2007).

For all three items it can be said that the use of the risk reservation is questionable at least. The sprinkler installation was earlier indicated as a scope change and the migration of the Havenspoorlijn could also be labelled as a scope change.

5.6.2 Time development

Because of the different levels in the project organization (central, regional and contract) the planning, the planning is focused on those levels. On central level the planner is responsible for the reference list and checks scope changes on the aspect of time and conduct overall analysis. The regional planner is responsible for the regional project activities and conducts regional analysis. The contract planner aligns activities (planning received from contractor) between contracts, thus building a closed network of activities.

In Figure 39 the prognoses of the delivery dates of the A15 track and the Havenspoorlijn are presented according to their progress report date. In 2003 the planning is adjusted after delays in the construction of the substructure to 2007. The official opening of the Betuweroute was in June 2007, however the construction of the Havenspoorlijn is not yet finished. The Havenspoorlijn is detached from the project Betuweroute and continues under the project Havenspoorlijn. So if we look critical at the definition of the project Betuweroute, construction is still on the way but operational.

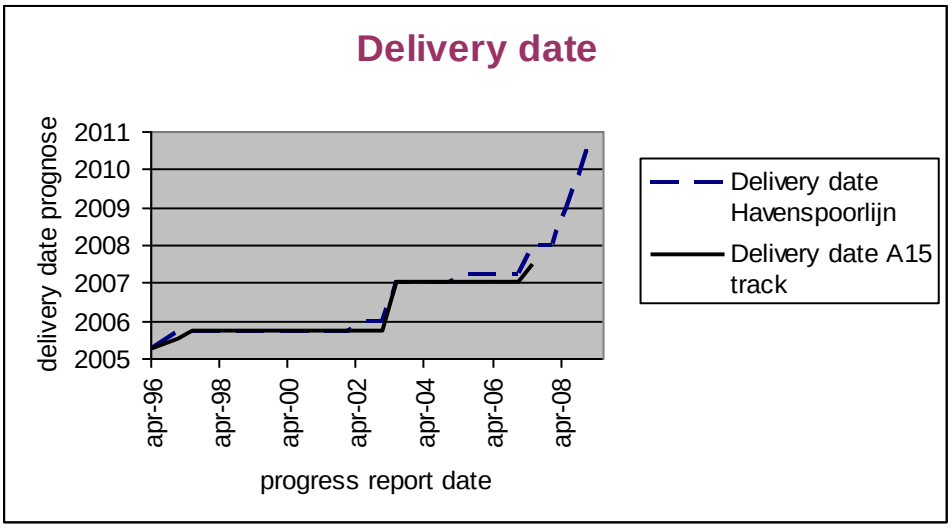


Figure 39, Prognoses of delivery dates in progress reports.

5.7 Scope changes

5.7.1 Scope change causes

If we compare the upgraded Betuwelijn, first mentioned by the Commission Van Dongen in 1985 and later included in the SVV2, and the Betuweroute today a lot of changes are made. First of all the upgrading of the Betuwelijn was dropped because the construction of a new trace, the Betuweroute, would have less impact on the environment because the existing Betuwelijn is bendy and crosses neighbourhoods. This change is rather the selection of an alternative than a scope change.

Once it had been decided to plan a new west-east rail connection (Betuweroute), the first design made by the NS resulted in a lot of resistance of local governments and communities. To compensate these groups a lot of changes have been made to the original design (PKB1) for better integration in the surroundings (PKB3). Important extra scope changes were among others extra tunnels, a cover up roof (Barendrecht) and deepened alignments. This of course had consequences for the quality of the Betuweroute (less landscape and noise pollution), higher cost and different planning.

After the Trace Decision in 1996 the project in essence stayed the same, however several scope changes have been made that made a significant impact on the budget (see appendix 9.4). In some places scope was simplified and in other places scope was added. There are several causes why a scope change can occur:

1. *New laws and regulations*. Unavoidable external demands on which no control can be exercised. Think of new legislation on safety and environment.
2. *Requirements of the client change*. Strategies of a client change over time, this may affect project scope.
3. *Risks taking place*. There is always the possibility that risks will take place causing scope changes to be needed to complete the project successfully.
4. *Effects of other projects*. Other projects may affect the project, which can result in scope changes.
5. *New insights*. During the process, information becoming available, for example soil composition, which can lead to scope changes.
6. *Technological breakthroughs*. New technologies come on the market that can be applied on a project.
7. *Imposition by the State Council*. One can think of individuals or groups object and receive compensation awarded by court. Think of the placement of additional noise barriers.
8. *Scope definition is not complete*. During the development there is scope missing for a successful completion.
9. *New economic situation*. New economic situations influence the financial feasibility of a project. Scope changes can then necessary to overcome these negative effects.

In Table 3 the main scope changes after the Trace Decision are presented with the associated cause.

	Scope change after Trace Decision	**Cause**
1	Adjustments for double stack, *double stack for capacity increase*	*Requirements of the client change*
2	Reparation Trace Decision, *several procedures against TD are granted*	*Imposition by the State Council*
3	Simplification of Kijfhoek, *capacity decrease to decrease project cost*	*Requirements of the client change*
4	Integration Waalhaven Zuid, *adjustments needed to connect to Waalhaven*	*Scope definition is not complete*
5	Integration HTS-east, *integration of HTS tunnel with Betuwe tunnel*	*Effects of other projects*
6	Other simplifications within project, *to decrease project cost*	*Requirements of the client change*
7	Sprinkler installation tunnels, *experiment proves sprinkler installation beneficial*	*Technological breakthroughs*
8	Train safety system, *policy decision to deploy same system for entire Betuweroute*	*New laws and regulations*
9	Noise reduction measures Calandbrug, *research shows need for measurements*	*New insights*
10	Scope change intersection Geldermalsen, *capacity increase intersecting track*	*Effects of other projects*

Table 3, Scope Changes after Trace Decision and their causes.

5.7.2 Scope change scenarios

The causes mentioned above do not only affect the scope of the project, but also through their linkages the other project constraints. In the figure below the scenarios for the above mentioned scope changes are presented. In all cases scope is an intervening variable which in all cases except two affects the cost and time of the project, either decreasing it (simplifications) or increasing it. It can also be noticed that in six of the ten cases it is the need for a change in the quality constraints that results in a scope change. Either the quality definition at the beginning was not complete or the quality constraint changed during the PLC.

The scope changes have an effect on the cost and time of a project. For the Betuweroute only the effect on the cost constraint is given in appendix 9.4. Scope changes will always have a direct effect on the cost of the project in comparison with the planning. If a scope change does not redirect the critical path(s) it will not have a direct effect on the delivery date. When consulting appendix 9.4 it can be noticed that the adjustment to double stack (+67€ million) and simplifications (-69 €million) had the greatest impact on the cost of the project. The causes of both scope changes were introduced by the client itself.

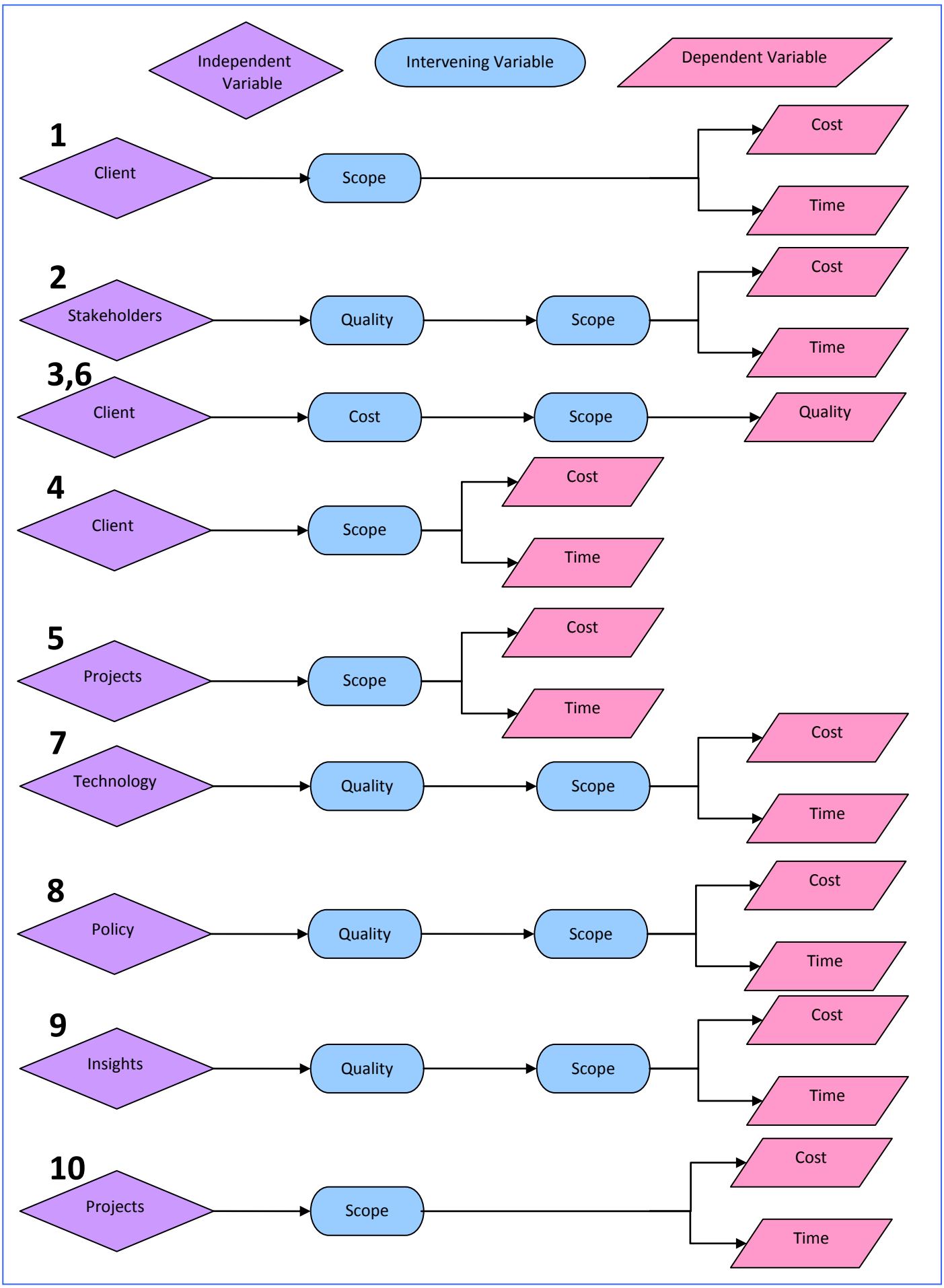


Figure 40, Scope change scenarios during Betuweroute.

5.8 Scope development

5.8.1 Scope fixation

In the early phase of agenda setting the cabinet is focused on an physical object (scope) rather than a desirable functionallities (quality). In the SVV 2 the Betuwelijn is included and later on this option is converted to a new route, the Betuweroute. Because of this fixation other real options for reaching the goals of the cabinet do not get the same chance as the Betuweroute. For example the consideration of the upgrading of transportation by water for which the Netherlands has a good infrastructure does not have the same chance. Even though transportation by water reaches the same main goal as transportation by rail, namely the reduction of transportation by road and thus less impact on the environment (CO2 emission).

5.8.2 Scope analysis

Instead of evolving to the solution of the Betuweroute by profound analysis of which solution direction creates the most value (economical, social, environmental, et.) for the country, those analysis were done when the development of the Betuweroute had great momentum. The cost-benefit analysis done initially by Knight Wendling had more the intention to justify the choice of the Betuweroute, rather than a subjective analysis of an alternative. This could be the result of early fixation on a physical object and trying to "bend" the outcome or highlight the positive outcome to meet your objectives. Several other studies are done to give a prediction about future cost and benefit of the Betuweroute. From Table 4, Published cost and benefit (Onzekerheid over de baten van de Betuwelijn, C. Heij, M. Van Regenmortel, H. Steehouwer, V. Voeten and S. De Wijs, 1996). it can be concluded that the results differ greatly between the studies. C. Heij, et al. (1996) give the following four causes for these differences:

1. *Used model.* Different models are used for the analysis (micro-economic models of the transport sector trough multi sector models, as far as purely macro-economic models of the Netherlands)
2. *Quantification of the models.* Different inputs are used like results from preceding studies, expert opinions, historical data and econometric models.
3. *Development of external factors.* Different developments in external factors have an impact on future benefits, like future supply of goods, European economic development, position of Rotterdam Harbour, tariff development of transportation and levies on transport by road.
4. *Other unforeseen developments.* Sensitivity of the outcomes of structural changes, like the reaction of other competing harbours, development of economies in Eastern Europe, technological developments, etc.

Discussion caused by the differences where mainly focused on the reliability of the used models and quantification of the development of external factors. No consent has been reached which led the policy makers to use own judgement and subjective trust in certain studies to make their decision (C. Heij, et al., 1996). The last study conducted by the CPB shows high costs and lower benefits than most studies before. One can conclude by the last study that the investment in other alternatives is favourable.

Study	Year	Cost [billion]	Benefit [billion]	Corrected Benefit
Knight Wendling	1992	5	34-46	48-71
CPB	1993	8	19-33	15-21
Twijnstra Gudde	1993	7-10	-	-
Muller	1994	37	-	-
NijFER	1995	9	52	52
CPB	1995	9-11	7-10	-

Table 4, Published cost and benefit (Onzekerheid over de baten van de Betuwelijn, C. Heij, M. Van Regenmortel, H. Steehouwer, V. Voeten and S. De Wijs, 1996).

The commission Duivesteijn (2004) concludes about the scope analysis the following:

- Although questions are posed by institutes about the profitability and necessity of the project, the debate in Parliament is not settled.
- The increase of cost of two billion guilders does not give more clarity about utility and necessity.
- Research indicated that the environmental benefits could be lower than expected.

Van Mierlo (2004:3-5) notes that many policy programs suffer from a lack of scientific substantiation. In combination with a wrong philosophy guiding this defect leads to failure of policy programs. He gives four sources of policy failure. First there are gaps in the scientific underpinning of policy, or knowledge gaps, the scientific basis of policy. The "scientific theory" which cause-effect relationships are central, but they are less certain than we would like and many policy makers and some researchers decide it is. There are also pitfalls in the translation to the policy theory, the quality of policy theory determined by the quality of the underlying scientific cause-effect theory. If that basis is wrong, it cannot properly reflect the policy theory. Thirdly policy makers are subjected to cognitive dissonance and blind ideological bias. They tend to neglect or modify information about the empirical reality, that is inconsistent with their views or preferences. And last inadequate management philosophy. Notwithstanding any other formal influence and participation opportunities in the process, policy makers still seem to behave as political engineers, with turnkey solutions for policy problems.

5.8.3 Scope description & Contracting

In the early stages of agenda setting the upgrading of the existing Betuwelijn is mentioned, because of this a part of the scope, the trace, is more or less fixed. Once it is decided to construct a new trace, the scope is more loosened and thus the solution space.

The Key Planning Decision (PKB) includes a description of why the Betuweroute is built, where it is situated and what environmental impact the construction has. The PKB consists of 4 parts, namely PKB Part 1: Design PKB, PKB Part 2: Design Comments PKB, PKB Part 3: Cabinet position including summary and PKB Part 4: The PKB including maps. The Tracebesluit describes the route of the railway. Trace Decision also includes a part of the construction of the motorway A15. The Trace Decision is prepared within the framework of the Infrastructure Planning Law and consists of 6 sections, namely: General Betuweroute, Betuweroute B1: trace-Papendrecht Rotterdam, Betuweroute B2: trace Sliedrecht-Gorinchem, Betuweroute B3: trace Lingewaal-Tiel, Betuweroute B4: trace Echteld-Elst and Betuweroute B5: trace Bemmel Zevenaar.

The project scope/content is defined in the Functional Program Requirements Betuweroute (Functional List Of Requirements). In this Functional List Of Requirements (the properties and characteristics) of the outcome of the project Betuweroute are described in the form of preconditions, functional and operational requirements and overall design solutions. The Functional List Of Requirements is then detailed in the Technical Program Requirements Betuweroute . The Technical Program Requirements contains the technical details of the Functional List Of Requirements.

A mix of contracts has been applied, the substructure has been procured in a Design and Build contract. This means that a functional description together with a list of requirements is provided to the contracting party. The contractor produces a detailed design based on that description and requirements. The client should examine the design, quality and construction methods based on the PVE in the standards and guidelines and the agreed upon terms (procedures, quality plan, safety plan, etc.). For four substructure a RAW contract form contracts is deliberately chosen. It concerns the construction of the track (including artwork) on a large distance along the A15 in Gelderland. The design flexibility was very limited here.

Originally the entire superstructure would be tendered in a Design Build and Maintain contract (DBM). DBM integrates design approach (design), construction (Build) and maintenance (Maintenance) in one contract. The builder does not only construct, but is also responsible for the design and performs maintenance after delivery. He is not only responsible for the end product, the special requirements (in terms of quality, time and money), but also to the realization process: organization, execution and contract management and information. In early 2001 it was decided to abandon the maintenance part, because research had shown that the potential benefits of such a contract could not outweigh the risks that were associated with an unknown contract form for both the contractor and the client. In May 2001,the design part was completely removed from the tender. For the track work, the sound barriers and the traction power supply installations and the tunnel of the superstructure an Engineering & Construct contract was chosen.

5.9 Stakeholder impact

Today we are moving into an era when networks of stakeholders are becoming at least as important, if not more important, than markets and hierarchies[17]. Attention to stakeholders is important throughout the strategic management process because 'success' for public organizations – and certainly survival – depends on satisfying key stakeholders according to their definition of what is valuable[18]. When beginning a stakeholder analysis it is important to determine what term you are going to use[19]. In our paper a stakeholder is any person or organization who can be positively or negatively impacted by, or cause an impact on the project.

5.9.1 Process analyses decision-making phase

In the report "Sporen naar een nationaal project: de Betuweroute" a process analysis of the process of the formulation of the PKB and Trace Decision is presented. From this report several important moments and their active stakeholders can be identified and are underlined:

SVV2

- At the end of 1989 the commission Van der Plas advises a west-east corridor solely dedicated to freight, a modernized and lengthened Betuwelijn should be included in the SVV2. At the same time several parties in the Betuwe (seven Chambers of Commerce, Province of Gelderland and Zuid-Holland and several transport organizations) also propagate the modernisation of the Betuwelijn. In 1990 the NS in his future plan for freight also includes the modernisation of the Betuwelijn. So several parties are proponents of a modernised Betuwelijn.
- In June 1990 the Betuwelijn has a prominent place in the SVV2, due to the effort of the earlier mentioned parties.

Trace Law

- The cabinet is convinced of the urgency of the project, and the current procedure takes at least 90 months before construction can be started. So in 1992 a new Trace Law was announced to better streamline and accelerate the procedure. Projects of national importance have a separate arrangement in this new law. The most important change is that once a trace decision has been approved it is binding for regional and local plans. This means that the decision-making takes place on a national level, thus Parliament has final approval and decides about utility and necessity and global integration. Citizens can no longer question the local and regional integration of the trace, but trace decision and PKB can be challenged by the State Council.
- The NS realizes that the construction of a new route is also an option, and in 1990 it discusses possible alternatives with involved municipalities. Most municipalities start to realize the extent of the consequences, and feel the approach of the NS as "Get out of the way, we're coming through".

PKB1,2

- In 1992 the first PKB under the new Trace Law created some confusion during public participation. Under the old law the cabinet does not give an opinion about their preferred trace, under the new law they do. So people question the influence of their voice, because a decision seems to be made already.
- Public Participation. Because the notification of intent is so detailed, the following information evenings for public participation create a lot of attention also from the media.
    - Several local action groups see the light of day that question the need of the Betuweroute and have a high "not in my backyard" attitude. These actions groups have bundled their power in the VLOB (National Union Consultation Betuweroute), which coordinates the actions. The emphasis of the public participations are the local negative environmental , noise and vibration hinder, safety and landscape effects.
    - The opinion of the regional and national stakeholders is mainly pro Betuweroute during the public participation. National companies and freight organizations stipulate the macro-economical importance of the Betuweroute. Private river transportation companies warn for unfair competition, but are not explicitly against the Betuweroute. Other organizations however stipulate the benefit of transportation by water, the cabinet however is convinced of the need for a strong variety of transportation options (water, rail and road).
- After the Public Participation three other institutes give their opinion;
    - The commission MER (Environmental Impact Assessment) is judges the environmental impact assessment is of good quality.

[17] Powell 1990
[18] Bryson 1995; Moore 1995
[19] Lewis 1991

- The advice council for spatial planning is divided, but positive in their advice. A small minority prefers a more phased implementation.
- The consultative body traffic infrastructure is also positive in their advice, however they have comments of the combined procedures (planning decision, environmental impact assessment and trace procedure).

PKB3,4

- After this Public Participation the cabinet takes a definite decision, taking all reactions into account. The PKB part 3 appears in 1993 and the Parliament and Senate approve the PKB after the long debates. Once the PKB3 is approved by the Senate in turns into the PKB4, which concludes the decision-making phase.
- 171 Appeals are accepted by the State Council against the PKB4 and again there is a lot of media attention. The main characteristics of the appeals are:
  - Decision made on wrong assumptions (cost and benefits).
  - Proposed alternatives and appeals do not get a chance.
  - Construction socially irresponsible.
  - Procedural errors are made.
  - Environmental argument not valid.
  - Financial feasibility not proven and secured.
  - Uncertainty about connection with German network.
  - Construction leads to unacceptable deterioration of living environment.
  - Betuweroute causes vibrations and safety problems.
  - Noise calculations incorrect, noise level to high.
  - Deepened or tunnelled track necessary.

  Of the 171 appeals, 22 are partly justified by the State Council and 149 are not. The State Council however stipulates that with the development of more detailed plans, it definitely becomes clear if interests of all stakeholders are sufficiently compensated. So stakeholders wait for the opportunity to appeal against the Trace Decision.

Preliminary Trace Decision

- In the design phase of the preliminary Trace Decision resistance against the plans remain, not only by environmental groups, but also regional and local governments and citizens are worried about the effects. There are also irritations of the followed procedures and the lack of transparency by the initiators (Ministry of Transport, Public Works and Water Management and NS RIB). As a reaction to this resistance the Ministers of TPWWM and Housing, Regional Development and the Environment decided to give people the opportunity to react on the preliminary Trace Decision. This legal novum results in a longer design phase, but it is a serious attempt to let stakeholders have the opportunity to influence the project. The underlying idea is that leads to more acceptation and understanding of the plans. The attention of media and citizens is again very high for the information evenings held to give the people the opportunity to react, the meetings are sometimes emotional, but overall people have some understanding and acceptance towards the plans.

Design Trace Decision

- During the development of the Design Trace Decision the relation/cooperation between municipalities, water boards, provinces, NS RIB and the ministries of TPWWM and HRDE is gradually becoming better because the realization sinks in that the construction of the Betuweroute is unavoidable. According to the reactions of citizens, regional and local governments on the preliminary Trace Decision, the Design Trace Decision is changed greatly on certain areas, for which extra budget is realized. As in the development phase of the preliminary Trace Decision phase information evenings are held and affected citizens receive a personal letter, all kinds of information and a information number is created. Again affected citizens are worried about safety, noise, vibration and damages due to the construction of the Betuweroute.
- In 1996 the Trace Decision is finished and there is the possibility to appeal by the State Council. In 1997 and 1998, 157 appeals are handled, which leads to;
  - Three parts of TD are rejected.
  - 36 Appeals are partly or fully grounded.
  - Positive assessment about the procedure, handling of noise, vibration and safety aspects.
  - 95% Of the TD is approved, adjustment of planning not necessary.

The report concludes that the decision-making process can by typified as viscous, inflexible and not transparent. According to the Scientific Board for Governmental Policy early social support is essential for the acceptance and construction of projects like the Betuweroute. Stakeholders had the opportunity to give reaction on the proposed plans but were not active in the conceptualization of those plans, which created little

social support. Stakeholders were approach in a late stage of decision-making of which resistance was one of the results. The communication towards stakeholders and the facilitation of stakeholders gradually became more transparent. However it seems inevitable that stakeholders appeal with the State Council and that some get approved.

5.9.2 Stakeholder analysis

To get more insight in the interests of the different stakeholders and the issues they have towards the project is of importance in creating a successful stakeholder approach. In the preceding section the stakeholders have been underlined, their involvement, opinion and influence at different stages of decision-making. There are several techniques to analyse stakeholders, Bryson (1999) divided them into four categories;

1) Creating ideas for strategic interventions.
2) Building a winning coalition around proposal development.
3) Review and adoption.
4) Implementing, monitoring and evaluating strategic interventions.

The purpose of our analysis is related to the last two categories. We have used a list of interest/problem perception/goal/resource, a list of critical actors, a power versus interest grid[20] and a stakeholder-issue interrelationship diagram[21] (see appendix 9.5 - 9.8). In the next section we will explain the tools and why they are so useful in our case.

Stakeholder overview

In this list all stakeholders (mentioned in the preceding sections) are summarised, it gives a clear overview of the main characteristics. This list is the starting point for all the other analysis methods, so profound research has to be done to compose the list. It gives a brief description of the global interest, the problem perception, the specific goals and their most important resources derived from the process analysis. After a quick scan you can already see conflicting interests and goals, different perceptions and the allocation of the important resources. Important resources recognised in the overview are: money, authority, relations, blocking power, knowledge and information.

Critical actors

Trough the determination of the degree of replace-ability and dependency of resources of each stakeholder, a decision can be made if an actor is critical or non-critical. It is very important to allocate the stakeholders that must be involved in the decision making process to legitimize the project.

The critical actors are all governments and the NS and these have been involved in the decision-making process, however the local and regional governments were approached to late and the Parliament was not properly informed during implementation.

Visualization tools

Now the most important characteristics are determined and all that is missing are visualizations to help a process manager to determine his strategy. The following tools will give this visualization, every tool with a different approach.

Power versus interest grid

The grid determines which stakeholders' interest and power bases must be taken into account in order to address the problem or issue at hand. It can provide some information on how to approach a stakeholder. In the stakeholder overview important resources are mentioned, these can be used to asses the power of a stakeholder. A process manager can also allocate the powerless and try to empower them through coalition or appeal.

Governments by their power of authority have high power, the cabinet set the policy and controls the budget. The national governments outpower the regional and local governments because the Betuweroute is a national project of national importance. Individual citizens have the lowest stakeholder power, they can create action groups, and these action groups can unify to increase their power and thus impact on the project, as has been done with the VLOB. And even individual citizens can make an appeal with the State Council to crystallize their stakeholder power

[20] Eden and Ackermann 1998
[21] Bryant 2003

Stakeholder-issue interrelationship diagram
The diagram helps show which stakeholders have an interest in different issues, and how they might be related to other stakeholders through their relationships with the issues. The resulting diagram helps provide some important structuring to the problem area, in which a number of actual or potential areas of cooperation – or conflict – may become apparent.

The Stakeholder Issue Interrelationship Diagram shows the points of interest for the different stakeholders. It shows that economy, cost, time, scope, environment, safety, noise and landscape are the most important factors. It is clear that the proponents and opponents have different interest in issues, which is the root of the differences of opinion.
The main reason to use these tools is to give simplified models of the complex reality. By looking step by step, from a different point of view, to the problem, you can develop different strategies.

5.10Scope management

5.10.1 Scope Control & Configuration Management

If we look a scope control during the implementation phase a couple of remarks can be made:

- *(1995-1998).* In the begin of the implementation phase the relationship between project board (Ministry of Transport, Public Works and Water Management) and the project organization (NS) is not optimal.
- *(1998-2002).* Changes are made, steering committee for large projects is introduced within the ministry to regain control on large projects. However the relationship between project board and organization remains not optimal.
- *Malle Jan Agreement.* At a certain point radical changes are made in project scope to move the project within budget. The shunting yard Kijfhoek was simplified by reducing its capacity.

Configuration Management has been the responsibility of the System Manager. For this control a Configuration Management Team (CBT) was appointed. Within Configuration Management the technical integration of systems are tailored and coordinated. The configuration of the Betuweroute was continuously controlled. This was done with the V model (EN50126) to track and monitor. The EN50126 process is based on a general lifecycle view; the lifecycle starts when the product is in a concept phase. Then the product is developed, approved and put into operation and finally it is disposed. This lifecycle is expressed in the V-model, see Figure 10 from EN 50126 below.

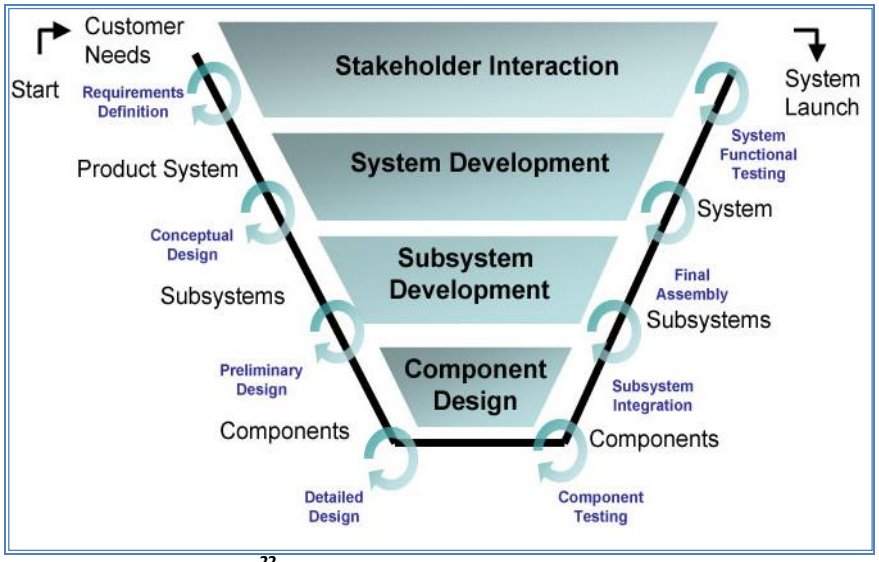


Figure 41, The V Model[22].

[22] http://esd.mit.edu/HeadLine/keio010308/V-model.jpg

Professional experts had the task of monitoring requirements (fixed reference) and control changes (the scope change process). The emphasis was on controlling the operation of the integrated system instead of individual disciplines to achieve. It appears that Configuration Management in a complex environment such as the Betuweroute works best when both the physical and organizational performance is close to execution[23]. The Court of Audit (Algemene Rekenkamer) concludes in 2001 that after the strengthening of the scope control instrument it still does not function optimal. Especially in the scope mutation procedure it is still possible for new scope changes to sneak trough the procedure, creating scope creep.

5.11Verification with theoretical framework

In paragraph 2.4 the research framework was discussed and in Figure 1 it was illustrated that after the execution of the case study there will be a verification round with the theoretical framework. In this section the findings of the case study will be verified with the theoretical framework to see if the framework holds up. The verification will be done by the different subjects of the framework; project, scope changes, scope development, stakeholder impact and scope management. Each section has research questions connected to it and these will be answered per subject.

5.11.1 Project

- Is there a clear relationship between the project constraints and external influences?

The relationship between the project constraints and the influences from outside of the project could be identified. The client, economy and stakeholders played an important part in shaping the project. The client being the government wanted the project to strengthen the economic position of the Netherlands. The stakeholders played a major part in the scope of the project which led to a redesign of the Betuweroute with a totally different scope and sequentially higher costs. These influences could be indicated as independent variables because they are difficult to influence. Stakeholders have their own interests and they can not be changed by the client. The project constraints are clearly dependent variables influenced by the independent variables.

- Is there a clear relationship between the project constraints? Does a change in scope lead to a change in one or more project constraints?

Major changes in scope such as the sprinkler installations and double stack adjustments led to major cost increases and also a different planning.

- Is there a clear ranking in the project constraints and do they change during the PLC?

During the PLC of the Betuweroute it could be noticed that the driven constraint changed. In the initiative phase time was the driven constraint by stipulation that the west east corridor must be upgraded as soon as possible. This was part due to window of opportunity that could be closing at any time, so there was political pressure to decide whether or not to procede with the project. Ones the initial design changed rigorously and the cost became higher and higher the driven constraint changed to cost.

5.11.2 Scope changes

- What were the causes for the scope changes that occurred?

The main scope changes in the construction phase of the Betuweroute can be related back to the causes mentioned in the theoretical framework. The main scope changes during the construction phase had various causes, the most important one being that the requirements of the client changed.

- What was the impact and frequency of those scope change causes?

During the design phase the most important and frequent cause of the scope change was negotiations with stakeholders. These scope changes eventually had a large impact on the costs of the project, raising the initial cost estimation with more than one billion euro's.

- What scope change scenarios occurred during the PLC?

When looking at the main scope change scenario's that occurred the first intervening variable most of the times is quality.

- What was the effect of scope changes on the other constraints?

There is a desire to change the quality and functional scope of the project and thus the specific scope of the project needs to adapt to provide this quality in the end. Adapting the scope will also change the cost and time constraint.

[23] http://www.kennis.betuweroute.nl/home/systeemintegratie/configuratiemanagement

5.11.3 Scope development

- How did the scope develop during the PLC?

The biggest issue in the scope development should not be the Betuweroute itself, but the lack of exploration of other solution directions. If we look in the figure below we see the possible solution directions for increasing mobility, the main quality criterion for the government. Investment in road was not an option, because the second quality criterion was to decrease the traffic of cargo by road for environmental reasons. In the development towards the Betuweroute the focus was to early on investment in rail, partly due to the inclusion of the NS in the commission Van der Plas and the lack of representation of the shipping sector. The second scope fixation was on a new railconnection when there was still room for capacity increase by upgrading the existing network.

In the initiative phase the government was too early fixated on scope (The Betuweroute) rather than being fixated on the needed quality. In the end it seemed that they were looking justifications for the scope rather than creating the scope that best fits the needed quality and that provides the best value.

5.11.4 Stakeholder impact

- What was the impact of stakeholders on the scope of the project?

The main problem of the scope development of the Betuweroute itself was that there was no consensus on the quality and functional scope definition of the project between the main stakeholders. The translation of this imcomplete quality and functional definition to a specific scope definition (design) led to a lot of resistance among stakeholders because the designed scope did not provide their needed quality of the project (landscape, noise pollution, safety, ect.). In order to get more support for the project major scope changes had to be made to meet the quality changes, which led to higher cost that stressed the value of the project and thus the economic feasibility of the project.

- Does the level of impact of the stakeholders suggested in Figure 34 represent the reality?

National and regional governments are from the beginning pro Betuweroute and as the design becomes clearer affected municipalities, environmental groups and local action groups position themselves contra Betuweroute. This suggests that the local stakeholders will be more involved in the design phase than is suggested in Figure 34. During the design phase the regional governments express their concerns about the effects on the environment and become more reserved.

- Could the effect of the impact of the stakeholders on the scope of the project be reduced by involving them earlier in the project?

The introduction of the new trace law, which was ment to speed up decision-making process, created some confusion during public participation. Under the old law the cabinet does not give an opinion about their preferred trace, under the new law they do. So people question the influence of their voice, because a decision seems to be made already. The report “Sporen naar een national project: de Betuweroute” also indicate that because of the trace law municipalities get the feeling they need to get out of the way for the project. A part of the resistance of stakeholders is that they have the feeling that they are neglected and their opinion does not matter. By involving these stakeholders earlier in the project and giving them the opportunity to express their opinion a lot of the resistance can be tempered or at least be noticed early enough to develop strategies.

5.11.5 Scope management

- Could any of the suggested scope management methods in Figure 35 have prevented problems related to scope or could they have benefited the project?

The management methods proposed in the theoretical framework could have been of great value in the case of the Betuweroute. The application of value management could have led to a better scope that better fitted the needed quality and created the highest value by keeping all options open and not fixate on one solution (Betuweroute). From the beginning there was little attention for other stakeholders and their interests, good stakeholder management is essential for a succesfull project. In the case of the Betuweroute good stakeholder management could have prevented the major scope changes or at least made the design phase much smoother. During the construction phase much more sttention was paid to stakeholders and the information provision was much better.

- How did the scope change procedure function during the PLC?

The project organization during the construction phase was not sufficient and was changed during the project. A clear description of the relationship between NS Railinfrabeheer and the Ministry of Transport, Public Works and Water Management is lacking and the audit function is not working properly. A different organization such as the dynamic project organization could have been beneficial for the Betuweroute because it better fits the dynamics of a large infrastructure project as explained in section 3.3.7.

The lack of a scope change procedure during the design phase of the project resulted in a large amount of scope changes for which no profound value analysis was done. From the initial design the economic feasibility was small, and after the major scope changes the economic feasibility was not reassed. Not looking at the bigger picture will lead to scope creep and eventually a project that is creating negative value.

The management methods suggested in the theoretical framework are of great value for defining and controlling scope. The major problem with the Betuweroute was defining the scope and espacially value management could have led to a better scope by including all possible solutions.

6 Survey among project managers

6.1 Introduction

After conducting the literature and case study we have a good idea of the concept of scope definition and control both in literature and practice. The case study however is only a deep and thorough investigation in one case, and further projects need to be investigated to draw a more reliable picture of scope definition and control in large infrastructure projects in the Netherlands. Just as with the case study the outcome of the questionnaire is tested against the theoretical framework. The outcome of the questionnaire is also tested against the case study to indicate whether the Betuweroute is a good representation for a general large infrastructure project or whether it is an outlier.

To test the case study the following awnsers found in the case study for the research questions need to be tested on their viability and generalizability for other infrastructure projects.

- With the Betuweroute there was a clear ranking of the project constraints, first cost than time in the design phase and in the execution phase first time and than cost. Is there also a clear ranking in the selection of projects and is there an accurate general ranking?
- The case study indicated that the client causes the most scope changes, due to different requirements. Is this also the case for the selection of infrastructure projects?
- For the Betuweroute the scope changes had the greatest impact on the cost of the project, does this also hold for the selection of infrastructure projects?
- One major drawback of the initiative phase of the Betuweroute was the lack of exploration into other suitable solutions and the focus was early on a new rail connection. There was an early fictation on specific scope rather than functional scope. Does the development of the scope on the other projects tell a similar story?
- Local stakeholders became very active in the early stages of the design phase, rejecting the assumption of the theoretical framework which suggests a later activety. Which scenario fits the activity of the local stakeholders with the selected projects?
- The Betuweroute showed that there was a lack of attention for a proper evaluation of changed scope. The government stuck to the results of an early investigation which was positive. However since that evaluation the scope changed drastically making it financial, economical and social inbeneficial. Was there also a neglection in the investigation of the effects of proposed scope changes with the selected projects?

In this chapter the design of the questionnaire is explained. The selection procedure (sampling) for both projects and people are discussed, the objectives are defined (what do we want to know), the manner in which the information is obtained and last the actual design of the questionnaire. In the second section the result of the questionnaire are presented per objective and interpreted. The last section verifies the questionnaire results against the theoretical framework and the case study.

6.2 Questionnaire design

6.2.1 Population

The population of the questionnaire is the group where the researcher is interested in. In this questionnaire the population is all project team members active during one of the phases of initiation, design and construction of infrastructure projects.

6.2.2 Sample

A sample is a subset of the population, which is representative for the population so general conclusions can be drawn about the entire population. Or sample is a selection of project members of a selection of infrastructure projects, the project managers. In this research it is important to gain understanding about the preferences and experiences of project members of infrastructure projects. It is important that every field (risk, time, cost, etc.) is represented in the sample of each individual infrastructure project being investigated. Most project

managers are only active during one project phase; members active in the initiation phase will not have the same knowledge of the members active in the construction phase and vice versa.

6.2.3 Sampling

Because of the restriction on the number of infrastructure projects to be investigated because of time limitations, judgement sampling is done on the available project members. Judgement sampling is a form of purposive sampling where a specific target group is used to obtain the desired information for the research. *Judgement sampling is used where the collection of "specialized informed inputs" on the topic area researched is vital, and the use of any other sampling designs would not offer opportunities to obtain the specialized information (U. Sekeran, pag 285, 2003).*

Project managers from middle and upper management are approached because of their overall knowledge about the scope development of a project. The number of available project managers to approach is related to the size of the project. The goal is to approach 10-12 project managers and to obtain 6 complete responses per project, with a total of 48 (8 projects) completed responses. The sampling method used is a form of non probability sampling, one must be very critical when generalizing findings on the entire population.

The projects that are selected are a mix of water, road and rail infrastructure projects for a sufficient representation of infrastructure projects undertaken in the Netherlands. The projects (for detailed information see appendix 9.10) are;

Road: A4, N201 and N470.
Rail: Randstadrail, Noord/Zuidlijn, Hanzelijn and Betuweroute.
Water: Maaswerken.

6.2.4 Defining the objectives

According to Sinclair (1975) this is an essential step, which is often the hardest. The three questions one must ask when defining the objectives are:

1. What are the result suppose to show?
2. To what degree of accuracy?
3. What additional data will be needed to link this survey with other work?

Question one and two imply that the objectives have to be clearly defined and measurable, because:

"No matter how sophisticated the rest of the activities may be, from fieldwork to statistical analyses, if one start out with fuzzy thinking one continues with fuzzy questions, and at the best the result is a set of sophisticated fuzzy answers (Sinclair, 1975)."

The main objective for the questionnaire is to gain more understanding about the current state of scope (management) in infrastructure projects in the Netherlands. This main objective is composed of several objectives. These objectives are presented in the following section, where the result, accuracy, theoretical relativity and the questionnaire question(s) are given per objective.

Objective 1: The relative importance of the four project constraints
Theoretical rel.: The success of a project is dependent on the success criteria (project constraints) for a project. The relative importance of the constraints will partly determine the level of success because these considerations are taken into account when scope changes arise. If a scope change arises and cost is the driven constraint, than delay will be chosen over extra cost (see paragraph **Error! Reference source not found.**).
Question: Determine the level of importance of the four project constraint from the viewpoint of the client.
Accuracy: 5 point interval scale ranging from not important to important.
Result: The relative importance of the project constraints per project, which can be used to investigate the scope changes. If cost is for example the driven constraint, will cost overruns be small?

Objective 2: What scope change scenario's occurred during the project and to what extend.
Theoretical rel.: A scope change (more or less) will have different effects on the other project constraints (more or less) (see paragraph 0).
Question 1: How large where the changes in the project constraint in the project phase
Accuracy: 5 point interval scale ranging from very small to very large.
Question 2: How large was the amount of delay, cost overrun and quality difference due to a scope change on the total budget, planning and quality level?
Accuracy: 5 point interval scale ranging from 0% - 100%, and much less and much more.
Question 3: Indicate how many times a scope change scenario occurred during the project phase.
Accuracy: 5 point interval scale ranging from never to very often.
Result: With the knowledge of the relative importance and the occurred scenario's we can see if they influence each other.
Objective 3: What are the causes of the scope changes in the project and to what extent.
Theoretical rel.: The causes of scope changing were set out in paragraph 0. When looking at the causes of scope changes it becomes clear on what area more attention should be paid. When a lot of scope changes occur because the scope description was not clear or the wishes of the client change , more attention should be paid on scope definition (value management, flexibility management). If a main cause is imposition by the council state because stakeholder appeal to the project, maybe more attention to stakeholder management in the initiative phase should be paid.
Question 1: How often did the cause of a scope change occur during the project phase?
Accuracy: 5 point interval scale ranging from never to often.
Question 2: What was the impact of the cause of a scope change during the project phase?
Accuracy: 5 point interval scale ranging from very small to very large.
Result: When combining the frequency and impact of causes one can see for which causes one must pay close attention in infrastructure projects.
Objective 4: The description of the scope during the three project phases.
Theoretical rel.: The development of the description of scope from functional to specific will say something about how scope was formed. Was there an early scope fixation (to specific in the beginning) than value management can be helpful to prevent this (see paragraph 3.2.4).
Question: Determine the description of scope documents of the project in the three project phases.
Accuracy: 5 point interval scale ranging from functional to specific
Result: Development of the description of scope documents over the PLC.
Objective 5: What was the impact of stakeholders on project scope during the different phases.
Theoretical rel.: Stakeholders can play a major part in a project, that is why stakeholder management is an important part of process scope management (paragraph 3.2.3). Each stakeholder must be indentified and an appropriate strategy must be chosen to handle this stakeholder.
Question: Determine the impact of the stakeholder per project phase.
Accuracy: 5 point interval scale ranging from very small to very large.
Result: The outcome will give us more understanding on the level of impact of the different stakeholders per project phase. This understanding can help set up strategies to reduce their impact and/or move their impact towards the front of the PLC where the effects will be smaller.
Objective 6: What effects of a scope change were investigated?
Theoretical rel.: In paragraph 0 and 3.3.10 the importance of the investigation of the effects of a scope change was stipulated. Because the overall effects will determine whether a scope change should be carried out or alternatives have to be investigated. In deciding to implement a scope change a cost/benefit analysis needs to be undertaken.
Question: Determine the attention to the effects of a scope change during the project phase
Accuracy: 5 point interval scale ranging from very small to very large
Result: The results will give an overview of the level of attention per effect. If the level is to low according to the respondents, than in future projects more attention should be paid to those effects.

Objective 7: How do project members feel about the scope change procedures used.
Theoretical rel.: A clear scope change procedure will benefit the project because it is clear to which effects the change is measured and when a scope change is implemented or not (paragraph 3.3.10).
Statement 1: Judgement of a scope change was good.
Statement 2: Large scope changes got enough attention.
Statement 3: Procedure was strictly followed.
Statement 4: Runtime of scope change was to long.
Statement 5: Person responsible for procedure had sufficient mandate.
Statement 6: The procedure was to vague for project members
Statement 7: Responsibilities of project members were vague in the procedure.
Accuracy: 5 point interval Likert scale from totally do not agree to totally agree.
Result: Besides the overall opinion of the scope change procedure it is also possible to see the development of the procedure during the project phase because the opinion is measured for the beginning and end of the project phase.
Objective 8: Who was responsible for leading the scope change procedure?
Theoretical rel.: For the scope change procedure it is important that it is clear who is responsible for the procedure. Ideally the scope change procedure should be his main responsibility, so the scope change procedure gets the level of attention it deserves.
Question: Who was responsible for the scope change procedure?
Accuracy: Project manager, contract manager, scope manager or other.
Result: Per project one can see if it is clear who was responsible by the level of homogeneity in the answers. The importance can get related to whether or not a scope manager was assigned whose main responsibility is the scope change procedure.
Objective 9: What is the opinion of the project members about the produced scope.
Theoretical rel.: When the project is finished it is interesting to see if the produced scope meets the expectations set out in the beginning of the project.
Statement 1: Produced scope is worth the cost.
Statement 2: Produced scope is worth the time.
Statement 3: Produced scope is worth the quality.
Statement 4: Produced scope is equal to the prospected scope in the beginning of the project.
Statement 5: Client is satisfied with the produced scope.
Statement 6: Produced scope fits the strategy of the client.
Accuracy: 5 point interval Likert scale from totally do not agree to totally agree.
Result: The outcome will give an indication of the overall effectiveness of the produced scope.

6.2.5 Data collection method

A electronic questionnaire is used for the collection of the necessary data because of the following advantages:

- Easy to administer
- No location boundaries
- Very inexpensive
- Fast delivery
- Respondents can answer at their own convenience
- Data is easy to process

In comparison with for example face-to-face and telephone interviews there are two important disadvantages:

- Little room for clarifications about questions
- Most of the questions are closed questions, little room for refinements by respondents

To limit these disadvantages the draft versions are evaluated several times to specify the questions as clearly as possible and to provide the essential information for making the questions without making the questionnaire too long. At the end of the questionnaire there is room for the respondent to give suggestions in the form of an open question.

6.2.6 Pre-assumptions

For the data collected it is presumed that the data is on an interval scale, this means that the distance between the scale points are equal. This condition for the scale points is required to adopt a normal distribution for the data. The central limit states that the sampling distribution of the sample mean is normally distributed. As the sample size increases, the means of the random samples taken from practically any population approach a normal distribution with mean μ and standard deviation σ. This theory stipulates the importance of the sample size and the sampling method.

6.2.7 Set up of the questionnaire

The questionnaire is divided in several topics (for the full questionnaire see appendix 9.9) related to the goals stated earlier:

- *Introduction*
  - Project name
  - Project phase involved (questionnaire is made for one project phase)
  - Respondents name
  - Respondents organization
  - Respondents function in project and organization
- *Scope*; description of the scope in the three project phases
- *Project constraints*
  - Importance of the constraints
  - Amount changes of the constraint during phase
- *Scope changes*
  - Share of changes on total
  - Frequency of change scenarios
  - Frequency of causes of scope changes
  - Impact of causes of scope changes
- *Stakeholders;* impact of stakeholders during the project phases
- *Scope change procedure*
  - Responsible agent of procedure
  - Attention to scope change effects
  - Opinion of procedure at the beginning and end of project phase
  - Suggestions for scope change procedure
- *Overall scope satisfaction*

6.3 Questionnaire Results

6.3.1 Introduction

The results of the questionnaire will be discussed according to the structure of the theoretical framework. In this section the respondents per project are provided and the implications this has on the outcome of the questionnaire. The central limit theorem will be introduced which is used to interpret the collected data.

Respondents

Collecting e-mail addresses of project managers for one project was harder than for the other. The connection and size of the project were the most important factors that determined the pool of respondents, and for one project the disturbance of project managers played a role in delivering e-mail addresses. The result is that the amount of responses differs greatly between projects (see Table 5). The second comment is the amount of responses per phase, most respondents were active during the construction phase of the project and very few in the initiative phase. For an better understanding of the scope change procedure which is mostly used in the construction phase, it was important to get a lot of responses for the construction phase.

The division of responses per project and phase will of course influence the outcome of the questionnaire and comments will be placed where they are necessary.

Project	Phase			Total
	Initiative	Design	Construction	
Randstadrail	0	4	9	13
Maaswerken	1	1	8	10
A4	2	4	2	8
Hanzelijn	0	2	5	7
N201	1	0	4	5
N470	0	2	2	4
Noord/Zuidlijn	0	0	3	3
Betuweroute	1	0	1	2
Totalen	5	13	34	52

Table 5, Responses per project and phase.

The results of the questionnaire will be discussed according to subjects of the set up of the questionnaire (scope, project constraints, scope changes, stakeholders, scope change procedure and overall scope satisfaction).

Central Limit Theory

In its simplest form, the theorem states that the sum of a large number of independent observations from the same distribution has, under certain general conditions, an approximate normal distribution. Moreover, the approximation steadily improves as the number of observations increases. The parameters of the normal distribution are μ and σ^2, where μ is the mean (expectation) of the distribution and σ^2 is the variance. Because of the central limit theory we can state that a random variable:

$$Z = \frac{\bar{X} - \mu}{\sigma/\sqrt{n}}$$

Where X is the mean of the sample set and n is the sample size. By standardizing we get a random variable dependent on the parameter μ to be estimated, but with a standard normal distribution independent of the parameter μ. Hence it is possible to find numbers $-z$ and z, independent of μ, where Z lies in between with probability 1 − α, a measure of how confident we want to be. We take 1 − α = 0.95. So we have:

$$P(-z \leq Z \leq z) = 1 - \alpha = 0.95.$$

The number z follows from the cumulative distribution function:

$$\Phi(z) = P(Z \leq z) = 1 - \tfrac{\alpha}{2} = 0.975,$$

$$z = \Phi^{-1}(\Phi(z)) = \Phi^{-1}(0.975) = 1.96,$$

and we get:

$$0.95 = 1 - \alpha = P(-z \leq Z \leq z) = P\left(-1.96 \leq \frac{\bar{X} - \mu}{\sigma/\sqrt{n}} \leq 1.96\right)$$

Which represents the 95% confidence interval, and we can say that there is a 95% chance that a given interval contains the parameter. The intervals will for the research questions will be presented in the appendix. For the presentation of the result box-and-whisker plots are used because they give a is a convenient way of graphically depicting groups of numerical data through their five-number summaries: the smallest observation (sample minimum), lower quartile (Q1), median (Q2), upper quartile (Q3), and largest observation (sample maximum).

6.3.2 The project

Objective 2: The importance of the four project constraints have to be qualified and their proportion to each other.

Question: Determine the level of importance of the four project constraint from the viewpoint of the client.

As mentioned in paragraph 3.1.3, every project will have a driven constraint. If we look at the box-and-whisker plots for the four project constraints we can see that time is the most important constraint on overall. And in Table 6, time is important followed by scope and cost and the least important is quality. This implies that the client will be inclined to exchange quality to save construction time. This representation is a bit distorted because the sample size per project influences the total outcome. So if we look at a single project, for instance the Randstadrail , the sample size will be smaller which will influence the reliability. The project constraint time is clearly the driven constraint for the client in the viewpoint of the respondents with a small reliability interval in comparison with the other constraints. This means that the respondents were more consentient about the importance of time for the client.

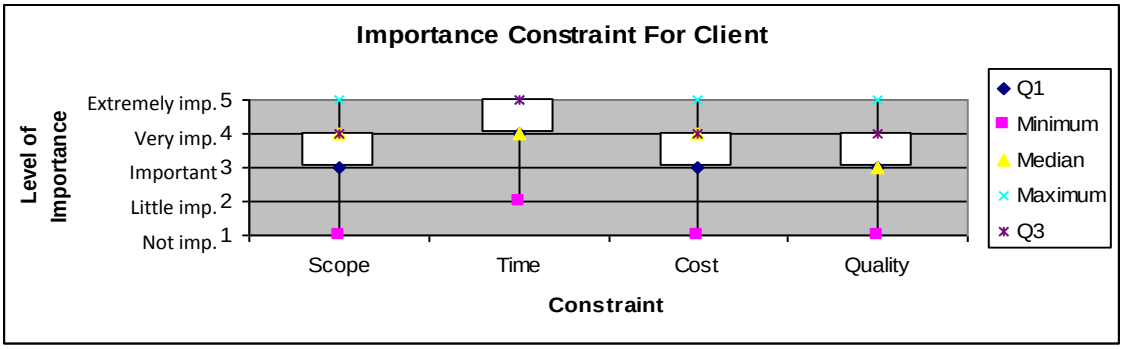


Figure 42, Box-and-whisker plot of the importance of the four project constraints.

All projects	scope	time	cost	quality
sample size	40	40	40	40
average value	**3,75**	**4,33**	**3,70**	**3,33**
standard deviation	1,06	0,76	0,80	0,83
Reliability	0,32	0,23	0,24	0,25
upper boundary	4,08	4,56	3,95	3,58
lower boundary	3,42	4,09	3,45	3,07

Table 6, Importance of the four project constraints for all projects.

Randstadrail	scope	time	cost	quality
sample size	13	13	13	13
average value	3,08	4,46	3,69	2,92
standard deviation	0,95	0,52	0,98	1,08
Reliability	**0,51**	**0,28**	**0,53**	**0,58**
upper boundary	3,60	4,75	4,23	3,51
lower boundary	2,56	4,18	3,16	2,33

Table 7, Importance of the four project constraints for Randstadrail.

6.3.3 Scope changes

Objective 3: What scope change scenario's occurred during the project and to what extent.
Question 1: How large where the changes in the project constraint in the project phase
Looking at the box-and-whisker plots of the changes during the PLC, the medians for all project constraint are the same (normal).

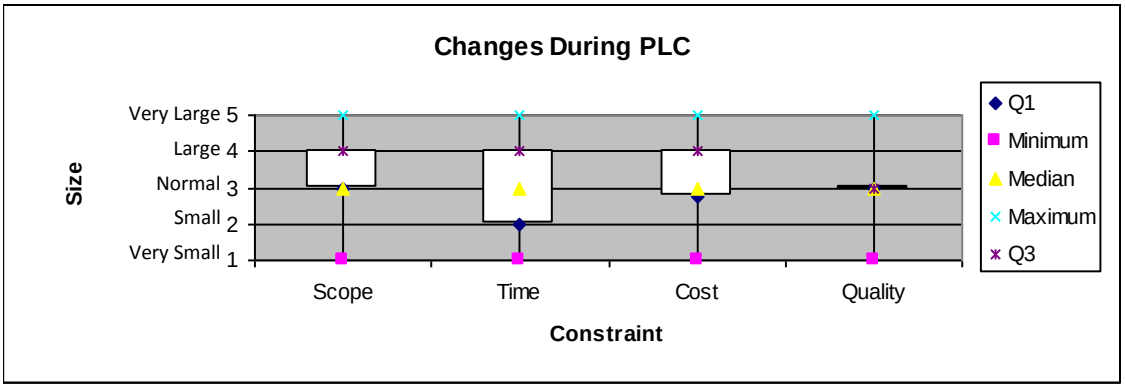


Figure 43, Size of project constraint change during PLC.

Instead of focusing on the changes for the entire PLC, it is more interesting to look at the changes per phase. In the figure below the amount of changes in the project constraints are decreasing except for the time constraint which is highest in the execution phase. This could be the consequence of sticking too long to an opportunistic planning, so in the execution phase the delays will be large.

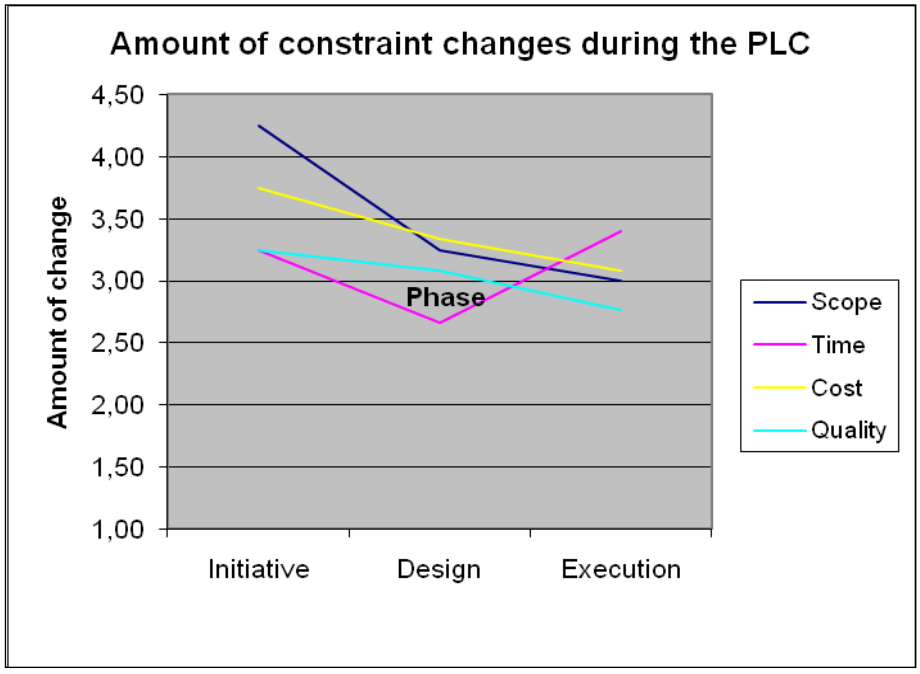


Figure 44, Development of changes of project constraints during the PLC.

Question 2: How large was the amount of delay, cost overrun and quality difference due to scope changes on the total budget, planning and quality level?
From the figure below it can be concluded that a scope change has the largest impact on the quality level, this can be due to the fact that quality is seen as less important than the cost and planning of a project.

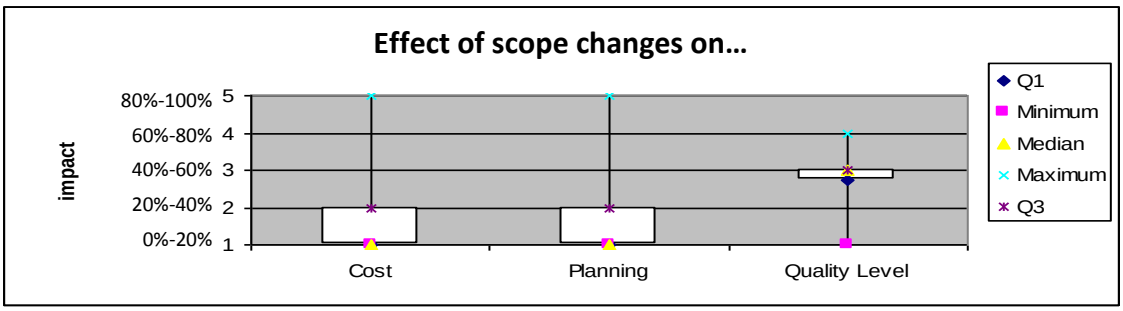


Figure 45, Impact of the scope change on cost, planning and quality level.

During the PLC the effects of scope changes remain more or less on the same level (see figure below). The effect on cost shows a slight decline and the effect on planning shows a slight incline. Together with the information that the amount of scope changes declines it can be concluded that the effect per scope change rises.

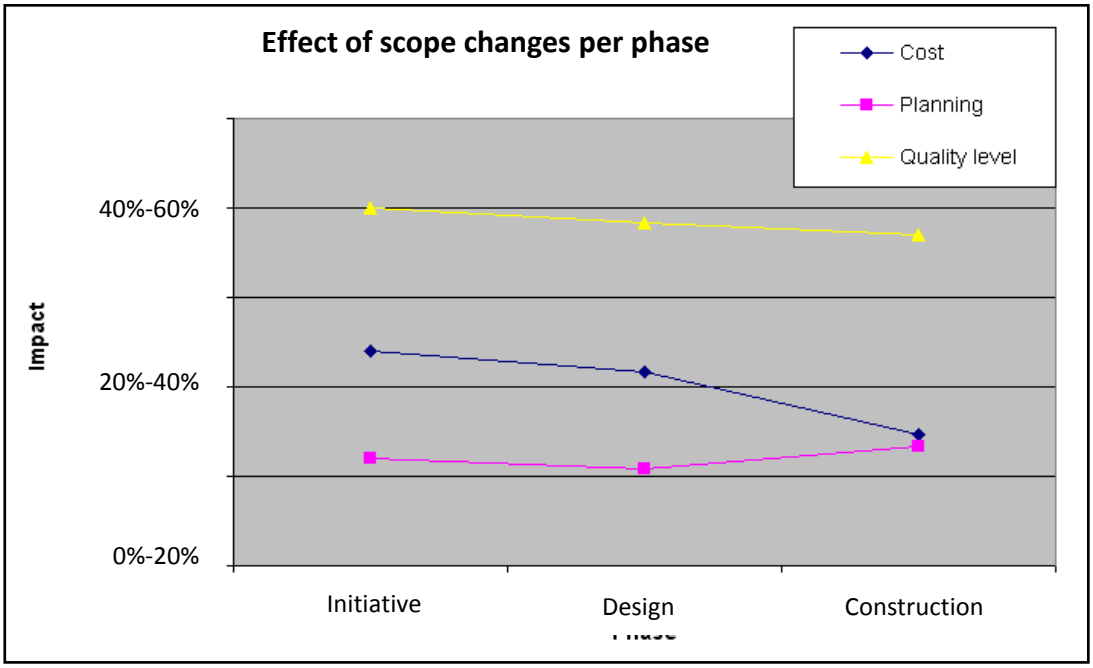


Figure 46, Effect of scope changes on other constraints per phase.

Question 3: Indicate how many times a scope change scenario occurred during the project phase.
When a scope change occurs it can mean two things, more scope is added or scope is extracted to the project. In the case that scope is added, the frequency of more cost is higher than of time and quality. And when scope is extracted from the project it rarely has an effect on the other project constraints. An explanation could be that the scenario where scope is extracted is small in comparison when scope is added.

The average values for the scenarios per project phase (see appendix 9.11.2) show that the frequency of the scenario's diminish from the beginning of the PLC towards the end. But the scenario where more scope leads to more time increases (2,50 in the design phase and 2,80 in the execution phase).

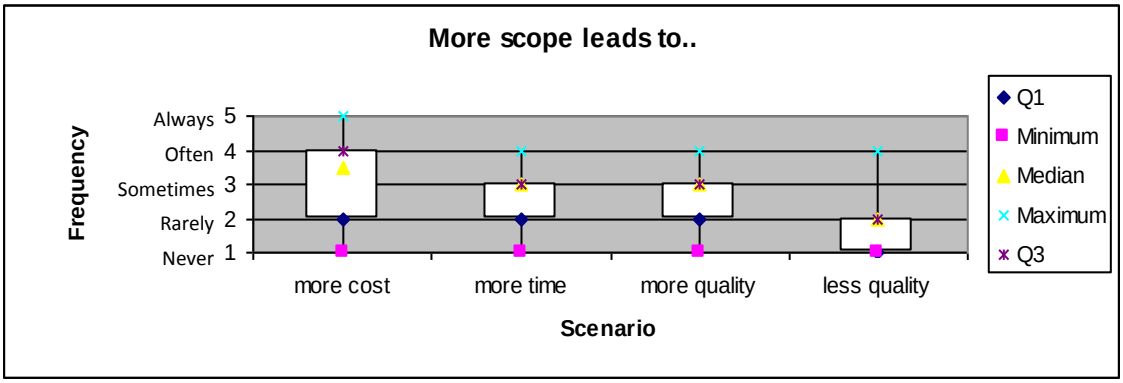


Figure 47, Frequency of scenario's when more scope is introduced.

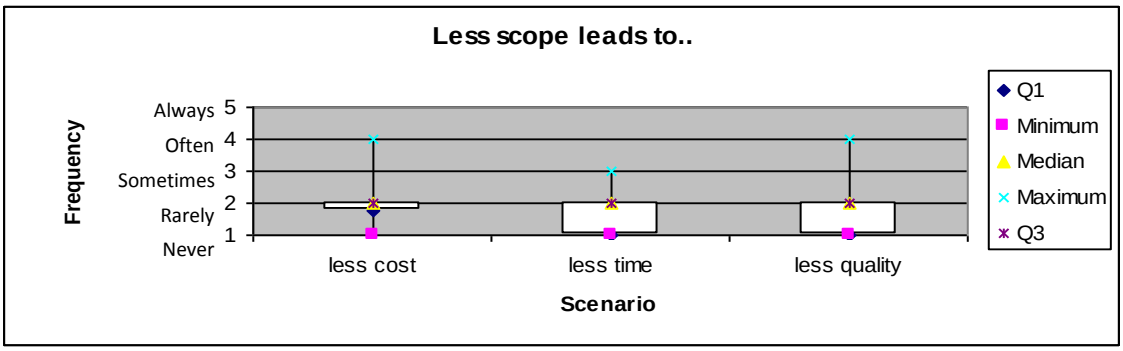


Figure 48, Frequency of scenario's when less scope is introduced.

Objective 4: What are the causes of the scope changes in the project and to what extent.
Question 1: How often did the cause of a scope change occur during the project phase?
Question 2: What was the impact of the cause of a scope change during the project phase?

The main causes of scope changes are risks foreseen, changing demands of clients, influence of other projects, unclear scope definition and negotiations with stakeholders. They all occur on average more than occasionally as can be seen in appendix 9.11.3. The impact of changing demands of clients, influence of other projects, unclear scope definition and negotiations with stakeholders are also above important.

In the tables in the appendix 9.11.3 it can be seen that the causes of scope changes due to negotiations with stakeholders is higher in the design phase than in the execution phase. For the rest of the causes there is no significant difference for the frequency of the causes of scope changes in the design and execution phase. The impact of the causes of scope changes due to other projects and negotiations with stakeholder vary significantly between the design and execution phase. The impact of both are more important in the design phase than the execution phase.

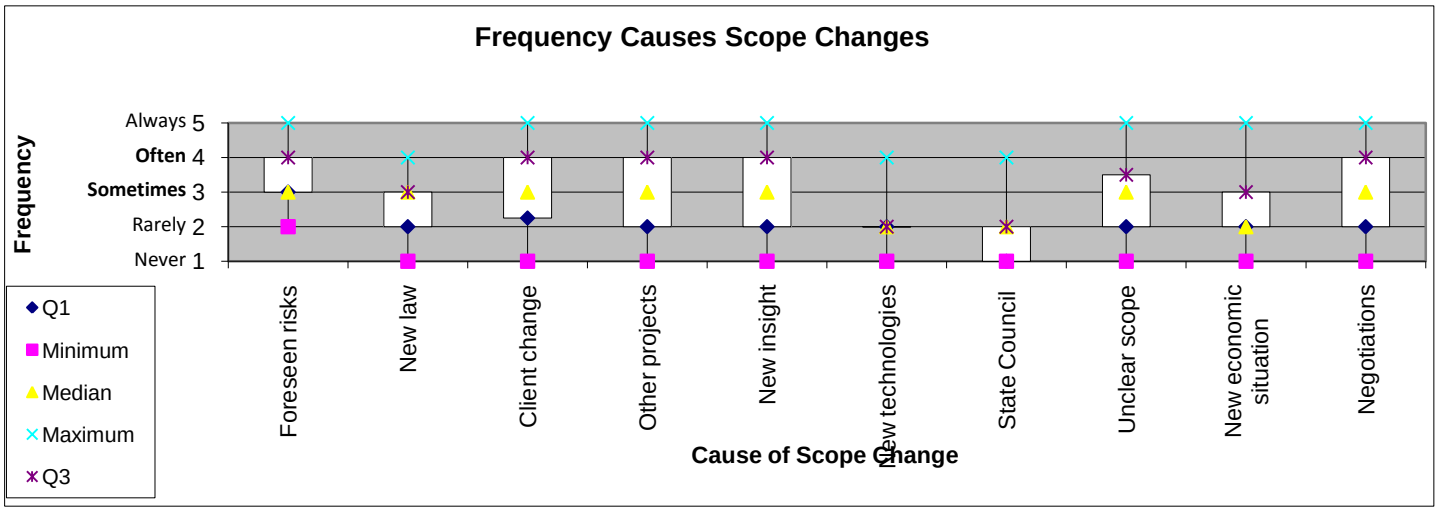


Figure 49, Frequency of the causes of scope changes.

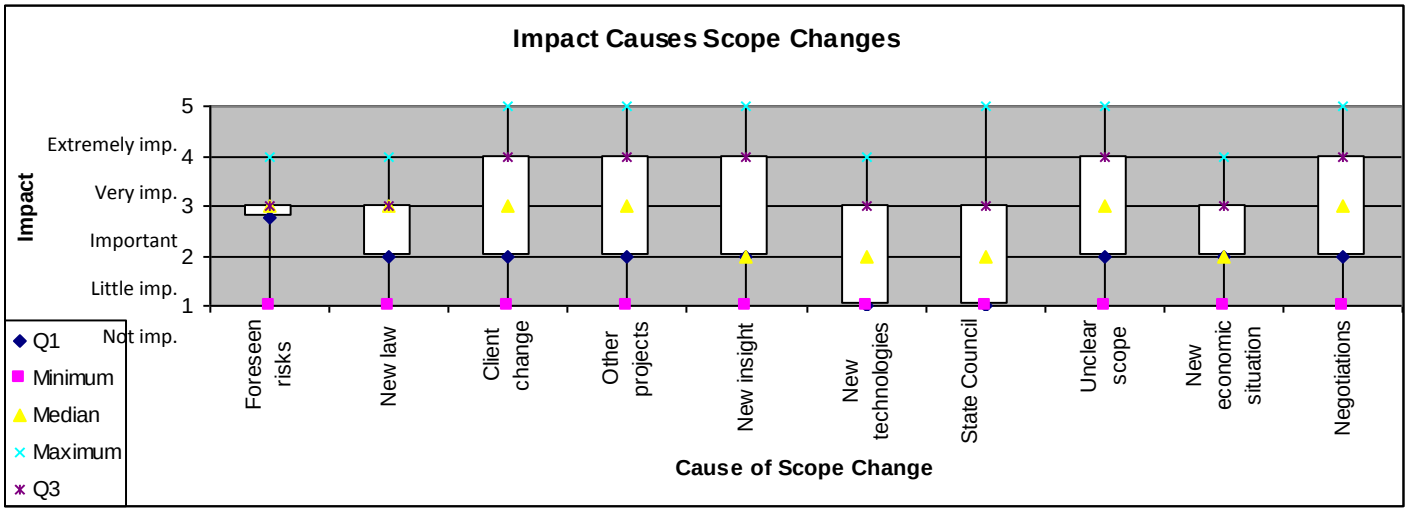


Figure 50, Impact of the causes of scope changes.

With the frequency and the impact of the causes of scope changes it is interesting to see if there is a correlation between impact and frequency. The establishment of a correlation does not necessarily imply a causal relationship between the variables, or even if this relationship is a direct one. To determine the correlation the Pearson correlation can be applied because we assume an interval scale, the Pearson correlation coefficient is calculated by the following formula:

$$r = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}$$

The coefficient can have a value between -1 and 1, and Table 8 the critical values are given for the coefficient.
To determine the correlation we introduce the null hypothesis:
Ho = There is no correlation between the variables frequency and impact.
Ha = There is a correlation between the variables frequency and impact

We reject Ho when the calculated correlation is equal or higher than the critical value, in the table below it is shown that causes the null hypothesis can be rejected, there is a correlation between frequency and impact. The correlation between the frequency and impact of unclear scope is strongly positively correlated. When the frequency of this cause is high, the impact will also be high.

	risk foreseen	**risk unforeseen**								
		new laws	client	other projects	new insights	new techniques	State Council	unclear scope	economy	negotiation
Degrees of freedom	31	32	33	33	32	33	33	33	33	33
Critical r value (0,1)	0,345	0,340	0,336	0,336	0,340	0,336	0,336	0,336	0,336	0,336
Pearson Correlation	0,490	0,604	0,645	0,606	0,559	0,336	0,478	0,801	0,742	0,783

Table 8, Pearson correlation between the frequency and the impact of the causes of scope changes.

6.3.4 Scope development

Objective 1: The description of the scope during the three project phases.

Question: Determine the description of scope documents of the project in the three project phases.
For the description of scope the respondents have to make clear if the description in the three phases was more functional or specific. The results are shown in the form of box-and-whisker plots in Figure 51, the upper boundary of the box represents the 75% percentile and the lower boundary the 25% percentile. As expected the description begins functional and becomes more specific during the PLC.

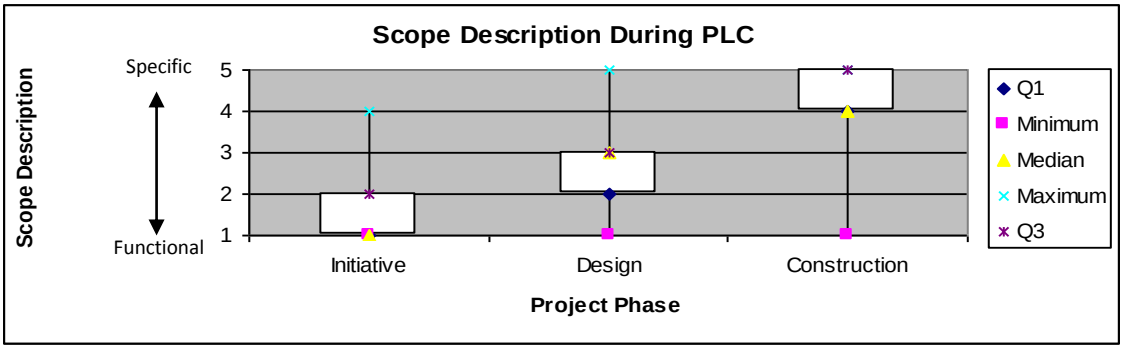


Figure 51, Box plot of the description of scope documents during the PLC.

6.3.5 Stakeholder impact

Objective 5: What was the impact of stakeholders on project scope during the different phases.
Question: Determine the impact of the stakeholder per project phase.

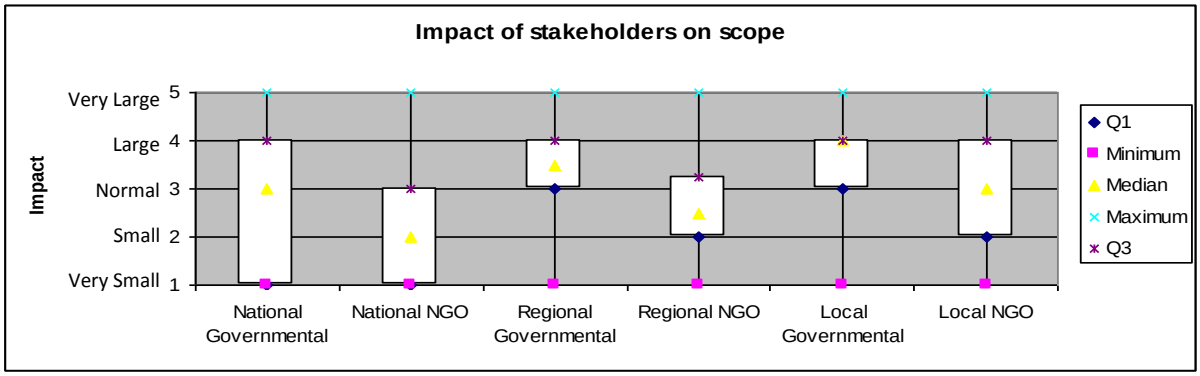


Figure 52, Impact of stakeholders on project scope.

In both the design and execution phase local governmental organizations have the highest impact on the scope of a project (see appendix 9.11.4), and where the impact on scope in the design phase is higher than in the execution phase. This is in contrast with Figure 18 in the theoretical framework where the impact of local governmental stakeholders is highest in the execution phase. Agreements with local governmental organizations before the execution phase can explain this contrast, for example covenants between client and organization. The assumption that the impact of national and regional organization becomes less important is confirmed by the data.

6.3.6 Scope management

Objective 6: What effects of a scope change were investigated?
Question: Determine the attention to the effects of a scope change during the project phase

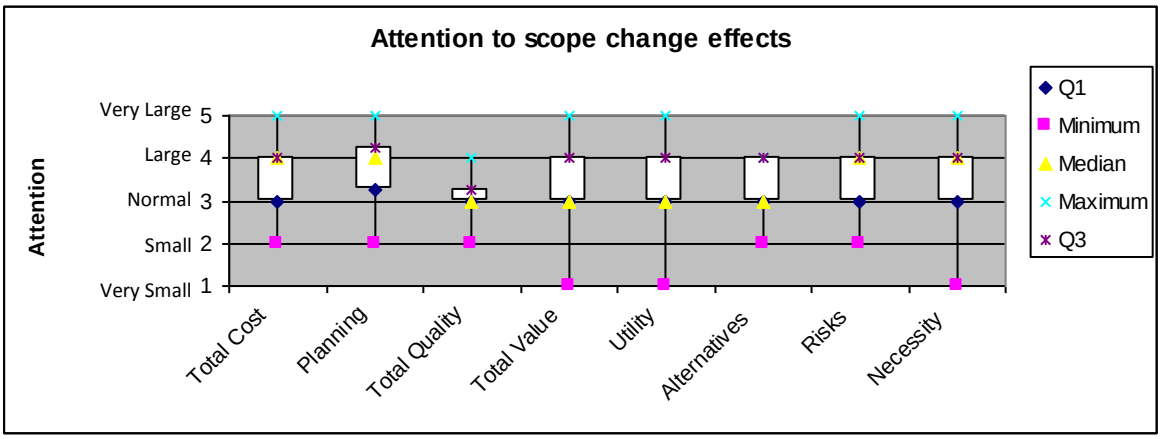


Figure 53, Attention to the effects of scope changes.

When we rank the attention for the effects of a scope change from the data in appendix 9.11.5, we get the following ranking:

1. Effect on total planning
2. Need for the scope change
3. Effect on total cost
4. Risks of a scope change
5. Effect on total utility
6. Effect on total value
7. Effect on total quality

The attention for the total planning follows from the driven project constraint time. The driven project constraint influences the focus on the effects of a scope change.

Objective 7: How do project members feel about the scope change procedures used.
Statement 1: Judgement of a scope change was good.
Statement 2: Large scope changes got enough attention.
Statement 3: Procedure was strictly followed.
Statement 4: Runtime of scope change was to long.
Statement 5: Person responsible for procedure had sufficient mandate.
Statement 6: The procedure was to vague for project members
Statement 7: Responsibilities of project members were vague in the procedure.

The average values in Figure 54 do not show significant deviation from the neutral opinion (score value 3). On average the respondent lightly disagree with the positive statements that the procedure was good, large scope changes got enough attention and the mandate. The first statement is a general statement and the opinion of the respondents implies that there is room/need for improvement of the procedure. The last two statements are more focused on particular aspects of the procedure. It is also interesting to investigate if there is a difference of opinion towards the procedure in the beginning of a phase and in the end. In the next section we will investigate if indeed there is a difference and if this difference is significant.

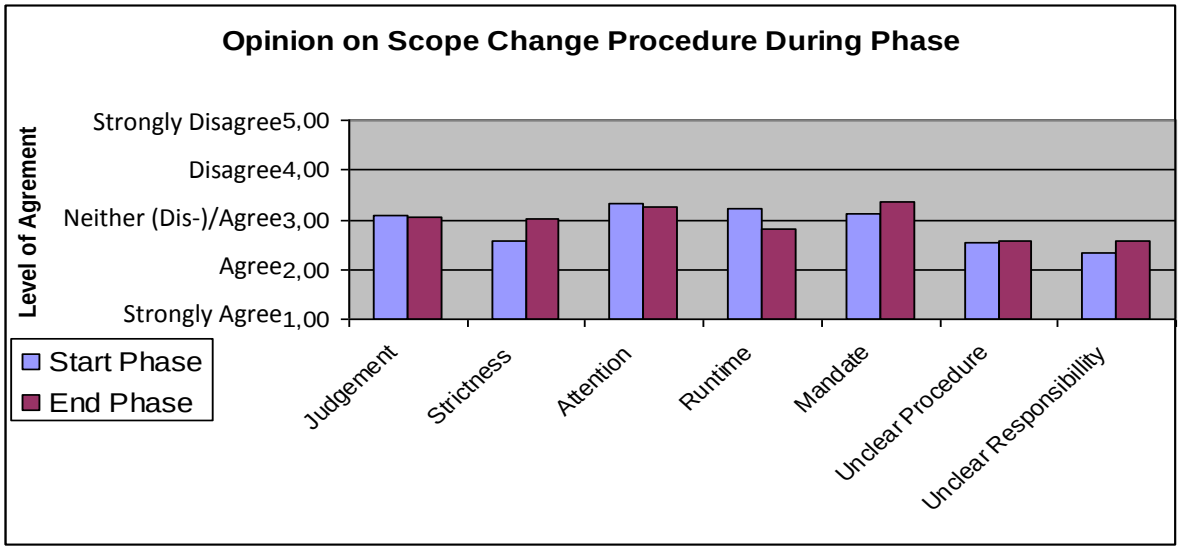


Figure 54, Opinion on the scope change procedure at the start and the end of the project phase.

To investigate if the difference of opinion in the begin and end of the phase are significant a paired student t-test is done. A paired t test provides an hypothesis test of the difference between population means for a pair of random samples whose differences are approximately normally distributed. The t-value for the differences are calculated with the following formula:

$$t = \frac{\bar{d}}{\sqrt{s^2 / n}}$$

To determine the significance of differences we introduce the null hypothesis:
Ho = There is no significance difference between the two samples.
Ha = There is a significance difference between the two samples.

We reject the null hypothesis when the modulus of the calculated t-value is higher than the critical t-value for a two sided test with a probability value of 5%. In the table below it shows there is only a significance difference for the strictness of the procedure, during the phase the procedure is followed stricter. The overall goodness of the procedure does not change during the phase.

	goodness	strictness	attention	runtime	mandate	clearness procedure	clearness responsibilities
average change	0,00	-0,68	0,04	0,14	-0,07	-0,21	-0,46
standard deviation	0,61	0,94	1,17	1,33	0,98	1,47	1,23
degrees of freedom	27	27	27	27	27	27	27
critical t-value	2,05	2,05	2,05	2,05	2,05	2,05	2,05
t-value	0,00	-3,80	0,16	0,57	-0,39	-0,77	-1,99

Table 9, T-test on the difference of the opinion of the scope change procedure.

Objective 8: Who was responsible for leading the scope change procedure?
Question: Who was responsible for the scope change procedure?

.

In most cases the project manager was responsible for the scope change procedure. However for some projects there is no clarity about who is responsible for the procedure (N201), this could be prevented by better communication about the procedure.

Project	Responsible				
	Project Manager	Contract Manager	Scope Manager (Line)	Scope Manager (Staf)	Other
Randstadrail	8	0	1	1	1
Maaswerken	7	2	0	1	0
A4	2	1	0	1	3
Hanzelijn	3	2	0	0	0
N201	2	1	1	1	1
N470	3	0	0	0	1
Noord/Zuidlijn	3	0	0	0	0
Betuweroute	1	0	0	0	0
Total	29	6	2	4	6

Table 10, Responsibility for the scope change procedure.

Objective 9: What is the opinion of the project members about the produced scope.
Statement 1: Produced scope is worth the cost.
Statement 2: Produced scope is worth the time.
Statement 3: Produced scope is worth the quality.
Statement 4: Produced scope is equal to the prospected scope in the beginning of the project.
Statement 5: Client is satisfied with the produced scope.
Statement 6: Produced scope fits the strategy of the client.

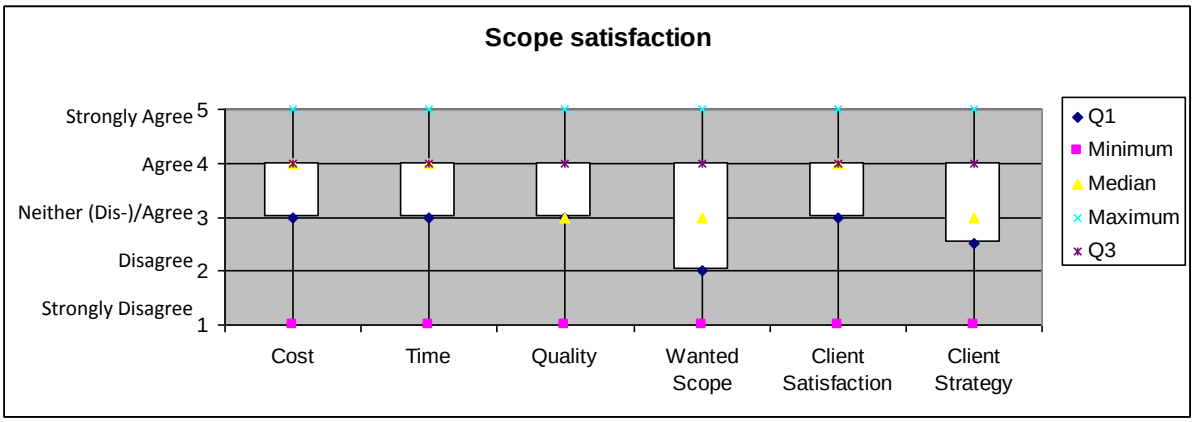


Figure 55, Satisfaction of the produced scope.

In the table below the produced scope is compared to six other aspects for its effectiveness. The respondents on average are on the agreeing scale of the scores, and they most agree with the statement that the client is happy with the produced scope (see appendix 9.11.7).

There are six questions to measure the effectiveness of the produced scope, and to determine if all the questions indeed measure the same concept the Cronbach's alpha is calculated to measure the internal consistency. When the Cronbach's alpha is higher than 0.7 it can be assumed that the questions measure the same concept. Cronbach's alpha is calculated with the following formula:

$$\alpha = \frac{N}{N-1}\left(1 - \frac{\sum_{i=1}^{N} S_{Y_i}^2}{S_X^2}\right)$$

From the table below it can be concluded that the questions are internally consistent, they measure the same concept.

	1	2	3	4	5	6
Sy	0,99	1,11	0,90	1,15	1,07	0,96
Sx	4,01					
N	6					
α	0,72					

Table 11, Cronbach's alpha for measuring the effectiveness of produced scope.

Objective 10: Where do project members see opportunities for improvement?
In the open question respondents had room for their own thoughts on the scope change procedure. Some interesting thoughts were:

- Clear mandate and responsibilities needed
- Definition of scope change not always clear
- Procedure needed, before scope changes surface
- Application of reference project important
- Application of one method important for uniformity

6.4 Verification with theoretical framework and case study

In this section results of the questionnaire will be verified with the theoretical framework and case study to see if there are similarities and differences. The verification will be done by the different subjects of the framework; project, scope changes, scope development, stakeholder impact and scope management. The findings of the case study will be verified by answering the earlier stated questions:

- With the Betuweroute there was a clear ranking of the project constraints, first cost than time in the design phase and in the execution phase first time and than cost. Is there also a clear ranking in the selection of projects and is there an accurate general ranking?
- For the Betuweroute the scope changes had the greatest impact on the cost of the project, does this also hold for the selection of infrastructure projects?
- One major drawback of the initiative phase of the Betuweroute was the lack of exploration into other suitable solutions and the focus was early on a new rail connection. There was an early fictation on specific scope rather than functional scope. Does the development of the scope on the other projects tell a similar story?
- One major drawback of the initiative phase of the Betuweroute was the lack of exploration into other suitable solutions and the focus was early on a new rail connection. There was an early fictation on specific scope rather than functional scope. Does the development of the scope on the other projects tell a similar story?
- Local stakeholders became very active in the early stages of the design phase, rejecting the assumption of the theoretical framework which suggests a later activety. Which scenario fits the activity of the local stakeholders with the selected projects?
- The Betuweroute showed that there was a lack of attention for a proper evaluation of changed scope. The government stuck to the results of an early investigation which was positive. However since that evaluation the scope changed drastically making it financial, economical and social inbeneficial. Was there also a neglection in the investigation of the effects of proposed scope changes with the selected projects?

6.4.1 Project

- With the Betuweroute there was a clear ranking of the project constraints, first cost than time in the design phase and in the execution phase first time and than cost. Is there also a clear ranking in the selection of projects and is there an accurate general ranking?

According to the respondents time was clearly a driven constraint for the client, this could be due to the fact that most respondents were active in the construction phase. In the construction phase the planning is detailed and there are hard deadlines for the project manager. But also in the design phase the results show that time is the driven constraint for the client. From the case study on the Betuweroute time was the driven constraint in the initiative phase and changed to cost as the project developed and the budget was stressed. Such a tipping point can not be concluded in the questionnaire because people were asked to fill it in for one phase. For future research it is interesting to do also a longitudinal questionnaire to investigate the presence of tipping points.

During the entire PLC of the projects the overall changes were normal. However for all constraints the amount of scope changes decrease during the PLC except for the constraint time. Together with the result that time is the driven constraint and the total change in time was not larger than for the other constraints it suggest that changes in time are small but numerous. It raises the question; why is the amount of changes for the driven constraint so high? You would expect that because time is the driven constraint the other constraint would change to keep the driven constraint time the same; for example investing more financial resources to reach the deadline.

6.4.2 Scope changes

- For the Betuweroute the scope changes had the greatest impact on the cost of the project, does this also hold for the selection of infrastructure projects?

The results from the questionnaire show that the most scope changes lead to an increase in cost. This can be explained by the fact that extra scope raises the cost of the entire project. Extra scope does not always cause a delay in project delivery if the extra project scope does not lie on the critical path. And extra scope does not always have to lead in an increase or decrease of the quality level. In the Betuweroute every extra scope did result in an increase in cost and not always in time and quality. The questionnaire showed that the effect of a scope change will increase when introduced later in the PLC.

- The case study indicated that the client causes the most scope changes, due to different requirements. Is this also the case for the selection of infrastructure projects?

The main causes of the scope changes that were not foreseen (unforeseen risks) in the projects of the questionnaire can be related back to the client (change in demand and unclear scope definition), stakeholders and other projects. The causes which can be related back to the client are the easiest to prevent for the client by better defining the scope by applying value management. Stakeholders are harder to influence, but by applying good stakeholder management resistance for the project can be spotted early. When the issues are identified strategies can be developed by the client to minimise their influence on the scope of the project. The other causes in the theoretical framework; new insights, economy, technology and policy did not have a significant impact during the design and execution phase. An explanation for the causes economy, technology and policy could be that the movement of change within these causes is very slow and can be better anticipated. As was the case with the Betuweroute the impact of the client and the stakeholders are the highest of the named causes, but probably also the easiest to control.

6.4.3 Scope development

- One major drawback of the initiative phase of the Betuweroute was the lack of exploration into other suitable solutions and the focus was early on a new rail connection. There was an early fictation on specific scope rather than functional scope. Does the development of the scope on the other projects tell a similar story?

This problem did not surface in the questionnaire; the development of scope in the questionnaire shows an almost linear development from functional (quality) to specific (scope). This development was also suggested in the theoretical framework in Figure 32, where first the quality and functional scope is be defined and than the specific scope of the project. However in the case study the problem of scope fixation arose where the definition of scope was completed with an incomplete quality definition. More case studies or face-to-face interviews of other projects are needed to see if the problem of scope fixation does also occur in other infrastructure project or whether the Betuweroute is exclusive.

6.4.4 Stakeholder impact

In the questionnaire the stakeholders are divided not only on national, regional and local level but also in governmental and non-governmental. The data showed that the impact of non-governmental stakeholders was always lower than that of governmental stakeholders. The power of governmental organizations in infrastructure projects is higher, this is no surprise because in most causes they represent the client or they have important rights. For the Betuweroute the Ministry was a representing the national government as a client and regional and local governments were important because the trace was crossed their land. Although the new trace law was designed to give more executive power to national government when it concerns a project national importance, in the end the regional and local governments strongly influenced the scope of the project.

- Local stakeholders became very active in the early stages of the design phase, rejecting the assumption of the theoretical framework which suggests a later activety. Which scenario fits the activity of the local stakeholders with the selected projects?

The survey shows a similar trend where local stakeholders are active in the design phase of the project. In the design phase the scope of the project is already specific enough so that local governments can asses the impact on their community and influence the scope to their preferences or show resistance to the project. This results in the local stakeholders being the most important stakeholders in the design and execution phase. The data also showed that in comparison with the assumption in the theoretical framework the influence of local stakeholders is higher in the design phase than in the execution phase (see figure below).

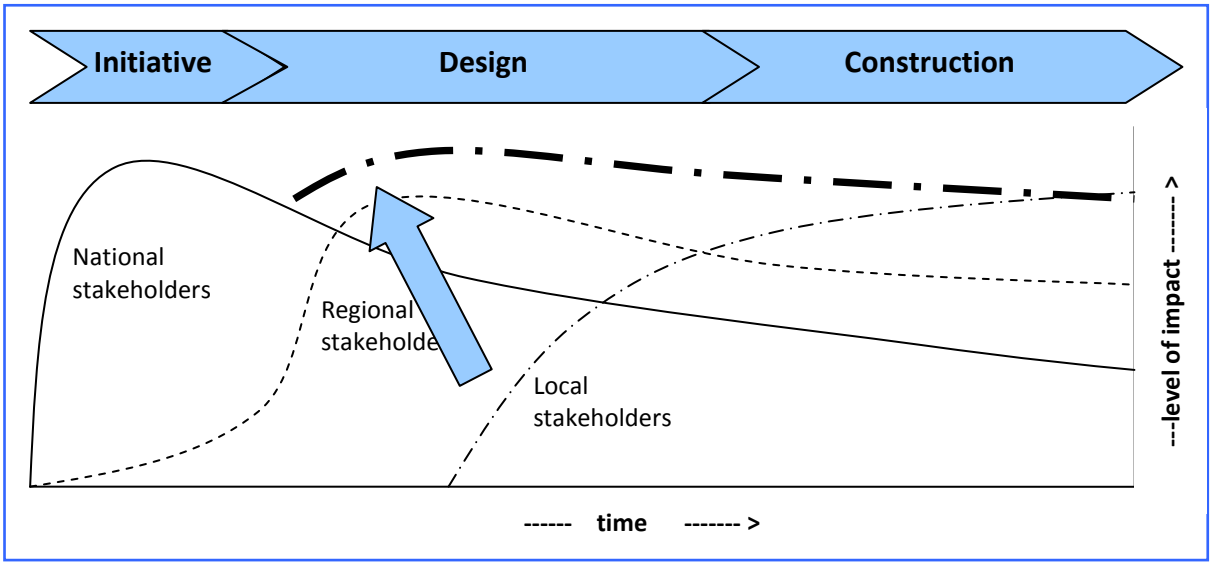


Figure 56, Adapted level of impact of stakeholders.

6.4.5 Scope management

- The Betuweroute showed that there was a lack of attention for a proper evaluation of changed scope. The government stuck to the results of an early investigation which was positive. However since that evaluation the scope changed drastically making it financial, economical and social inbeneficial. Was there also a neglection in the investigation of the effects of proposed scope changes with the selected projects?

The part of scope management investigated in the questionnaire is the controlling of scope and explicitly the scope change procedure. The level of attention for a scope change per subject seems strongly related to the importance of the constraint. The attention to time was ranked highest and time was also the driven constraint. Cost was also an important constraint and the level of attention in the procedure on cost was also ranked high (rank 3). Quality on the other hand was indicated as the weak constraint and this is also reflected in the level of attention in the scope change procedure. Interesting to see is that the attention for value is also less important for scope changes. This is very odd because the reason d'être for a project is that it creates value, so a change in value must be monitored. Comparing this with the Betuweroute which created negative value, because of the accumulating cost due to scope changes could be the problem in today's scope management.

7 Conclusions & Recommendations

7.1 Introduction

In this chapter the overall conclusions of the research are presented, combining the input of the literature study, case study and the results from the questionnaire. By comparing the outcome of the different studies it will be possible to give an answer to the research question:

Which experiences, methods and tools in scope management could be useful for better scope management for infrastructure projects?

7.2 Conclusions

After the literature research a theoretical frame work was set up to summarizes the most important concepts discussed and it provided structure and more specific research questions for the case study and questionnaire. The case study was a first investigation into the practice of scope management in a large infrastructure project, the Betuweroute. The questionnaire was set up to test the generalizability of the outcome of the case study on other infrastructure project in the Netherlands. This method of research provided the author the opportunity to understand the concept of scope and scope management and sequentially find the weak points of scope management in todays practice.

The conclusions will be presented according to the structure per subject set out in the theoretical framework; the project, scope changes, scope development, stakeholder impact and scope management. Per subject the research questions will be awnsered.

7.2.1 The project

This section will provide answers to the research question; what is scope?

- What definitions are available for scope?

The most used definition of scope and which best fits the concept of scope used in this paper (section 3.1.4), is that of The Project Management Body of Knowledge (2000:51), which distinguishes scope into two parts:

- **Product scope;** the features and functions that characterize a product or function.
- **Project scope;** the work that must be done to deliver a product with the specified features and functions.

The product scope and the project scope can be visualised in the Product Breakdown Structure (PBS) and the Work Breakdown Structure (WBS). The PBS and the WBS provide us with hierarchical structures of the entire product and project and helps more accurately and specifically define and organise the scope of the total project. The scope can be presented in functions (functional scope) or in objects (specific scope); the importance of these two descriptions will be stipulated in the scope development section.

- What relationship does scope have with other project aspects (time, cost, quality and value)?

The literature survey (section 3.1.3) provided the theory by Turner that all projects are bound by the quadruple constraints; scope, time, cost and quality. The constraints influence each other, so changing one constraint will change at least one other constraint. The levels of importance between these constraints differ per project, per phase and per stakeholder. The most important constraint is called the driven constraint and will determine the balancing between the constraints. This premise is important for creating the best possible value (section 3.1.8) for a project. The value of a project determines the success of a project and consist of the sum of these constraints and there relationships. In the case study of the Betuweroute showed that there was a lack of attention for the value of the project (section 5.5.2 to 5.5.5). Because of constant change in the project constraints the project in the end created negative value. This constant change was partly due to the alternation of the driven constraint. In the initiative phase time was the driven constraint, due to pressure of the cabinet to strengthen the west-east corridor as soon as possible. In the design phase quality was the driven constraint, due to pressure of local stakeholders to compensate the negative effects. And in the execution phase cost was the driven constraint, due to the extreme increase in cost incurred in the design phase. The project managers in the questionnaire indicated that time was the driven constraint in both the design and execution phase from the view point of the client (section 6.3.2). This could be due to hard deadlines in the contract for project delivery. The results also show a decrease of constraint changes during the Project Life Cycle, except for the constraint time (section 6.3.3). The amount of changes in time during the execution phase

is highest of all three phases. This could be due to sticking too long to an opportunistic planning, so in the execution phase the delays will be large.

7.2.2 Scope changes

This section will provide answers to the research question; what are scope changes?

- How can we identify a scope change?

A change in scope can either be a change in product or project scope, but in most cases it will be both. This is due to the interwoven nature of the linkages between the PBS and WBS. A scope change can be a change in functional scope (more or less functionalities) or in specific scope (more or less objects). The questionnaire indicates that the amount of scope changes decreases during the Project Life Cycle (PLC) (section 6.3.3). However the effects on the other constraints remain more or less the same, resulting higher effects per scope change during the PLC. This confirms the validaty of the assumption of **Figure 17** of a higher effect when a scope change is introduced later. However the data indicates a more linear development than an exponential development.

- What are the causes of scope changes?

The project and thus the scope are constantly exposed to external influences (section 4.3). These external influences shape the project and determine in the end the value of the project. In the literature study we have identified 10 causes for a scope change (section 3.3.4); new laws and regulations, requirements of the client change, risk take place, effects of other projects, new insights, technological breakthroughs, imposition by the State Council, incomplete scope definition, new economic situation and negotiations with stakeholders. The case study of the Betuweroute showed that the client and stakeholders were the most important causes for the scope changes that occurred (section 5.11.2). The results from the questionnaire confirm that the client and the stakeholders are the main causes of scope changes. The influence of other projects is also a major cause of scope changes. So the most effective way to decrease the amount of scope changes is to invest is methods that better help translate the client's and stakeholders' wishes. This can be done by introducing value management and stakeholder management early in the PLC.

- What effect do scope changes have?

Because a scope change can be more, less or different scope it has a variety of effects on the other project constraints either negative or positive (section 3.1.3). In the design phase of the Betuweroute the need for more quality led to more scope and logically to more cost. During the execution phase there was also extra scope added by the client, however also simplifications to reduce the extra cost of the extra scope. The results from the survey showed that all the scope changes together led to more quality, time and cost.

The mechanism of cause and effect displays a scenario containing intervening variables (section 4.3.2). For the Betuweroute the most important scope change scenario's during the design and execution phase could be reconstructed (Figure 40, Scope change scenarios during Betuweroute.). Clients are most likely to change the intended scope of a project and stakeholders the quality of a project. Quality and scope are intervening variables which in most cases influence the dependent variable cost and time. Of course rearranging the relationship between the constraints will lead to a different value of the project and needs to be monitored closely, as not to end up with a project with negative value. Scope change control and a scope change procedure set up early in the PLC will prevent this.

7.2.3 Scope development

This section will provide answers to the research question;

- How does scope change over time?

The theory of value management stipulates the importance of the scope development for the success of a project and in creating the best possible value (section 3.2.4). A first scope description should be the identification of the needed functionalities the future project must satisfy. Besides the functionalities it is also essential to include the required quality; the underlying and secondairy functions. During the design phase this functional scope and quality is translated in a specific scope, through the selection of alternatives. The Betuweroute has stipulated this importance, because in the first design (scope) the quality definition was not complete due to the absence of important stakeholders in the quality definition process. This led to a redefinition of the quality and thus redefinition of the scope. The results from the questionnaire display a more linear transgression from functional to a more specific scope description.

Scope fixation is a major problem in projects which can lead to a not optimal solution for the problem. This was especially the case with the Betuweroute, where the emphasis was on a rail connection in an early stage

(section 5.8.1). Proper exploration of other options such as transport by water and upgrading the current was not done because of this fixation. In infrastructure projects political influences play a major role and are subject to cognitive dissonance and blind ideological bias. This was the case with the Betuweroute where the feasibility study was questionable to say the least and applied on a totally different scope. However the policy makers fell back on that study and used the favourable data to their advantage.

The transgression from the quality definition and functional scope to the specific scope can be seen as a process of zooming in and out. As the project progresses the manoeuvrability within the design decreases and the effect of a scope change increases during the Project Life Cycle (Figure 4). This assumption was confirmed by the respondents of the questionnaire (section 6.3.4), which showed a decrease of the amount of scope changes where the effects of the total scope changes remained the same.

7.2.4 Stakeholder impact

This section will provide answers to the research question;

- What was the role of stakeholders in scope definition and control?

Stakeholders are an important external influence in large infrastructure projects, because of the longitudinal characteristic of infrastructure projects. Because of this characteristic infrastructure projects will affect many and a vast variety of stakeholders. The literature research (section 3.2.3) showed that developing appropriate strategies to approach those different stakeholders and developing relations is important for the success of a project. The timing of involving stakeholders may be as important as the strategy itself. Clients face the following stakeholder dilemma:

Involving stakeholders early in the project life cycle will lead to more scope changes however the effects on the other project constraints will be less. Not involving stakeholders will lead to (less) stakeholders being involved in a later stage with possible fewer scope changes but higher effects on other project constraints.

Stakeholders must be involved as early as possible in the project for three reasons. First, by including stakeholders in the conception of scope the overall value of the project will increase because wishes of stakeholders are included. Second, the case study and the questionnaire (sections 0 and 6.3.5) showed that stakeholders still have a significant impact on the scope of a project in the design and construction phases. More active stakeholder involvement in the initiative phase of the project when shaping the scope of the project will reduce their involvement in the latter phases. Stakeholder management tools as discussed in paragraph 3.2.3 help identify those stakeholders and use appropriate strategies to approach. And third it is important that wide stakeholder support is achieved throughout the project to support the justification and need for its outputs. This can be very helpful in achieving long term alignment of wider stakeholder interests with the project which is an important part of sustaining political support over the long construction timescales of major projects. The Betuweroute is a clear example of a project where important stakeholders were involved in a too late stage, were there was already a design to oppose to. By involving them in the quality definition their interest can be translated easier in the eventual design.

Because of the scope development from functional to specific more information becomes available on the geographical position and the exact effects the project will have on the area. This suggests that different stakeholders will participate during the Project Life Cycle. National stakeholders will be involved early in the initiative phase, followed by regional and local stakeholders. The questionnaire showed that, in comparison with the assumptions, the impact of local stakeholders is higher than the impact of regional and national stakeholders in the design and execution phase. An explanation could be that because of the geographical implications local stakeholders are affected on a personal level with the project. For the Betuweroute these were for example local farmers who were directly affected by the project because it crosses their land.

7.2.5 Scope management

This section will provide answers to the research question; what is scope management?
Scope management has two functions and these two functions can be divided into scope development and scope control.

- How can we determine scope?

In the initiative phase and the first half of the design phase it is essential to come to the right scope by the use of methods suggested in the literature study (sections 3.2 and 3.3) such as value management, stakeholder management and flexibility management. The Betuweroute showed a lack of creating proper value, because the emphasis was on an object (rail connection) and not on the function (strengthening west east corridor). Better value management could have created a better solution (specific scope) for the needed quality and

functional scope. Proper stakeholder management could have prevented the immense resistance against the Betuweroute by better and most important early stakeholder involvement.

- How can we control scope?

The second function of scope management is scope control which prevents unnecessary scope change request from being implemented and it assures that necessary scope changes are carried out in a proper manner. In the Betuweroute the main problem was scope development, in the design and construction phase there were also some irregularities in scope control (sections 5.5.6 and 5.6.1). Especially in the investigation of the effects of the suggested scope changes, the misuse of the risk reservation and the communication of cost overrun. The responses from the project managers of the survey show that there is still room for improvement in the scope change procedure (section 6.3.6). Suggestions for improvement were; clear mandate and responsibilities, procedure needed before scope changes surface and a reference project to value the scope changes.

7.2.6 Overall conclusion

The most important conclusion to be made is that there is still a lot of room for improvement for the process of defining the right scope in infrastructure projects so that the best value can be created. Value management plays an important role in identifying the needed quality and functionalities so that a complete specific scope can be composed. In identifying the needed quality and functional scope of a project it is essential to include stakeholders in this process or else they will oppose in latter stages when the consequences are higher. Besides a proper scope definition it is also important that proper scope control is in place. A scope change procedure is essential to ensure that only the necessary scope changes are implemented. By rejecting unnecessary scope changes it will be much easier to stay within budget and reach the deadline. Decomposition and a dynamic project organization will better help guide the process of scope changes by dividing the project in more manageable subprojects and by the use of an aspect level.

7.3 Recommendations

The experiences, methods and tools that were researched gave an insight in where there is room for improvement and how it can be improved. And thus the goal of the research can be reached:

To provide recommendations for better scope management during the initiative, design and construction phase of infrastructure project.

The recommendations for better scope management are elaborated by their two main functions; “coming to the right scope” and “controlling the scope”. The methods and there place in the Project Life Cycle are presented in the figure below.

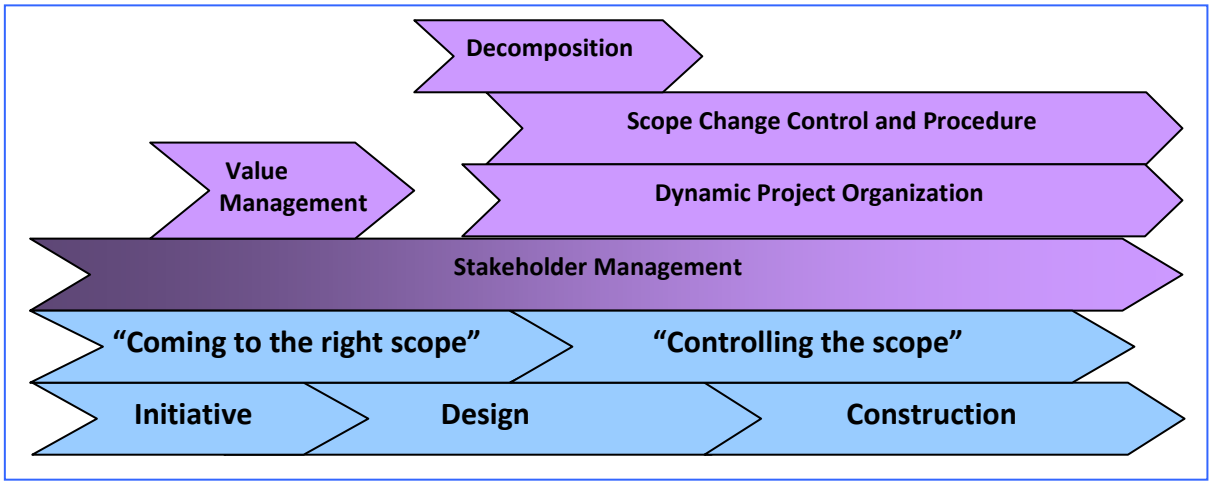


Figure 57, Scope management methods and the PLC.

7.3.1 Coming to the right scope

Stakeholder management

The conception of an infrastructure project starts when there is an idea or desire to change a situation (in the infrastructure network), and the initiative phase starts. The solution direction is still open and subject to different influences. One important influence to manage is the stakeholders that will influence the course of the project in both a negative and positive way. Both in the case study and in the questionnaire stakeholders

were a major cause of stakeholders, especially in the design and execution phase. Stakeholder management is needed during the entire PLC but the most benefit can be reaped in the first halve of the PLC. Several stakeholder management tools were introduced that help identify and map all stakeholders and their interests. Strategies can be developed to approach the different stakeholders, empower supporters and sway opponents. Important part of stakeholder management is to reach mutual consent on the scope of the project.

Value management
Important for coming to the right scope is to first describe the functions that the scope must provide. In case of the Betuweroute it could be concluded that there was an early focus on a specific object (railconnection), rather than a proper investigation in the needed functions. People are visually minded and tend to think in objects rather than functions; value management forces them to think in functions. This method insures that all important qualities surface and the best scope can be developed that best fits this quality definition. During the application of value management the involvement of stakeholders is essential in creating the best possible value. So the necessary stakeholders for the value analysis have to be identified on beforehand.

7.3.2 Controlling the scope

Decomposition
Decomposition can make a complex system simpler by dividing it in several less complex subsystems which can work parallel on the short run. Because there are few relationships between the subsystems the effects of most scope changes do not have to be calculated for the entire system. Simplification of the system will make coping with scope changes easier.

Dynamic project organization
A dynamic project organization can make scope control more efficient because of the use of aspect managers. Every project constraint should be represented by an aspect manager so when a scope change arises the effects can be investigated per constraint. The aspect manager has current knowledge of the constraint for the entire system at any moment in time. Another important aspect of this type of organization is because of the use of an aspect level communication lines are reduced drastically.

Scope change control and procedure
A project takes place in a dynamic environment and even with a robust scope definition, scope changes will occur. Important is how these scope changes are controlled in the design and construction phase. If scope changes are not controlled properly scope creep can be the result, which will lead to budget overruns and delays. For the Betuweroute this was the case and the data in the questionnaire indicate that there was more attention for the cost and time of a scope change than the added value. In the implementation of scope changes, decisions should be taken gradually if the proposed scope change is actually to be implemented. In the control mechanism a difference has to be made between avoidable and unavoidable scope changes. Important is that for each major scope change the effects are investigated which will form the basis for decision making. The procedure will reduce the number of scope changes because unnecessary scope changes will be identified and rejected.

The scope change procedure that will guide the scope change from request till implementation must be ready and agreed upon from the start of the design phase. When the procedure is implemented too late and not well communicated it will be too late to control budget overruns and delays. This is essential because in the scope change procedure every scope change is judged on feasibility, necessity and utility by investigating:

- Necessity of scope change (does a highly unfavourable/dangerous situation occur when not implementing?)
- Cost of scope change
- Effect on planning of scope change
- Risk associated with scope change, risk of implementing and not implementing
- extra benefits (lower exploitation costs, longer lifespan, higher incomes, etc.) of scope change
- value change of scope change
- availability of other more favourable scope changes

This investigation stretches out over several different specialisations and needs to be well structured throughout the organization. A manager may be appointed to steer this process with sufficient mandate to review, reject and implement a scope change. The scope change procedure should play an important part in the project control of a project. Time and cost are often the driven constraints of a project and a good scope change procedure will reduce delays and cost overruns because unfavourable scope changes are spotted in time.

7.4 Future research

The approach of this research was to explore the behaviour of scope and its impact on the project. This was done by the deep investigation of the Betuweroute and a broad questionnaire among project managers of several projects. This approach gave a good picture of that behaviour and impact, however a deeper investigation into more projects good result in more profound results. The project managers in the initiative phase were underrepresented, so and face-to-face interview or questionnaire targeted to those project managers good give a better idea of the behaviour and impact of scope in the initiative phase. The target group of this research were project members; however a research into the experiences of stakeholders and clients towards scope development and scope control could be valuable to design better methods. The importance of the relationship between the client and the contractor regarding scope management was outside the research area of this paper. A research in this relationship and the strategic behaviour of the client and contractor might also prove beneficial for better scope definition and scope control.

This research introduced several management methods to develop and control scope in infrastructure projects. It would be interesting to investigate how these methods perform if applied. Stakeholder management has been applied on many projects on different levels. Value management applied on the initiative phase is still rather new. Decomposition or another form of project simplification is being applied on large projects. Scope change procedures are applied on infrastructure projects. So to summarize there are several directions for future research into scope management:

- Case study of other large infrastructure projects.
- Face-to-face interviews with project managers active in scope development or/and control.
- Survey targeted at clients and stakeholders to obtain their experiences.
- Research in the relationship between the client and contractor regarding scope management.
- Evaluation of infrastructure projects that applied methods introduced in this paper.

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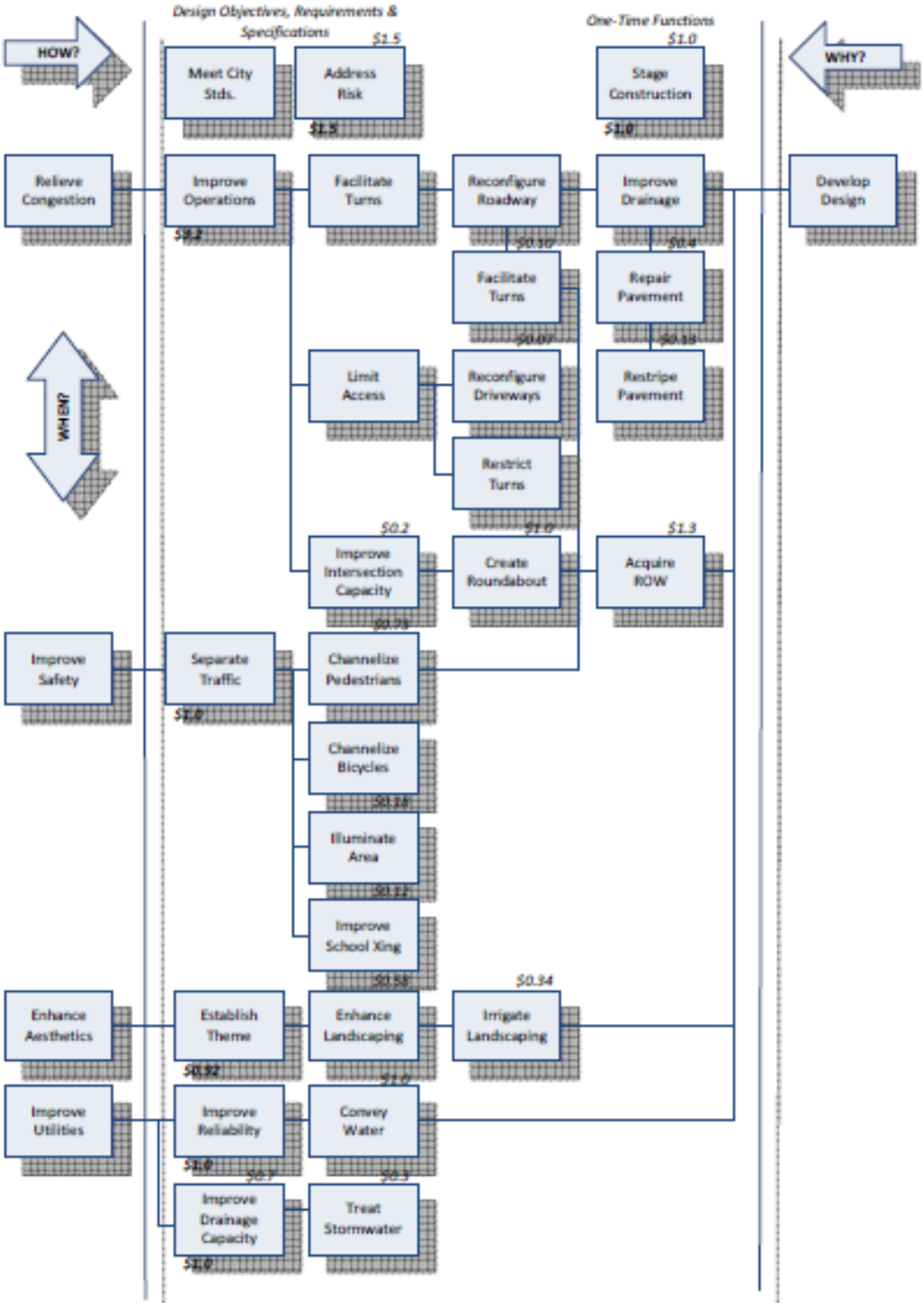
9 Appendix

9.1 FAST Diagram, Road Improvement[24]



[24] Stewart R.B. (2009) Value Management Kitchen, course material .

9.2 Decomposition example

Decomposition occurs in a number of chronological steps:

1. Compile a list (brainstorm) of all the components of the project, while avoiding naming elements. Focus should be in composing a complete list, of which the size is manageable for the next steps (no more then 25 components). In this step all relevant stakeholders and experts should be present.
2. The next step is to capture all relationships between the components, which are displayed in a matrix, as shown. It is also possible to indicate gradations in the relationships through the use of varying diameter of the dots.
3. Now it is key to move (thick) dots to the diagonal axis by shifting components (columns and rows) without breaking relations. Several iterations will be necessary to ultimately come to a matrix that is acceptable.
4. Then clusters with as many dots as possible are created which are manageable in terms of complexity. The clusters are squares and should not overlap.
5. The last step is the acceptance of the clusters by the parties and the dividing of responsibilities. The dots (links) that fall outside the clusters should also be managed, through the application of interface management.

When creating the size and amounts of subsystems it is important to keep in mind that creating more subsystems will reduce complexity of a single subsystem. But on the other hand more relations will fall outside the subsystem border and thus more elaborate interface management is needed. So for every project there will be an optimal size and amount of subsystems.

For illustration of the method the decomposition of the Maeslantkering is given in . As many points are tried to be included in clusters, that on the short term can be controlled independently. The clusters represent different disciplines, “wet construction” (A), "dry construction" (B) and water protection system (C).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1.Sill	●	●	●		●		●							●					
2.Filter	●	●	●		●														
3.Bed protection	●	●	●	●	●														
4.River works			●	●															
5.Abutment	●	●	●		●	●	●		●	●	●	●			●		●		
6.Site arrangements					●	●	●												
7.Dry dock	●				●	●	●	●		●		●		●	●		●	●	
8.Dry dock pumps							●	●									●		●
9.Foundation					●				●				●	●	●				
10.Guiding tower					●		●			●		●		●		●			
11.Control building											●	●							●
12.Power station							●			●	●	●				●		●	●
13.Ball and socket system									●				●	●	●	●		●	●
14.Gates									●	●			●	●	●	●		●	●
15.Frame work					●				●				●	●	●				
16.Locomobile & rails										●		●	●	●		●			●
17.Dry dock gate	●				●		●	●									●		●
18.Ballasting system												●	●	●				●	●
19.Power supply								●			●	●	●	●		●		●	●

Table 12, Decomposition of the Maeslantkering [25].

[25] De Ridder H.A.J. (2009) collegesheet Dynamic control of projects September 22nd . Technische Universiteit Delft, Faculteit Civiele Techniek en Geowetenschappen, Sectie bouwprocessen.

9.3 Dynamic Project Organization example

The dynamic project organization will be explained through a number of two scenarios:

Scenario 1: In Figure 58 the scenario is displayed of a exogenous scope change (change from outside of the project). The change enters the organization for example through the project leader, who wants to know the overall effects of implementing the scope change. So he/she wants to learn about the effects on various aspects (scope, cost, time, quality, etc.) so an information request is placed by the aspect leaders (blue line). In order to minimise the amount of arrows the information flow through one branch is illustrated. In most cases the subsystem leader can estimate the effect of a scope change for a given aspect and can report back to the aspect leader. If the subsystem leader needs specific information, he can consult with the element leader. Ones the aspect leaders have information on the effects on the aspects due to the scope change, they can report back to the project leader, who can make a decision. The big advantage is that at every moment in time the information is available per aspect for the entire project and not fractured amongst subsystem leaders.

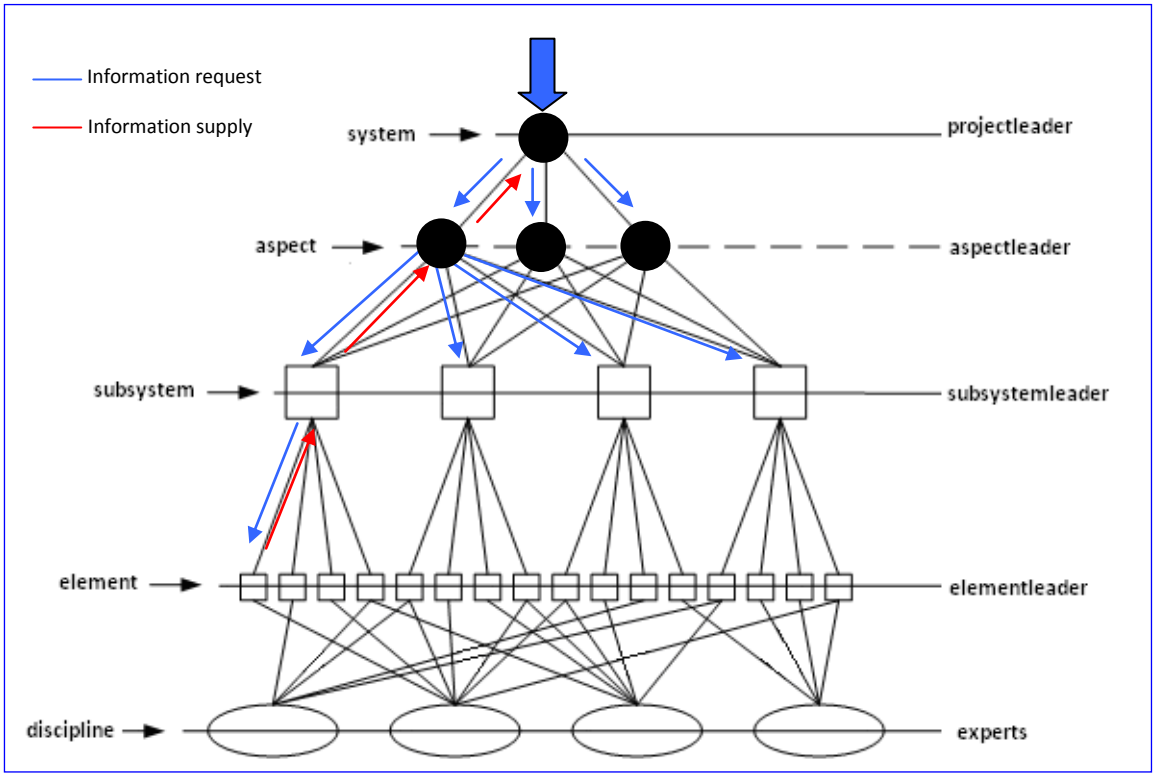


Figure 58, Scenario 1; exogenous scope change.

Scenario 2: Figure 59 is an endogenous process of scope changes appear (change from within the project). Suppose a risk occurs with an element, it is reported (red line) to the subsystem leader, who then may request a scope change (big blue line). Because of decomposition a change in one subsystem will on the short term not influence other subsystems. So the a change in an element in one subsystem will not influence other subsystems. Other subsystem leader will not be involved in the change procedure.

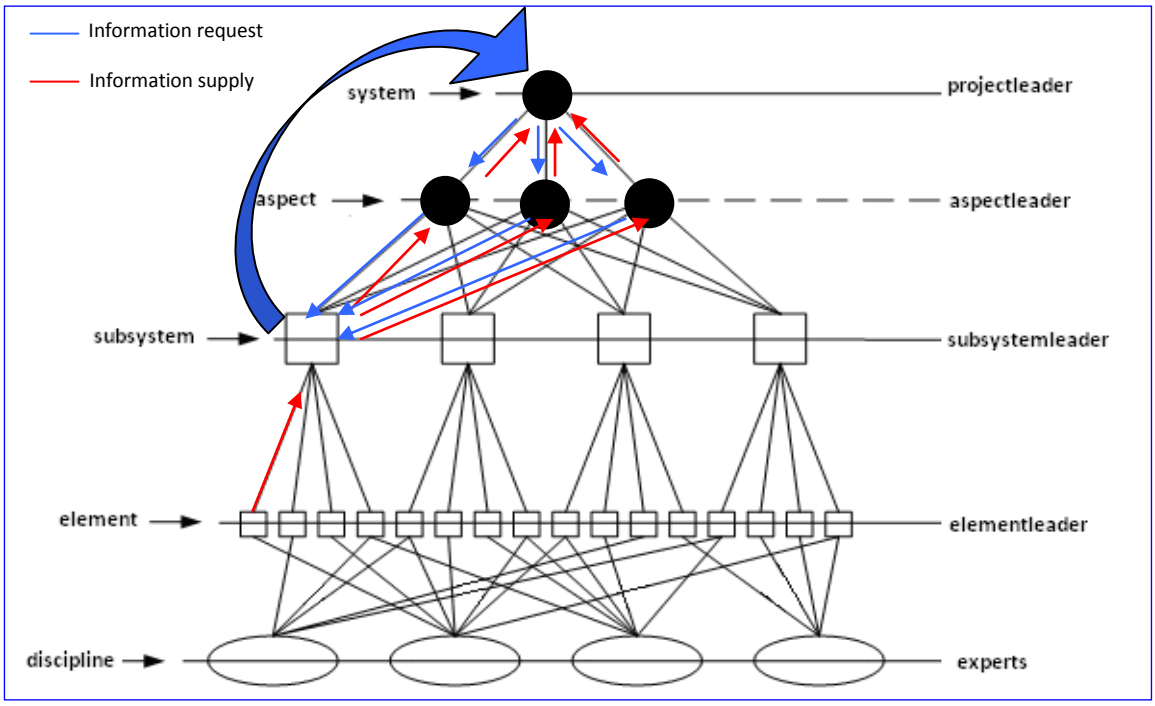


Figure 59, Scenario 2; endogenous scope change.

9.4 Mutation overview Betuweroute, Progress Report 24 (June 2008).

Tabel 2: Mutatie overzicht projectbudget ***Bedragen in mln. EUR (excl. BTW)***	**Bedrag Prijspeil 1995**	**Gecom muni-ceerd met Tweede Kamer**	**Prijspeil**	**Bron: VGR-nr.**
PKB/TB	**3.744**	**3.744**	**1995**	**1**
Scopewijzigingen				
- Double stack-vervoer westelijke tunnels	67	68	1996	3
- Dintelhavenbrug	10	11	1996	3
- Rijkswegenfonds ("nieuw voor oud")	7	7	1996	3
- Studie en onderzoek (commissie Hermans)	18	18	1996	3
- Waalhaven Zuid	4	5	2000	8
- Verlegde Havenspoorlijn	7	8	2000	8
- HST-Oost tunnel	13	14	2000	8
- Ongelijkvloerse kruising Europaweg	12	13	2000	8
- Double Stack oostelijke tunnels	17	19	2000	8
- Raad van State/reparatie TB-besluit	16	18	2000	8
- Mer-evaluatie	1	1	2000	8
- Archeologie	8	10	2000	8
- Beheer kruisende infra	15	18	2000	8
- Versobering binnen het project	-69	-79	2000	8
- Niet doorgaan Noordoostelijke Verbinding (NOV)	3	3	2001	11
- Kortetermijnproblematiek VGR 10				
- Tunneltechnische Installaties (TTI); veiligheid	15	17	2001	11
- Treinbeveiliging (ATB-EG)	5	6	2001	11
- Boog Geldermalsen (capaciteit personenvervoer)	7	8	2001	11
- Geluidsproblematiek Calandbrug	20	23	2001	11
- Restant budgettaire spanning februari 2000	5	6	2001	11
- Kijfhoek	8	9	2001	11
- Tot 1-7-2001 gerealiseerde meevallers	-25	-29	2001	11
Totaal scopewijzigingen	**258**	**282**		
Totaal versoberingen binnen het project	-94	-108		
- Saneringen		36	2002	14
- TTI (sprinklers)		104	2003	15
- B&I		6,9	2003	15
Saldo scopewijzigingen	**164**	**320,9**		
Tegen- en meevallers				
- versobering communicatieactiviteiten	-9	-10	1999	7
- overboeking "Letter of Intent"BR (LOI)	-2	-2	2001	10
- overdracht voor het project "Private Exploitatie BR (PEB) t.b.v. DG Goederenvervoer	-3	-3	2001	10

Aanbestedingsmeevaller		-160	2004	16
Aanbestedingsmeevaller		-117	2004	17
Aanbestedingsmeevaller		-48	2004	18
Aanbestedingsmeevaller		-25	2005	19
Saldo tegen- en meevallers	**-14**	**-365**		
Technische mutaties				
- loon- en prijspeilontwikkeling	0	54	1996	2
- loon- en prijspeilontwikkeling	0	132	1996	3
- loon- en prijspeilontwikkeling	0	104	1997	4
- loon- en prijspeilontwikkeling	0	100	1998	5
- correctie rekenkoers euro	0	5	1998	6
- loon- en prijspeilontwikkeling	0	49	1999	7
- loon- en prijspeilontwikkeling	0	77	2000	8
- loon- en prijspeilontwikkeling	0	121	2001	10
- loon- en prijspeilontwikkeling	0	73	2002	12
- loon- en prijspeilontwikkeling	0	47	2003	14
- loon- en prijspeilontwikkeling	0	16,8	2004	16
- loon- en prijspeilontwikkeling	0	3,8	2005	18
- loon- en prijspeilontwikkeling	0	14	2006	20
- loon- en prijspeilontwikkeling	0	0,8	2007	22
- loon- en prijspeilontwikkeling	0	1,4	2008	24
Saldo technische mutaties	**0**	**798,8**		
Afrondingen				
- afrondingen	1	1	2001	11
Saldo afrondingen	1	1		
Subtotaal mutaties	**151**	**754,7**		
Bijdrage ProRail aan EAT kosten		97	2002	12
Schuif van Duu naar IUU		-2,8	2002	
EU bijdrage		33	2002	14
Compensatie prijspeil Bodemsanering		5,8	2003	14
Overboeking PIEK regeling VROM		-5	2004	16
Extrapolatie		2,3	2004	16
Lagere bijdrage EU Botlektunnel		-1,6	2004	17
Extra EAT		37	2005	19
Migratie Havenspoorlijn		14	2007	23
Totaal	**3.895**	**4.678**	**2008**	**24**

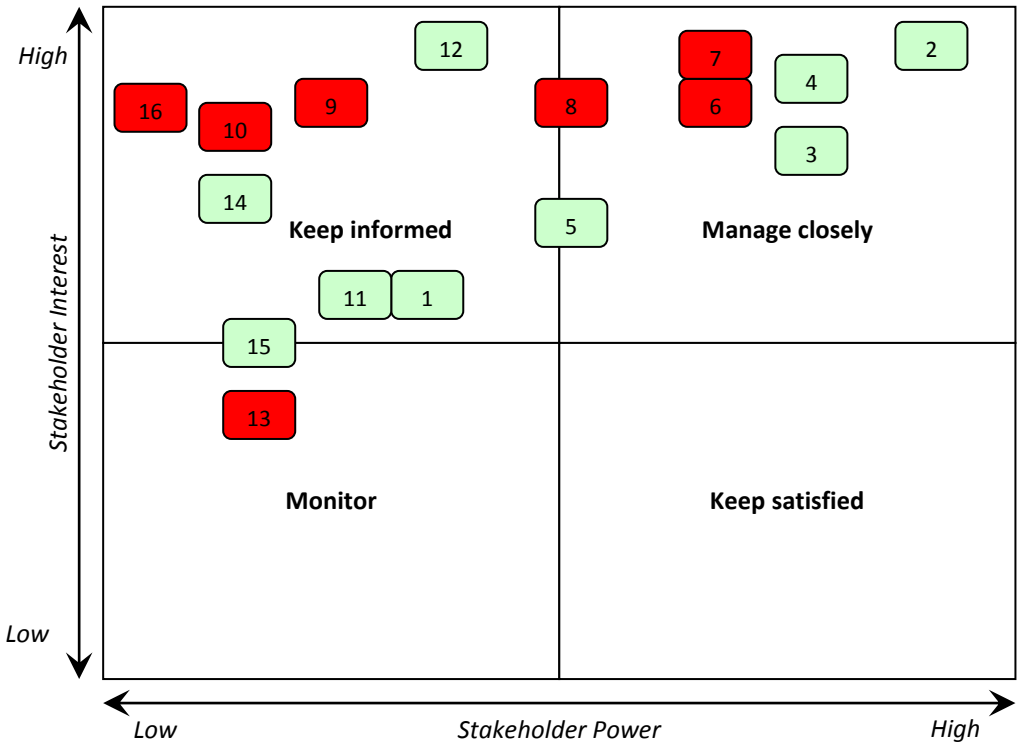
9.5 Stakeholder overview

Governmental actors	Interest(s)	Problem Perception	Goal	Resources
German Government	Economy	Facilitating growth in freight transport	Stronger (European) rail network	Authority
National				
Cabinet	Economy Durability	To much freight by road	More freight by rail	Authority Budget
Parliament and Senate	Economy	Correctness and feasibility of plans	Control the cabinet	Blocking power
Ministry of Transport, Public Works and Water Management	Good and safe transportation	To much freight by road	More freight by rail	Authority
Ministry of Housing, Regional Development and the Environment	Efficient and durable use of space	Spatial "fitness" of Betuweroute	Proper "fitness" of Betuweroute	Authority
Regional				
Province of Gelderland	General welfare of the region	New rail connection disturbs general welfare	Proper integration of Betuweroute in region	Authority Relations
Province of Zuid-Holland	Economic position of the region	Weak rail connection with "Hinterland"	Increasing economic position	Authority
Local				
Municipalities Z-H and Gelderland	Living environment	Decrease of living environment	Decrease impact Betuweroute	Authority
Nongovernmental actors	**Interest(s)**	**Problem Perception**	**Goal**	**Resources**
VLOB (National Union Consultation Betuweroute)	Living environment	Decrease of living environment	No Betuweroute	Relations
Environmental groups	Environment	Damage to environment	No damage to environment	Relations
Rotterdam Harbour Companies	Position harbour	Weak rail connection with "Hinterland"	Durable, safe and attractive harbour	Relations
NS	Rail network	Weak position NS Freight	More freight by rail	Knowledge Resources
River transportation companies	Position river transport	Possibility of unfair competition	Fair competition	Relations
Transport companies	Position companies	Weaker position, because of weak infrastructure	Strong infrastructure	Relations
Chamber of Commerce	Economy	Weak position commerce	Better trade routes	Information
Affected citizens	Living environment	Betuweroute affects Living environment	No Betuweroute	Relations

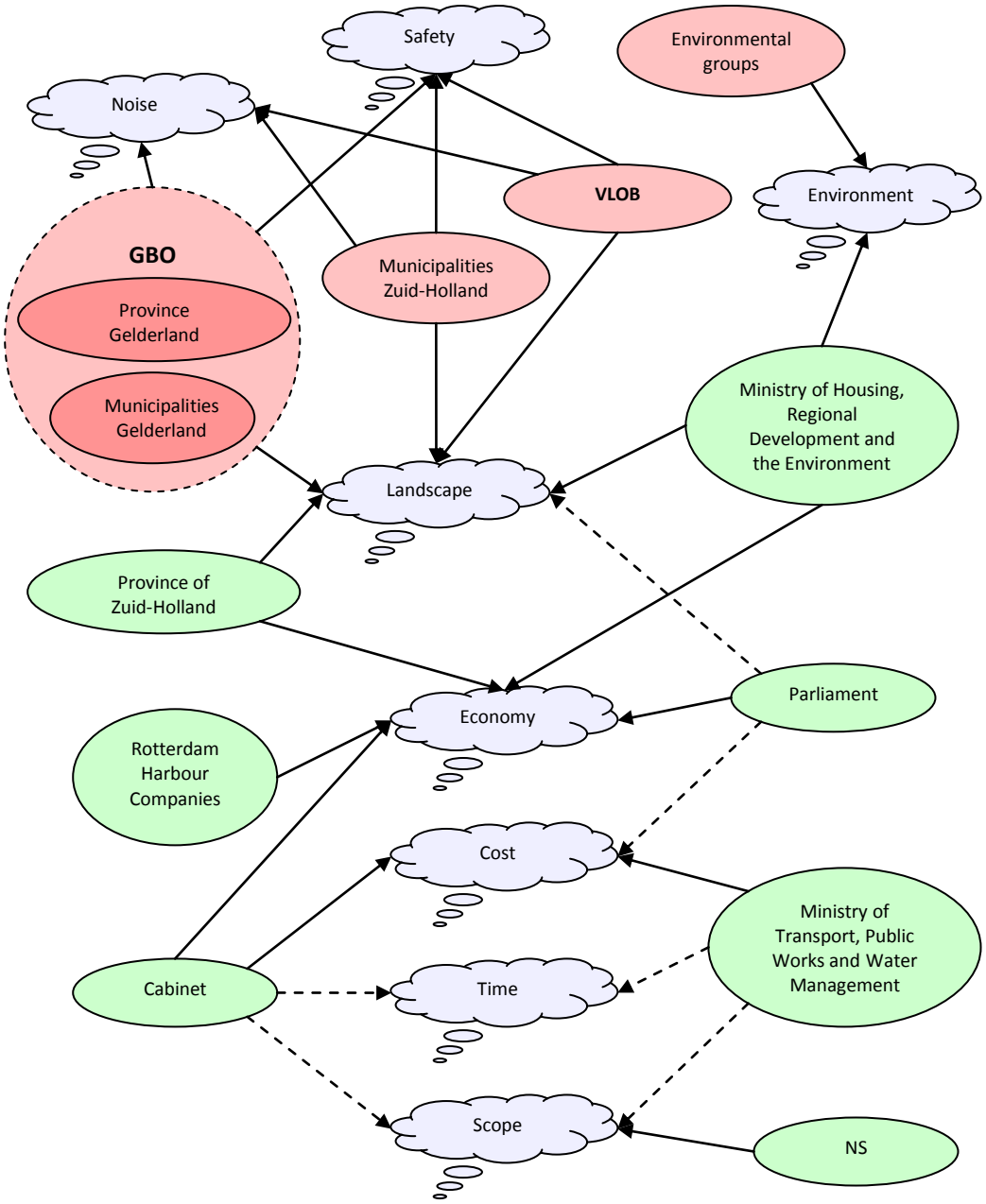
9.6 Critical actors

	Governmental actors	Important resource	Replaceability (high/low)	Dependency (high/moderate/low)	Critical actor (yes/no)	Proponent (yes/no)
1	German Government	Authority	Low	Low	No	Yes
	National					
2	Cabinet	Authority	Low	High	Yes	Yes
3	Parliament and Senate	Blocking power	Low	Moderate	Yes	Yes
4	Ministry of TPWWM	Authority	Low	High	Yes	Yes
5	Ministry of HRDE	Authority	Low	Moderate	Yes	Yes
	Regional					
6	Province of Gelderland	Authority	Low	Moderate	Yes	No
7	Province of Zuid-Holland	Authority	Low	Moderate	Yes	No
	Local					
8	Municipalities Z-H and Gelderland	Authority	Low	Moderate	Yes	No
	Nongovernmental actors					
9	VLOB	Relations	Low	Moderate	No	No
10	Environmental groups	Relations	Low	Low	No	No
11	Rotterdam Harbour Company	Relations	Low	Low	No	Yes
12	NS	Knowledge	Low	High	Yes	Yes
13	River transportation companies	Relations	Low	Low	No	No
14	Transport companies	Relations	High	Low	No	Yes
15	Chambers of Commerce	Information	Low	Low	No	Yes
16	Affected citizens	Relations	Low	Low	No	No

9.7 Power Vs Interest Grid



9.8 Stakeholder-issue interrelationship diagram



9.9 The questionnaire

1. *Binnen welke organisatie was/bent u werkzaam tijdens/bij project..?*_____
2. *Wat was/is uw functie binnen organisatie … tijdens/bij project …. ?*_____
3. *Wat was/is uw functie binnen project……?* _____
4. *In welke fase van het project was/bent u voornamelijk betrokken?*

O initiatieffase *(vragen over ontwerp- en uitvoeringsfase worden overgeslagen)*
O ontwerpfase *(vragen over initiatief- en uitvoeringsfase worden overgeslagen)*
O uitvoeringsfase *(vragen over ontwerp- en initiatieffase worden overgeslagen)*

Scope

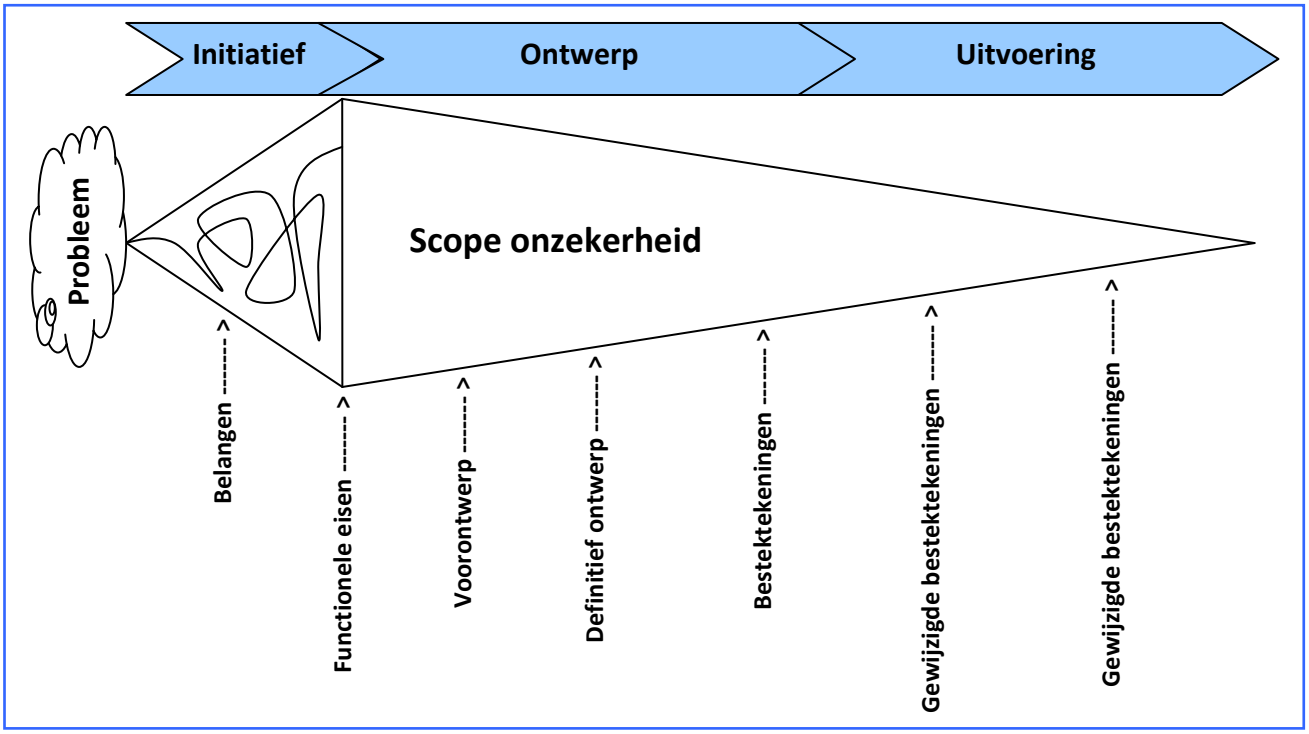
*In deze enquête wordt met **scope** bedoeld:*
*De functionele of specifieke kenmerken en functies van het product **plus de activiteiten** die nodig zijn om het product te verkrijgen (definitie volgens Project Management Body Of Knowledge, 2000).*

Verschillende activiteiten, zoals bijvoorbeeld grond bevriezen of damwanden slaat hoeft niet te leiden tot een ander eindproduct. De twee bouwmethodes hebben echter wel andere kosten en effect op de planning.

Projectfasen

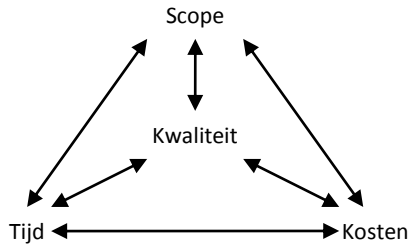
In deze enquête wordt de nadruk gelegd op de projectfasen; initiatieffase, ontwerpfase en uitvoeringsfase. In de onderstaande figuur worden deze fasen weergegeven met de bijbehorende scopebeschrijvingen. Tevens is de onzekerheid weergegeven in de loop van een project in vliegervorm.

- *Initiatieffase: in deze fase is men zich aan het oriënteren naar mogelijke oplossingsrichtingen, en naar de haalbaarheid daarvan. Één enkele of enkele oplossingen worden uitgewerkt in de ontwerpfase.*
- *Ontwerpfase: de oplossing(-en) worden verder ontwikkeld in deze fase, wat leidt tot voorontwerpen, definitieve ontwerpen en bestektekeningen.*
- *Uitvoeringsfase: bestektekeningen voor de uiteindelijke uitvoering zijn nog onderhevig aan wijzigingen.*



5. Bepaal de **omschrijving** van de scopedocumenten van het project in de verschillende projectfasen.

	Functioneel	< ----------	----------	---------- >	Specifiek
Initiatieffase	0	0	0	0	0
Ontwerpfase	0	0	0	0	0
Uitvoeringsfase	0	0	0	0	0



De "quadruple constraint" is gebaseerd op de ijzeren driehoek (Dobson, 2007) waarvan de zijden korter of langer kunnen worden, echter breken doen ze niet. Ze kunnen meebewegen waar nodig, maar zijn constant met elkaar verbonden. Het veranderen van één beheersaspect heeft consequenties voor de andere beheersaspecten.

Scope en kwaliteit
Bij functionele/specifieke scope hebben we het bijvoorbeeld over capaciteit, volumes en frequenties. Bij kwaliteit gaat het om kenmerken zoals veiligheid, levensduur, gebruikersvriendelijkheid en esthetica. Kwalitatieve aspecten zoals binnen budget, oplevering op tijd en geen gebreken vallen onder respectievelijk kosten, tijd en scope.

6. Bepaal de mate van belangrijkheid van de vier projectbeheersaspecten gezien **vanuit de opdrachtgever.**

	Niet belangrijk	Beetje belangrijk	Belangrijk	Erg belangrijk	Extreem belangrijk
Scope	0	0	0	0	0
Tijd	0	0	0	0	0
Kosten	0	0	0	0	0
Kwaliteit	0	0	0	0	0

7. Veranderingen in onderstaande projectbeheersaspecten tijdens de **initiatieffase** waren:

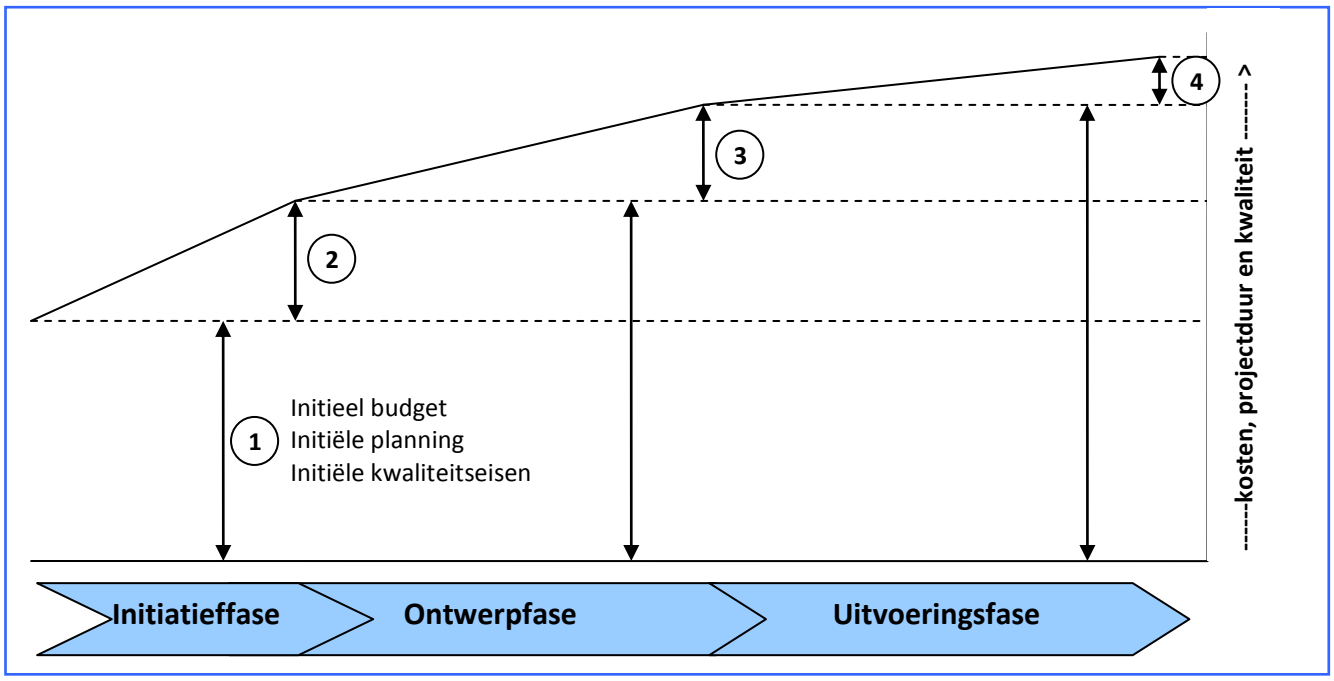
	Erg klein	Klein	Normaal	Groot	Erg groot
Scope	0	0	0	0	0
Tijd	0	0	0	0	0
Kosten	0	0	0	0	0
Kwaliteit	0	0	0	0	0

8. Veranderingen in onderstaande projectbeheersaspecten tijdens de **ontwerpfase** waren:

	Erg klein	Klein	Normaal	Groot	Erg groot
Scope	0	0	0	0	0
Tijd	0	0	0	0	0
Kosten	0	0	0	0	0
Kwaliteit	0	0	0	0	0

9. Veranderingen in onderstaande projectbeheersaspecten tijdens de **uitvoeringsfase** waren:

	Erg klein	Klein	Normaal	Groot	Erg groot
Scope	0	0	0	0	0
Tijd	0	0	0	0	0
Kosten	0	0	0	0	0
Kwaliteit	0	0	0	0	0



10. Geef aan wat het geschatte aandeel van de extra kosten en vertragingen door scopewijzigingen (2) tijdens **initiatieffase** was op het budget en planning (1):

	0-20%	20-40%	40-60%	60-80%	80-100%
Projectkosten	0	0	0	0	0
Projectplanning	0	0	0	0	0

11. Geef de verandering van het kwaliteitsniveau aan door scopewijzigingen tijdens **initiatieffase**:

	Veel minder	minder	gelijk	meer	Veel meer
Kwaliteitsniveau	0	0	0	0	0

12. Geef aan wat het geschatte aandeel van de extra kosten en vertragingen door scopewijzigingen (3) tijdens **ontwerpfase** was op het budget en planning (1+2):

	0-20%	20-40%	40-60%	60-80%	80-100%
Projectkosten	0	0	0	0	0
Projectplanning	0	0	0	0	0

13. Geef de verandering van het kwaliteitsniveau aan door scopewijzigingen tijdens **ontwerpfase**:

	Veel minder	minder	gelijk	meer	Veel meer
Kwaliteitsniveau	0	0	0	0	0

14. Geef aan wat het geschatte aandeel van de extra kosten en vertragingen door scopewijzigingen (4) tijdens **uitvoeringsfase** was op het budget en planning(1+2+3):

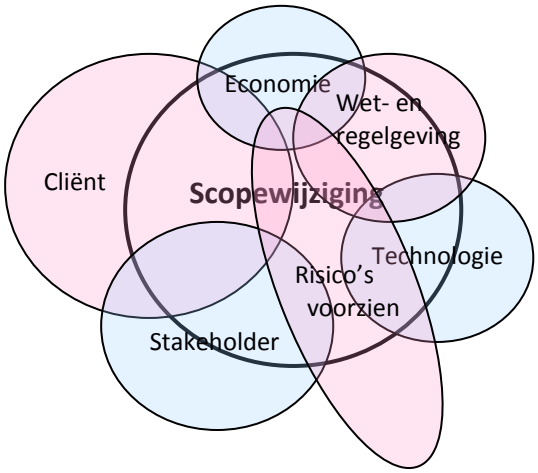
	0-20%	20-40%	40-60%	60-80%	80-100%
Projectkosten	0	0	0	0	0
Projectplanning	0	0	0	0	0

15. Geef de verandering van het kwaliteitsniveau aan door scopewijzigingen tijdens **uitvoeringsfase**:

	Veel minder	minder	gelijk	meer	Veel meer
Kwaliteitsniveau	0	0	0	0	0

16. Bepaal het voorkomen van de volgende scopewijzigingscenario's gedurende projectduur:

	Nooit	Nauwelijks	Soms	Regelmatig	Vaak
Scopevermeerdering					
1. Extra kosten door scopevermeerdering	0	0	0	0	0
2. Vertraging door scopevermeerdering	0	0	0	0	0
3. Meer kwaliteit door scopevermeerdering	0	0	0	0	0
4. Minder kwaliteit door scopevermeerdering	0	0	0	0	0
Scopevermindering					
5. Minder kosten door scopevermindering	0	0	0	0	0
6. Tijdswinst door scopevermindering	0	0	0	0	0
7. Minder kwaliteit door scopevermindering	0	0	0	0	0



Deze weergave probeert duidelijk te maken dat er verschillende oorzaken ten grondslag liggen aan een scopewijziging en dat deze oorzaken aan elkaar gerelateerd kunnen zijn en elkaar overlappen.
-Economische risico's kunnen bijvoorbeeld als risico zijn geïdentificeerd.
- Veranderende materiaalprijzen kunnen leiden tot nieuwe eisen vanuit de cliënt.

Om de duidelijkheid van de weergave te behouden is het aantal overlappen beperkt, meerdere overlappen zijn mogelijk en verschillen per project.

17. Geef aan **hoe vaak** de volgende oorzaken van een scopewijziging zich voordeden tijdens **initiatieffase**:

	Nooit	Nauwelijks	Soms	Regelmatig	Vaak
Voorziene risico's (=opgenomen in risicoregister)	0	0	0	0	0
Onvoorziene risico's:					
Nieuwe wet- en regelgeving	0	0	0	0	0
Eisen van de cliënt vernaderen	0	0	0	0	0
Invloed van andere projecten	0	0	0	0	0
Nieuw inzicht (bijv. bodemonderzoek)	0	0	0	0	0
Nieuwe beschikbare technieken	0	0	0	0	0
Oplegging door Raad van State	0	0	0	0	0
Onheldere scopeomschrijving	0	0	0	0	0
Nieuwe economische situatie (bijv. prijsveranderingen)	0	0	0	0	0
Onderhandelingen met stakeholders	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0

18. Bepaal de **impact** van de volgende oorzaken van een scopewijziging tijdens **initiatieffase**:

	Niet belangrijk	Beetje belangrijk	Belangrijk	Erg belangrijk	Extreem belangrijk
Voorziene risico's (=opgenomen in risicoregister)	0	0	0	0	0
Onvoorziene risico's:					
Nieuwe wet- en regelgeving	0	0	0	0	0
Eisen van de cliënt vernaderen	0	0	0	0	0
Invloed van andere projecten	0	0	0	0	0
Nieuw inzicht (bijv. bodemonderzoek)	0	0	0	0	0
Nieuwe beschikbare technieken	0	0	0	0	0
Oplegging door Raad van State	0	0	0	0	0
Onheldere scopeomschrijving	0	0	0	0	0
Nieuwe economische situatie (bijv. prijsveranderingen)	0	0	0	0	0
Onderhandelingen met stakeholders	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0

19. Geef aan **hoe vaak** de volgende oorzaken van een scopewijziging zich voordeden tijdens **ontwerpfase**:

	Nooit	Nauwelijks	Soms	Regelmatig	Vaak
Voorziene risico's (=opgenomen in risicoregister)	0	0	0	0	0
Onvoorziene risico's:					
Nieuwe wet- en regelgeving	0	0	0	0	0
Eisen van de cliënt vernaderen	0	0	0	0	0
Invloed van andere projecten	0	0	0	0	0
Nieuw inzicht (bijv. bodemonderzoek)	0	0	0	0	0
Nieuwe beschikbare technieken	0	0	0	0	0
Oplegging door Raad van State	0	0	0	0	0
Onheldere scopeomschrijving	0	0	0	0	0
Nieuwe economische situatie (bijv. prijsveranderingen)	0	0	0	0	0
Onderhandelingen met stakeholders	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0

20. Bepaal de **impact** van de volgende oorzaken van een scopewijziging tijdens **ontwerpfase**:

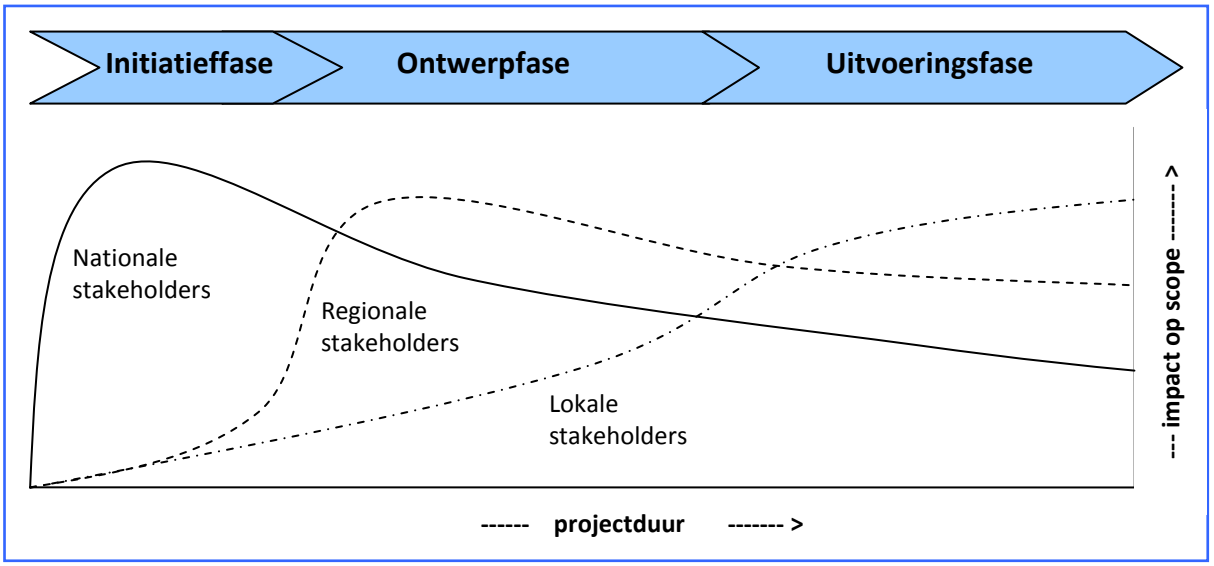
	Niet belangrijk	Beetje belangrijk	Belangrijk	Erg belangrijk	Extreem belangrijk
Voorziene risico's (=opgenomen in risicoregister)	0	0	0	0	0
Onvoorziene risico's:					
Nieuwe wet- en regelgeving	0	0	0	0	0
Eisen van de cliënt vernaderen	0	0	0	0	0
Invloed van andere projecten	0	0	0	0	0
Nieuw inzicht (bijv. bodemonderzoek)	0	0	0	0	0
Nieuwe beschikbare technieken	0	0	0	0	0
Oplegging door Raad van State	0	0	0	0	0
Onheldere scopeomschrijving	0	0	0	0	0
Nieuwe economische situatie (bijv. prijsveranderingen)	0	0	0	0	0
Onderhandelingen met stakeholders	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0

21. Geef aan **hoe vaak** de volgende oorzaken van een scopewijziging zich voordeden tijdens **uitvoeringsfase**:

	Nooit	Nauwelijks	Soms	Regelmatig	Vaak
Voorziene risico's (=opgenomen in risicoregister)	0	0	0	0	0
Onvoorziene risico's:					
Nieuwe wet- en regelgeving	0	0	0	0	0
Eisen van de cliënt vernaderen	0	0	0	0	0
Invloed van andere projecten	0	0	0	0	0
Nieuw inzicht (bijv. bodemonderzoek)	0	0	0	0	0
Nieuwe beschikbare technieken	0	0	0	0	0
Oplegging door Raad van State	0	0	0	0	0
Onheldere scopeomschrijving	0	0	0	0	0
Nieuwe economische situatie (bijv. prijsveranderingen)	0	0	0	0	0
Onderhandelingen met stakeholders	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0

22. Bepaal de **impact** van de volgende oorzaken van een scopewijziging tijdens **uitvoeringsfase**:

	Niet belangrijk	Beetje belangrijk	Belangrijk	Erg belangrijk	Extreem belangrijk
Voorziene risico's (=opgenomen in risicoregister)	0	0	0	0	0
Onvoorziene risico's:					
Nieuwe wet- en regelgeving	0	0	0	0	0
Eisen van de cliënt vernaderen	0	0	0	0	0
Invloed van andere projecten	0	0	0	0	0
Nieuw inzicht (bijv. bodemonderzoek)	0	0	0	0	0
Nieuwe beschikbare technieken	0	0	0	0	0
Oplegging door Raad van State	0	0	0	0	0
Onheldere scopeomschrijving	0	0	0	0	0
Nieuwe economische situatie (bijv. prijsveranderingen)	0	0	0	0	0
Onderhandelingen met stakeholders	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0
Andere namelijk: _____	0	0	0	0	0



In de onderstaande tabel zijn voorbeelden gegeven van de verschillende stakeholders die bij een project betrokken kunnen zijn, waarbij onderscheid is gemaakt tussen bestuurlijke en niet-bestuurlijke stakeholders.

	Nationaal	Regionaal	Lokaal
Bestuurlijk	kabinet, ministeries, tweede kamer	provincie	gemeente
Niet-bestuurlijk	Milieudefensie, FNV, Lobbies	Actiegroepen, milieugroepen	Omwonenden, bedrijven, actiegroepen

23. Bepaal de **impact** van de verschillende stakeholders in de **initiatieffase**

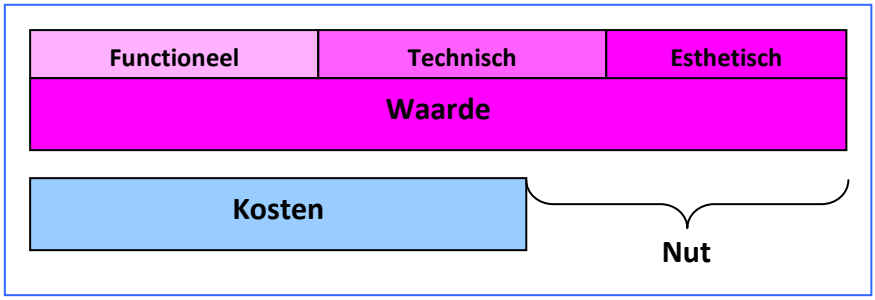
	Zwak	< --------	---------	----- >	Sterk
Bestuurlijke Nationale stakeholders	0	0	0	0	0
Niet-bestuurlijke Nationale stakeholders	0	0	0	0	0
Bestuurlijke Regionale stakeholders	0	0	0	0	0
Niet-bestuurlijke Regionale stakeholders	0	0	0	0	0
Bestuurlijke Lokale stakeholders	0	0	0	0	0
Niet-bestuurlijke Lokale stakeholders	0	0	0	0	0

24. Bepaal de **impact** van de verschillende stakeholders in de **ontwerpfase**

	Zwak	< --------	---------	----- >	Sterk
Bestuurlijke Nationale stakeholders	0	0	0	0	0
Niet-bestuurlijke Nationale stakeholders	0	0	0	0	0
Bestuurlijke Regionale stakeholders	0	0	0	0	0
Niet-bestuurlijke Regionale stakeholders	0	0	0	0	0
Bestuurlijke Lokale stakeholders	0	0	0	0	0
Niet-bestuurlijke Lokale stakeholders	0	0	0	0	0

25. Bepaal de **impact** van de verschillende stakeholders in de **uitvoeringsfase**

	Zwak	< --------	---------	----- >	Sterk
Bestuurlijke Nationale stakeholders	0	0	0	0	0
Niet-bestuurlijke Nationale stakeholders	0	0	0	0	0
Bestuurlijke Regionale stakeholders	0	0	0	0	0
Niet-bestuurlijke Regionale stakeholders	0	0	0	0	0
Bestuurlijke Lokale stakeholders	0	0	0	0	0
Niet-bestuurlijke Lokale stakeholders	0	0	0	0	0



26. Bepaal de **aandacht** voor de effecten van een scopewijziging op de:

	Niet belangrijk	Beetje belangrijk	Belangrijk	Erg belangrijk	Extreem belangrijk
Totale kosten	0	0	0	0	0
Totale planning	0	0	0	0	0
Totale kwaliteit	0	0	0	0	0
Totale waarde	0	0	0	0	0
Totale nut	0	0	0	0	0
Alternatieven voor de wijziging	0	0	0	0	0
Risico's van de wijziging	0	0	0	0	0
Noodzaak van de wijziging	0	0	0	0	0

27. Wie was hoofdverantwoordelijk voor de scopewijzigingsprocedure (plaats kruisje)?

_ projectmanager
_ contractmanager
_ wijzigings-/scopemanager in **lijn**organisatie
_ wijzigings-/scopemanager in **staf**organisatie
_ iemand anders namelijk_____

Efficiëntie van scopewijzigingsprocedure

28. Enkele stellingen over de scopewijzigingsprocedure

Begin uitvoeringsfase/ontwerpfase

	Geheel mee eens	Mee eens	Neutraal	Mee oneens	Geheel mee oneens
Beoordeling van een scopewijziging was goed	0	0	0	0	0
Grote scopewijzingen kregen genoeg aandacht	0	0	0	0	0
Procedure werd strikt gevolgd	0	0	0	0	0
Doorlooptijd wijziging duurde te lang	0	0	0	0	0
Er was genoeg mandaat voor de verantwoordelijke van de procedure	0	0	0	0	0
Er was onduidelijkheid over de proceduregang onder projectleden	0	0	0	0	0
Er was onduidelijkheid over de verantwoordelijkheden van projectleden m.b.t. de wijzigingsprocedure	0	0	0	0	0

Eind uitvoerings/ontwerpfase

	Geheel mee eens	Mee eens	Neutraal	Mee oneens	Geheel mee oneens
Beoordeling van een scopewijziging was goed	0	0	0	0	0
Grote scopewijzingen kregen genoeg aandacht	0	0	0	0	0
Procedure werd strikt gevolgd	0	0	0	0	0
Doorlooptijd wijziging duurde te lang	0	0	0	0	0
Er was genoeg mandaat voor de verantwoordelijke van de procedure	0	0	0	0	0
Er was onduidelijkheid over de proceduregang onder projectleden	0	0	0	0	0
Er was onduidelijkheid over de verantwoordelijkheden van projectleden m.b.t. de wijzigingsprocedure	0	0	0	0	0

Vragen betreffende **effectiviteit**

29. Wat is uw mening betreffende de volgende stellingen over de verkregen scope van het project?

	Geheel mee eens	Mee eens	Neutraal	Mee oneens	Geheel mee oneens
Verkregen scope is de kosten waard	0	0	0	0	0
Verkregen scope is de projectduur waard	0	0	0	0	0
Verkregen scope is de kwaliteit waard	0	0	0	0	0
Verkregen scope is gelijk aan de beoogde scope aan het begin van het project	0	0	0	0	0
Opdrachtgever is tevreden met de verkregen scope	0	0	0	0	0
De verkregen scope sluit aan op de strategie van de opdrachtgever	0	0	0	0	0

30. Heeft u suggesties voor de verbetering van de scopewijzigingsprocedure?

9.10Cases

Noord-Zuidlijn

Status: construction

Budget at start implementation: € 1.460.000.000 (2002)

Most recent budget indication:	€ 3.000.000.000 (2009)
Difference:	€ 1.540.000.000
Delivery date at start implementation:	2011 (2003)
Most recent delivery date:	2017
Difference:	6 years on initial 8 year planning

Betuweroute

Status:	completed
Budget at start implementation:	€ 3.740.000.000 (1995)
Most recent budget indication:	€ 4.663.000.000 (2007)
Difference:	€ 923.000.000
Delivery date at start implementation:	2005 (1995)
Most recent delivery date:	2007
Difference:	2 years on initial 10 year planning

Randstadrail

Status:	completed
Budget at start implementation:	€ 1.800.000.000 (2000)
Most recent budget indication:	€
Difference:	€
Delivery date at start implementation:	2006 (2000)
Most recent delivery date:	2010
Difference:	4 years on initial 4 year planning

Hanzelijn

Status:	construction
Budget at start implementation:	€ 895.000.000 (MIT 2007)
Most recent budget indication:	€ 1.087.000.000
Difference:	€ 192.000.000
Delivery date at start implementation:	2012 (MIT 2007)
Most recent delivery date:	12-12-2012
Difference:	no difference

N201+

Status:	construction
Budget at start implementation:	€ 562.000.000 (Realization Agreement 2005)
Most recent budget indication:	€ 613.000.000 (last quarter 2007)
Difference:	€ 51.000.000
Delivery date at start implementation:	last quarter 2011 (October 2006)
Most recent delivery date:	last quarter 2012
Difference:	1 year on 5 year planning

N470

Status:	completed
Budget at start implementation:	€ 104.000.000
Most recent budget indication:	€ 180.000.000
Delivery date:	April 2008
Difference:	

9.11Questionnaire Results

9.11.1 Description of scope documents

	Initiative phase	Design phase	Execution phase
Sample size	39	38	38
Average value	1,44	3,05	4,50
Standard deviation	0,77	0,92	0,95
Reliability	0,24	0,29	0,30
95% Interval	1,20 – 1,68	2,76 – 3,34	4,20 – 4,80

9.11.2 Scope change scenario's per phase

Initiative phase	>cost	>time	>quality	<quality	<cost	<time
sample size	4	4	4	4	4	4
average value	4,25	3,25	3,00	2,25	2,25	2,00
standard deviation	0,50	0,96	0,82	1,26	0,50	0,82
Reliability	0,49	0,94	0,80	1,23	0,49	0,80
upper boundary	4,74	4,19	3,80	3,48	2,74	2,80
lower boundary	3,76	2,31	2,20	1,02	1,76	1,20

Design phase	>cost	>time	>quality	<quality	<cost	<time
sample size	12	12	12	12	12	12
average value	3,33	2,50	2,67	2,00	2,17	1,67
standard deviation	0,98	0,80	0,89	0,60	0,94	0,65
Reliability	0,56	0,45	0,50	0,34	0,53	0,37
upper boundary	3,89	2,95	3,17	2,34	2,70	2,04
lower boundary	2,78	2,05	2,16	1,66	1,64	1,30

Execution phase	>cost	>time	>quality	<quality	<cost	<time
sample size	25	25	25	25	25	25
average value	3,04	2,80	2,40	2,00	1,80	1,48
standard deviation	1,21	1,04	0,91	0,82	0,58	0,51
Reliabillity	0,47	0,41	0,36	0,32	0,23	0,20
upper boundary	3,51	3,21	2,76	2,32	2,03	1,68
lower boundary	2,57	2,39	2,04	1,68	1,57	1,28

9.11.3 Frequency and impact of the causes of scope changes

Frequency	risk foreseen	risk unforeseen								
Execution phase		New laws	client	Other projects	New insights	New techniques	State Council	Unclear scope	economy	negotiation
sample size	25	25	25	25	25	25	25	25	25	25
average value	3,10	2,52	2,86	2,71	2,52	1,90	1,62	3,10	2,19	2,81
standard deviation	1,21	1,04	0,91	0,82	0,58	0,51	0,76	0,89	0,81	0,85
Reliability	0,47	0,41	0,36	0,32	0,23	0,20	0,30	0,35	0,32	0,33
upper boundary	3,57	2,93	3,21	3,03	2,75	2,10	1,92	3,44	2,51	3,14
lower boundary	2,62	2,12	2,50	2,39	2,30	1,70	1,32	2,75	1,87	2,47

Frequency	risk foreseen	risk unforeseen								
Design phase		New law	client	Other projects	New insights	New techniques	State Council	Unclear scope	economy	negotiation
sample size	12	12	12	12	12	12	12	12	12	12

average value	3,33	2,50	2,67	2,00	2,17	1,67	1,75	3,30	2,50	3,60
standard deviation	0,98	0,80	0,89	0,60	0,94	0,65	0,87	0,82	0,71	0,79
Reliabillity	0,56	0,45	0,50	0,34	0,53	0,37	0,49	0,47	0,40	0,44
upper boundary	3,89	2,95	3,17	2,34	2,70	2,04	2,24	3,77	2,90	4,04
lower boundary	2,78	2,05	2,16	1,66	1,64	1,30	1,26	2,83	2,10	3,16

Impact	risk foreseen	risk unforeseen								
Execution phase		new laws	client	other projects	new insights	new techniques	State Council	unclear scope	economy	negotiation
sample size	21	21	21	21	21	21	21	21	21	21
average value	2,81	2,57	3,10	2,67	2,38	1,76	2,05	3,10	2,29	2,67
standard deviation	0,93	1,03	1,09	1,06	1,07	0,70	1,12	1,00	1,01	1,11
Reliability	0,40	0,44	0,47	0,46	0,46	0,30	0,48	0,43	0,43	0,47
upper boundary	3,21	3,01	3,56	3,12	2,84	2,06	2,53	3,52	2,72	3,14
lower boundary	2,41	2,13	2,63	2,21	1,92	1,46	1,57	2,67	1,85	2,19

Impact	risk foreseen	risk unforeseen								
Design phase		new laws	client	other projects	new insights	new techniques	State Council	unclear scope	economy	negotiation
sample size	10	10	10	10	10	10	10	10	10	10
average value	2,30	2,50	3,50	3,50	2,50	2,10	2,20	3,10	2,60	3,40
standard deviation	0,64	0,65	0,75	0,75	1,19	0,94	1,34	1,08	0,92	1,14
Reliability	0,40	0,40	0,47	0,47	0,74	0,59	0,83	0,67	0,57	0,70
upper boundary	2,70	2,90	3,97	3,97	3,24	2,69	3,03	3,77	3,17	4,10
lower boundary	1,90	2,10	3,03	3,03	1,76	1,51	1,37	2,43	2,03	2,70

9.11.4 Impact of stakeholders on project scope

Design phase	National governmental	National non-governmental	Regional governmental	Regional non-governmental	Local governmental	Local non-governmental
sample size	10	10	10	10	10	10
average value	3,00	2,30	3,80	2,60	4,20	3,10
standard deviation	1,49	1,38	1,21	1,43	1,17	1,54
Reliability	0,92	0,85	0,75	0,89	0,72	0,95
upper boundary	3,92	3,15	4,55	3,49	4,92	4,05
lower boundary	2,08	1,45	3,05	1,71	3,48	2,15

Execution phase	National governmental	National non-governmental	Regional governmental	Regional non-governmental	Local governmental	Local non-governmental
sample size	21	21	21	21	21	21
average value	2,57	2,05	2,95	2,29	3,33	2,62
standard deviation	1,49	1,14	1,21	1,10	1,00	0,97
Reliability	0,64	0,49	0,52	0,47	0,43	0,41
upper boundary	3,21	2,53	3,47	2,75	3,76	3,03
lower boundary	1,93	1,56	2,44	1,82	2,91	2,21

9.11.5 Attention to scope change effects

	total cost	total planning	total quality	total value	utility	alternatives	risks	need
sample size	32	32	32	32	32	32	32	29
average value	3,84	4,16	3,28	3,41	3,56	3,28	3,63	4,07

standard deviation	0,70	0,79	0,62	0,73	0,73	0,62	1,02	0,70
Reliability	0,24	0,27	0,22	0,25	0,25	0,22	0,35	0,26
upper boundary	4,09	4,43	3,50	3,66	3,82	3,50	3,98	4,32
lower boundary	3,60	3,88	3,07	3,15	3,31	3,07	3,27	3,81

9.11.6 Opinion on scope change procedure

Begin of phase	goodness	strictness	attention	runtime	mandate	clearness procedure	clearness responsibilities
sample size	28	28	28	28	28	28	28
average value	3,55	2,94	3,55	3,55	3,39	3,03	2,71
standard deviation	0,78	0,97	0,89	1,11	1,10	1,06	1,01
Reliability	0,29	0,36	0,33	0,41	0,41	0,39	0,37
upper boundary	3,84	3,29	3,88	3,96	3,80	3,43	3,09
lower boundary	3,26	2,58	3,22	3,14	2,98	2,64	2,34

end of phase	goodness	strictness	attention	runtime	mandate	clearness procedure	clearness responsibilities
sample size	28	28	28	28	28	28	28
average value	3,41	3,37	3,52	3,04	3,78	2,67	2,85
standard deviation	0,98	1,00	1,10	1,02	0,91	1,14	1,14
Reliability	0,36	0,37	0,41	0,38	0,34	0,42	0,42
upper boundary	3,77	3,74	3,93	3,41	4,12	3,09	3,28
lower boundary	3,05	3,00	3,11	2,66	3,44	2,25	2,43

9.11.7 Opinion on produced scope

	cost	time	quality	wanted scope	client happines	client strategy
sample size	27	27	27	27	27	27
average value	3,52	3,37	3,04	3,11	3,74	3,63
standard deviation	0,99	1,11	0,90	1,15	1,07	0,96
Reliability	0,37	0,42	0,34	0,44	0,40	0,36
upper boundary	3,89	3,79	3,38	3,55	4,14	3,99
lower boundary	3,14	2,95	2,70	2,68	3,34	3,27