Playing with Complexity

Management and organisation of large infrastructure projects

Spelen met complexiteit

Management en organisatie van grote infrastructurele projecten

Proefschrift

Ter verkrijging van de graad van doctor aan de
Erasmus Universiteit Rotterdam
Op gezag van de
Rector magnificus

Prof.dr. H.G. Schmidt

En volgens besluit van het college voor promoties
De openbare verdediging zal plaatsvinden op

07-01-2010 om 11.30 uur
door

Marcel Jacques Christiaan Maria Hertogh geboren te Den Haag
Edward Westerveld geboren te Leeuwarden

Promotiecommissie

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ERASMUS UNIVERSITEIT ROTTERDAM

Playing with Complexity

MANAGEMENT AND ORGANISATION OF LARGE INFRASTRUCTURE PROJECTS

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FINAL LINGUISTIC EDITING BY CHARLES VICARY, COLCHESTER, UK
PRINTED IN THE NETHERLANDS BY THIEME AMSTERDAM BV

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Preface

Megaprojects are meant to fulfil big ambitions – and some turn out to be more successful than others. Some projects are showcases of best practices where others had too many 'lessons learnt' that could have been applied. Since our studies at university were completed, we had the privilege of working on large infrastructure projects. We have variously worked as members of contractors' project teams; of the client as well as of the project delivery organisation, and as external advisors. And, within the projects themselves, we had the luck to work with inspiring project managers, specialists and scientists in our road towards finding ways of achieving project success. A director of a steel company once said: 'you should not have more than one major challenge in your major project'. But in the projects we have worked in, we have observed many of these brain twisters arriving together, and we knew for sure that new ones would come up in future. How to manage these projects, Mr Director? This single question was a stimulus to us both.

Eddy's interest arose more from the scientific side. He asked himself: when is a project successful? When you stay within your budget limits, deliver in time and according to the formulated requirements? Or, should it be - if stakeholders are satisfied? If so, when are they satisfied? And, when in time do you judge this project success? The number of users of the Oresund link between Denmark and Sweden was disappointing during the first year of operation and a negative study was published concerning the success of the project. But after ten years this image has changed completely and the Oresund functions efficiently and effectively, and moreover it has had a positive influence on the economic growth of the regions of Copenhagen and Malmö that the link connects. And what were the factors leading to success, Eddy asked himself. He developed the 'Project Excellence Model', a model to study the success of strategies in managing complexity, by focusing on the factors that are of key importance in achieving project success. He started developing this model during his Master's Thesis, for which Marcel was one of his mentors – at the same time coming into contact with IPMA, the International Project Management Association where he started to give lectures and seminars. The involvement in international discussions and his continuous hunger to review project management literature, gave a boost to both his knowledge, and his network. He started a PhD around 2003 to study project success and project management in large infrastructure projects

Marcel's interest, on the other hand, arose from the many projects he worked on since the end of the '80's: a tunnel, a storm surge barrier, drinking water plants and other big environmental projects. At the Betuweroute project he was asked to set up

the project delivery organisation. As head of the Quality Control and Organisation section from 1995 to 1999, he fundamentally thought about how to organise the Betuweroute after a period of massive turmoil and national dissatisfaction about the project's performance. At the Betuweroute a triple focus was developed: an open approach towards stakeholders, excellent internal project and contract management, and many elements drawn from organisation of permanent organisations (e.g. annual planning and control cycle and HRM). In the meantime, in 1997 Marcel's first book was published about the different interests involved in large projects and he wrote his first insights about interactive management. Around 2002 he thought of starting a PhD to study the Betuweroute's project delivery organisation. Subsequently, he became in touch with other big Dutch projects and the Swiss tunnel projects which enabled the number of projects involved in studies to increase to three in The Netherlands and two in Switzerland. Later on, as a result of the NETLIPSE program, a sixth case was added (West Coast Mainline).

We both discussed our PhD's a lot since they tended to overlap more and more. Eddy was interested in using Marcel's cases and Marcel was interested in using the theory Eddy had accumulated. Finally we decided to combine our theses on the management of complexity. First we continued with our own chapters: Eddy from a project management and project success side, Marcel from the complexity and interactive management side. More and more we realised that the remarks we gave on the other's chapters enriched our work, and more and more we started to adapt the other's sections. As we changed the table of contents, in which chapters were combined were split up and combined, more and more joint written sections emerged. This was definitely of benefit to the overall PhD and we think this is a real advantage of doing a PhD together, from combining views and contributions. Another advantage of the joint PhD was that we could manage to study a much larger number of events thereby enabling us to draw conclusions more convincingly. Our thesis is not to judge whether a phenomenon emerged in one or two events or cases. We wanted to drawn lines across several events to find suitable ways to improve the management of the implementation process of large infrastructure projects in the European arena.

Originally, as a 'spin-off', we tried to interest the European Commission in our continuous search for project excellence in large projects. They advised us to tender to the 6th Framework Programme of December 2004. We were successful in delivering a successful proposal! The ideas developed in our thesis proved to be an excellent basis to get attention from the Commission and to set-up a successful proposal and consortium. We started the NETLIPSE project in May 2006 with 8 partners in Europe, and in May 2008 we, along with two colleagues, published the book 'Managing large infrastructure projects'. NETLIPSE and the PhD had some overlap and not only at the content level. A main overlap was the use of collective resources which meant that, although the study was facilitated – because of NETLIPSE we could barely find enough time for our PhD! Since 2008 we have been continuing NETLIPSE, starting a next phase – thanks to the European Commission. We now hope that our international network will benefit from this thesis.

The period we have worked on the PhD has been a dynamic and pleasant period in our lives. We both had children born, we moved house, we were involved in the buy out of AT Osborne, we had a full time job with interesting projects, and finally, after thousands of kilometres of cycling and running, oh yes, we had to finish our PhD. 'Playing with Complexity!'

We hope the thesis will inspire you and that you will enjoy reading it.

December 2009,

Marcel Hertogh & Eddy Westerveld

1 INTRODUCTION TO THE INTRIGUING WORLD OF COST OVERRUNS AND DELAY

The world of Large Infrastructure Projects, or 'LIPs' as we will call them, is an intriguing one. In this chapter we will indicate what main challenges are currently faced by the sponsor, project managers and others trying to implement LIPs in practice. To do so, we first elaborate on the difficult task facing a project director in a LIP (section 1.1).

We will start with a real life story from a project director. This story demonstrates some of the issues we, as active practitioners in the field, have come across the past years working on LIPs in the European arena. We will use many of the experiences of these undertakings in this thesis.

After the real life story of the project director we illustrate the huge ambitions (1.2), originating from the European and National political arena, that LIPs try to fulfil. Realisation of all these ambitions is falling short, as recent research shows us (1.3). On the other hand, LIPs are confronted with rising expectations and demands (1.4). In order to fulfil these demands and meet the stated ambitions, the management of LIPs will need to be improved. This challenge is further outlined in section 1.5. Understanding the characteristics of this challenge and helping project managers to deal with this challenge are the main objectives of this thesis.

In section 1.6 we present the research approach applied in this thesis. Dealing with complexity seems to be the key phrase, or sensitising concept, in the management of LIPs. So the main research questions of this thesis are (section 1.6):

> *How does the implementation process of large infrastructure projects in Europe evolve, how are the characteristics of complexity visible in implementation of large infrastructure projects, how is this process managed and what are suitable ways to improve the management of the implementation process?*

How we try to answer this question, is referred to in chapter 2 "Methodology". The first step, addressed in this chapter, is identifying the current problems, ambitions and challenges within LIPs today. This chapter 1 closes out with a short reading guideline in which the build up of this thesis is explained.

1.1 A REAL LIFE STORY OF A PROJECT DIRECTOR

> *"At certain moments in a project you are active on too many levels. The alignments of the track, negotiations with stakeholders, you have to battle on several fronts. At the same time you have to manage your internal project organisation, guarding the quality of your activities. At that point everything is mixed with each other."*
> Project manager, Betuweroute.

Peter Dijk was hired as the project director for the Betuweroute at the end of 2007. At the end of 2008 he was appointed the project director of the Noord/Zuidlijn, the new underground connection from North to South in Amsterdam. He is our colleague at AT Osborne and his experiences perfectly illustrate what issues project managers currently have to deal with in LIPs. This is why we start this thesis with a real life experience, based on his work at the Betuweroute, one of our studied cases.

Peter Dijk is driving in his Renault Espace along the A15 highway beside the Betuweroute, the new built rail freight line from Rotterdam to the German border. It is October 2007. The Betuweroute has been delivered on June 16 2007 and since then he has been the director of the project organisation of ProRail[1]. Although the Betuweroute is in operation, there are still many unfinished issues to be resolved. Just two weeks ago the Minister of Transport, Public Works and Water Management approved the scope changes and funded extra budget provision for ERTMS level 1 on the Rotterdam part of the track (Port Railway Line – 'Havenspoorlijn'), for switching on the 25 kV power supply and for the opening of the 'Kortsluitroute', a short cut of 4 kilometres at the south part of Rotterdam. At the same time the parliamentary committee also concluded that the number of trains on the Betuweroute was still disappointing, something which is not Peter's responsibility but will certainly cause some negative media attention.

Peter Dijk is in charge, as project director, of a project delivery organisation containing 150 people, not counting the large number of hired engineering consultants. This morning, he had just visited the mayor of the city of Barendrecht, who represents the local councils along the Betuweroute on issues concerning safety. At Barendrecht nine railway tracks run through the heart of the city, two of which belong to the Betuweroute. To minimise the inconvenience for local residents, all nine tracks have been put in tunnel using a special construction that hides the tracks from sight and blocks the noise. The roof is a massive concrete structure, which the project delivery organisation of the Betuweroute has constructed. During the meeting, Peter discusses the three year-old issue of safety on the station platforms, in case a train catches fire.

Whilst driving towards his new appointment, Peter is thinking about a talk he had yesterday with one of his contract managers about a big claim from the tunnel technical installation contractor and how to solve this issue.

Suddenly his counterpart of the Ministry of Transport phones him about the so called 'handheld terminal', a facility for closing part of the track for maintenance purposes. This handheld terminal causes intense debate between ProRail and the inspection department of the Ministry of Transport. Peter also discusses with him the fact that only diesel trains can still run on the line and that the 'switch on' of electricity planned for this month, has been delayed because firemen are insufficiently trained in case of accidents. Those at the Ministry are not amused about this delay and demand immediate action.

Peter Dijk now reaches his destination in the city of Sliedrecht for an informal meeting with the mayor, some aldermen and councillors in … a container! In this container a three dimensional movie is shown of the construction of the Betuweroute. Over the past months, the container has visited cities along the line so that inhabitants can see the movie. It was a farewell present from the project organisation and it turned out to be a big success.

It is already late when he drives home. Tomorrow he will have two progress meetings with some of his managers at the project delivery organisation office in Utrecht. One of his other concerns is that key members of his organisation will leave his project before the tasks are fully completed.

The real life experience of Peter Dijk, shows us the challenging – and as we will show later – complex – issues he is facing even when the project appears to be complete. It is an example what difficulties occur when trying to realise the large ambitions formulated for LIPs.

[1] ProRail is the organisation that is in general responsible for construction and maintenance of the rail infrastructure, as well as capacity management and traffic control. For the Betuweroute however Keyrail will be responsible for maintenance, capacity management and traffic control.

1.2 HUGE AMBITIONS

> *"Freedom of movement for people and goods depends not just on the opening of transport markets but also on physical infrastructures. By promoting the construction of infrastructures that cross borders and connect national networks, the Trans-European transport network accelerates the establishment of the internal market, links peripheral regions to the heart of the European Union and opens Europe to neighbouring countries."*
> Mrs. Loyola de Palacio (European Commissioner and Commissioner for Energy and Transport), [European Commission, 2002]

Transport networks are needed to enable modern economies to create wealth and employment. But the current infrastructure networks are not considered to be sufficient. The EC expects the growth in traffic between the member states of the European Union to double in 2020 [European Commission, 2005]. To meet the rising and changing demands, in Europe an ambitious programme of transport networks has been set up (figure 1.1).

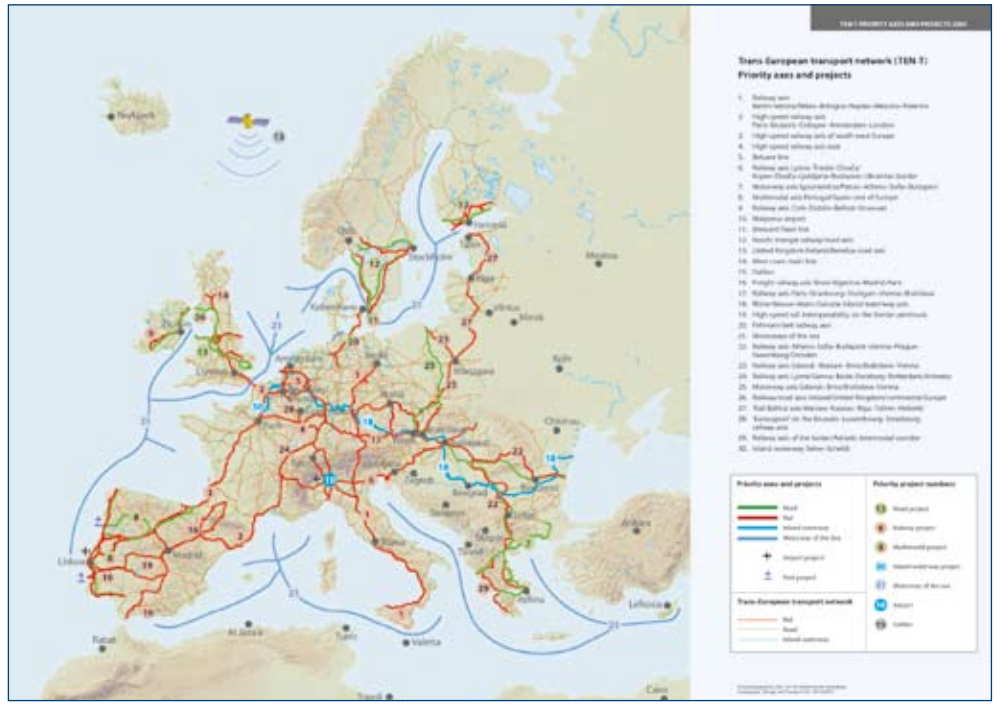


Figure 1.1: Trans-European transport network (TEN-T), priority axes and projects [European Commission, 2005]

The European Commission has initiated the Trans-European Transport Network (TEN-T), for which in 1994 in Essen for the first time the European Council identified "priorities with a real value to Europe as a whole" [European Commission, 2002]. The result was a concentration of effort on a first series of 14 priority projects. Many of these 'projects' were axes. For example, the first mentioned TEN-T project in the list was the 'High-speed train/ combined transport north-south': an axis from Berlin to Verona of 958 kilometres. In 2001 the European Commission proposed to extend the priority project from Verona all the way to Naples, which enlarged the project by another 828 kilometres and raised the total investment cost from € 17,8 billion by an extra € 15,9 billion [European Commission, 2002]. This axis crosses Germany, Austria and Italy. These are huge investments, but these ambitions were again upgraded. Mainly because of the extension of the European Union from 15 to 25 countries, the 14 priority projects in 1994, became 30 priority axes and projects in 2005, see the map in figure 1.1. It is important to note that in general the new member states have a less developed transport network so they require many new investments.

Mr Barrot, Vice President of the European Commission, with responsibility for Transport, wrote in 2005 [European Commission, 2005].

> *"In view of growth in traffic between Member States the investment required to complete and modernise a true trans-European network in the enlarged EU amounts to some € 600 billion."*

In 2005 the total remaining investment required to complete the 30 priority projects and axes in 2020 was estimated to be € 252 billion. If all the other projects of so-called common interest are included that are not on the priority list, the total cost of completing and modernising TEN-T exceeds € 600 billion. The European Commission funds up to 50% for preparatory studies and funds up to 20% of the total construction costs 'in exceptional cases' [European Commission, 2005].

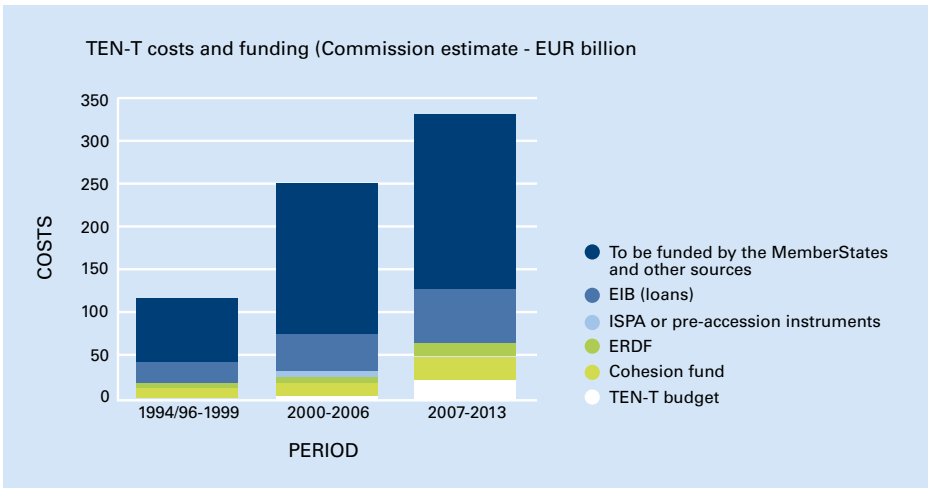


Figure 1.2: TEN-T costs and funding (Commission estimate – EUR billion) [European Commission, 2005]

Apart from the ambitions of the European Commission and its members states, other big programmes of large infrastructure projects are planned. Think of Switzerland, with the two eye-catching Gotthard and Lötschberg tunnels, together with a general programme to invest in rail (Bahn 2000) and road. The United Nations initiated the Trans-European Motorway (TEM) and Trans-European Railway (TER) for Central, Eastern and South east European countries: almost all countries east of Germany and Switzerland are involved: from Italy to Georgia, from Turkey to Lithuania, Belarus and Russia[2]. In total almost 500 projects (319 TEM and 172 TER) are part of the Master plan with an aggregate estimated cost of € 102 billion [United Nations, Economic Commission for Europe, 2006]. The goal of the United Nations Economic Commission for Europe, is to assist its member countries to elaborate and develop a realistic investment plan. In the map of figure 1.3 the TEM Master Plan Backbone Network is presented.

Figure 1.3. TEM Master Plan Backbone Network [United Nations, Economic Commission for Europe, 2006]

[2] Austria, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Georgia, Greece, Hungary, Italy, Lithuania, Poland, Moldova, Romania, Russian Federation, Serbia and Montenegro, Slovakia, Slovenia, The former Yugoslav Republic of Macedonia, Turkey and Ukraine.

The presented investment schemes illustrate that the ambition to implement LIPs is huge. Mobility is booming, both for business and for recreation. Mobility demands are expected to increase even more over the forthcoming decades. To meet these mobility demands, the current transport network is regarded as insufficient, which means that a lot of work remains to be done. But are we meeting these demands? What is our performance in LIPs up to date? In the next section we outline that the performance of LIPs is certainly not as spectacular as the formulated ambitions.

1.3 BIG PROBLEMS

As the EC ambition to implement an axis from Berlin to Naples demonstrates, large infrastructure projects often require investments of billions of Euros. The implementation of LIPs is an enormous task. This becomes visible when we look at activities necessary to design the new infrastructure facility and to construct it. Often for construction, participants rely on different kinds of new technology, which cause challenges. Also stakeholder networks active within LIPs cause challenges. Often with lengths of hundreds of kilometres, these projects have a big impact on the landscape, environment and generally on the numerous stakeholders that are involved. In this section we concentrate on the question: "what is the performance in realising large infrastructure projects?" As will be seen this performance is disappointing in the following areas:

1 Time
2 Budget and benefits
3 Stakeholder satisfaction

1 Time

We saw that in 1994 the European Commission initiated 14 priority projects. What were the results after ten years of priority projects? Mr. Jacques Barrot, reflected on the progress made so far in 2005 [European Commission, 2005]:

> *"After 10 years, however, it is clear that the results fall short of the overall ambitions. In 2003, barely one third of the network had been built. And only 3 of the 14 specific projects endorsed by the European Council at Essen in 1994 has been completed".*

Already in 2001, in the White Paper 'Time to Decide' [European Commission, 2001] the European Commission referred to the saturation of some major routes due in part to delays in completing trans-European network infrastructure:

> *"Only a fifth of the infrastructure projects in the Community guidelines adopted by the Council and Parliament have so far been carried out."*

Time delay is not only an issue in the European arena. Ten Heuvelhof (Van Twist et. al., 2003) investigated time delays on the specific case of the provincial road N201, nearby Schiphol and the main access road to the world's biggest flower auction Aalsmeer. The N201 has a history of about 50 years and is (for some: finally) under construction in 2008. Ten Heuvelhof reflected in an essay about the development of this project. He mentioned not only the disadvantages of delay, but also stressed some of the advantages that can arise from delay, because "time has defended us from taking decisions too quickly". However, he emphasized the need to speed up the decision making processes. His proposal is not to look for an answer in legislation, but in the need to improve the quality of the decision making process and the use of interactive management strategies[3].

Another example was found in the Province of Zuid-Holland in The Netherlands, which investigated the question: Why does the development of infrastructure projects take so much time? The 'Onderzoekscommissie Stagnatie Infrastructurele Projecten' [The Research Commission Stagnation Infrastructure Projects] of the province presented its report in 2005. The commission concluded that in many cases delays could be observed. Large delays were for example visible in the first stages of decision making of the project. Two important causes for the delay which were mentioned: the lack of political commitment by the province and its partners, as well as the lack of interactive management [Provincie Zuid-Holland, 2005]. A central quote from this report:

> *"Do not only put forward demands, do not only Judge, do not only criticise the missed objectives. But shape the role to determine the playing field and the role to control progress more realistically in such a way that it is based on knowledge and insight".*

2 Budget and benefits

Projects are not only failing in terms of time performance. The Danish professor Bent Flyvbjerg has studied 258 transportation infrastructure projects worth US$ 90 billion (Flyvbjerg et. al., 2002, 2003, 2005, 2007). From his database he studied the reliability of cost estimations and found that:

- Cost overruns of 50 to 100% in real terms are common in mega projects, overruns above 100% are not uncommon.
- Inaccuracy in cost forecasts is on average 45% for rail, 34% for bridges and tunnels 20% for roads.
- Cost underestimation cannot be explained by error and seems to be best explained by strategic misrepresentation, i.e., lying.
- For the 70-period time-span for which cost data were used, accuracy in cost forecasts has not improved.
- Transportation infrastructure do not appear to be more prone to cost underestimation than are other types of large projects.

[3] He calls this 'proces management' (in Dutch).

Type of project	Number of cases	Average cost overrun (%)	Standard deviation
Rail	58	44,7	38,4
Bridges and Tunnels	33	33,8	62,4
Road	167	20,4	29,9

Table 1.1: Inaccuracy of transportation cost estimates by type of project (Flyvbjerg, 2007)

It should be noted that because of the large budgets a cost overrun of about 20% of a € 3 billion project, is € 600 million. This means that in absolute terms the cost overrun can have a big effect since it may heavily limit the possibilities the realisation of other formulated political ambitions.

Flyvbjerg and his co-authors concluded that "the cost estimations used in public debates, media coverage, and decision making for transportation infrastructure development are highly, systematically, and significantly deceptive. So are the cost-benefit analyses into which cost estimations ate routinely fed to calculate the viability and ranking of projects." Flyvbjerg advises "not to trust the cost estimations presented by infrastructure promoters and forecasters" (Flyvbjerg et. al., 2002).

3 Stakeholder satisfaction

Apart from the disappointing performance in terms of money and time, we notice general dissatisfaction of involved stakeholders with the development and realisation of large infrastructure projects (Teisman 1992 and WRR 1994, more recently Hertogh et. al., 2008).

Cost overruns of two big projects were the immediate cause in The Netherlands for the parliamentary enquiry executed by the Temporary Committee for Infrastructure (TCI). The TCI was installed in 2004 and carried out a thorough investigation on the decision making process of infrastructure projects in The Netherlands. The two main investigated projects were the Betuweroute and the High Speed Line South, two projects that also are part of the TEN-T priority axes and projects. These project are also used as case projects in this thesis (see section 3.2 and 3.3). The focus of the TCI was on the role of parliament in the decision making process and on project control during the execution phase. One of the conclusions the TCI reported was that the development of new infrastructure projects is greatly hampered by inadequate policy-making as well as the management of the projects [TCI, 2004].

As the final report of the TCI illustrates, LIPs generally fail to meet the demands of society not only regarding the delays and overruns, but in other areas involved stakeholders are often not satisfied with the final results of a project in terms of the added value (benefits) and how the protection of 'negative interests' was dealt with. LIPs often seem to be 'out of fit' causing a democratic deficit (Nijssen, 2006). This democratic deficit means that government, and the other involved stakeholders, are not able to sufficiently align the project outcomes with the stakeholders interests. In chapter 7 and 8 we address the issue of stakeholder (dis)satisfaction in more detail.

To resume, the implementation of LIPs does not have a track record to be proud of. We experience time delays, cost overruns and a general difficulty in meeting the demands of stakeholders. How is this caused? Developments that might explain this are the enormous complexity and rising stakeholders demands. We will argue that these rising demands and complexity heavily hamper the successful completion of LIPs.

1.4 RISING DEMANDS

In the last decade we have seen a further increase in environmental requirements that are important for the execution of LIPs, both national and international. This has become visible in the legislation resulting from the Kyoto-protocol and the EU. Examples are habitat legislation, fauna legislation, rules for compensation, rules for air quality and the Malta-treaty concerning archaeology. These regulations are an expression of a general concern about the environment, but make the development of infrastructure more difficult and complex. The challenge for project managers and decision makers of infrastructure projects is to meet these tightened environmental requirements as formulated in a continuous stream of new rules and laws. Some project managers might even question if it is still possible to meet all these requirements.

Stakeholders involved in LIPs are more and more able to guard and speak out about their interest relating to projects (Hertogh, 1997). Nowadays, they have the knowledge, means, time and endurance to stand up for their own rights and interests. They can try to influence by themselves, but many align themselves with non governmental organisations, 'fighting' for people and planet. Some organisations are formed with the goal of influencing the decision making concerning a specific LIP. The way these NGO's work has also been evolving over the years. A representative of a local environmental interest group spelt this out when he mentioned that:

> *" … environmental interest groups have been developing from opposition to co-operation, from demanding to negotiating, from reactive to proactive."*

The development in working methods originates from the belief that stakeholders can act at the same level of competence as the project delivery organisations that are employed to execute LIPs. Whereas in the past one organisation – i.c. government – was dominant and was able to implement a project according to the

initial plan, the current situation is characterised by numerous stakeholders that all have some kind of influence, but none with decisive power. In short:

'No one is in charge.'

In The Netherlands a striking example is the planning of the Betuweroute in the first half of the 90's. The Dutch Railways (NS) initiated the railway and didn't focus sufficiently on the interest of local governments and people along the line and the co-operating pressure groups. NS underestimated their power, as you are able to read in section 3.2.

A general trend in society is that the acceptance of failures has diminished. Only risks that you chose to take yourself seem to acceptable, all other risks have to been taken away by the government. Tolerance of failure is diminishing, and this also influences the attitude towards new infrastructure projects.

The tightening of legislation; the big influence of all kinds of stakeholders with the need to co-operate; and the diminishing acceptance of flaws, all result in a severe challenge for the project delivery organisation trying to realise a large infrastructure project, but also to the other stakeholders involved. What was 'good' ten or twenty years ago, is not good anymore.

'Good is not good enough.'

The demands and expectations for LIPs have been rapidly rising during the last two decades. Ambitions are high and the performance is disappointing. It is now time to address that challenge we are facing in the next section.

1.5 ENORMOUS CHALLENGE

We saw that LIPs experience cost overruns, delays and are generally failing to meet demands of stakeholders. And we saw that the internal and external requirements have been and are expected to continue rising. Notwithstanding this the current European programme for LIPs is the most ambitious ever! The European Commission has referred to deploying LIPs more effectively [e.g. European Commission, 2001, 2005] and wants to speed up project implementation by taking action. Yet the EC and the member states have limited possibilities for forecasting and monitoring the effectiveness of these projects: it is unclear which elements in management and organisation influence the success of infrastructure projects. In addition the scale and complexity place great demands on the organisation and management of these projects. The European Commission and member states will face huge challenges to fulfil the ambitions of the priority axes and projects, and other large infrastructure projects in Europe.

Is management and administration able to cope with the challenges? Or is it "Mission Impossible"? We are convinced that it is possible, as long as the management and administration improves correspondingly (figure 1.4). However, we recognise an important discrepancy between the complexity of infrastructure development and the capability of project management to complete the task". We note that this discrepancy is still growing, due to the rise of internal and external requirements previously referred to. The European countries and the EC seem to be imprisoned in a situation between meeting mobility needs on the one hand and social requirements on the other. We think that these developments will not disappear, and on the contrary will probably increase in the future. We don't expect that the needs and requirements will be lowered. The only way to address this apparent impasse is to increase the level of competence of policymakers and managers (Hertogh et. al., 2005).

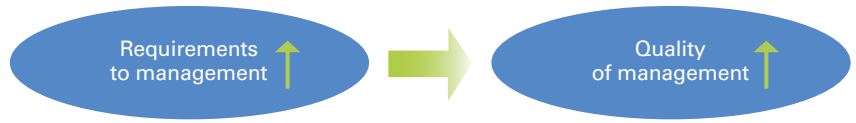


Figure 1.4: Requirements on management

To meet the rising and changing demands the project manager and other stakeholders need to improve their performance. How this can be done is the subject of this thesis.

1.6 CENTRAL RESEARCH QUESTION

The current knowledge exchange in the field of the management and organisation of large infrastructure projects has a national character, and is concentrated on a few domestic projects. Due to their scale and complexity, LIPS are often unique on a national level. In addition, currently international development and exchange of knowledge of the organisation and management of these projects is scarce (Hertogh et. al., 2008). Already in 1996 De Bruijn mentioned that for large projects only a few lessons learned are available from former projects and there is a lack of reference material for performance measurement from other projects (De Bruijn et. al., 1996). The TCI mentioned that domestic and foreign experiences should be better used (TCI, 2004). With this study we want to meet the growing desire for more knowledge from and international comparison between projects.

There are various possible approaches to investigating the challenges that LIPs are currently facing. Our first thought would be just to investigate 'general management practise' in this field. This is rather obvious since our main goal was to contribute to the improvement of the management of these large projects. At that point however it was already clear that this perspective was not specific enough to provide us with a clear focus

during our research. On the other hand the broad approach allowed us to have an open view to approach our cases.
The broad, or to speak in terms of methodology 'grounded', approach meant that the first step in our study was to identify the key theme, or sensitising concept, in the management of LIPs. After reading the literature, various interviews, studying documentation and a reflection of our own experience this key theme turned out to be 'complexity'. This term seems to play a more and more important role in both literature and practice as we will show in section 3.6 and chapters 4 and 5. The term 'complexity' is a concept that is recognisable and of importance for practitioners in the working field of LIPs.

The previous sections have already touched on some important aspects related to complexity. We showed the real life difficulties of a project manager in dealing with complexity. We addressed one cause of complexity: the huge ambitions formulated for LIPs in the political arena. At the present time we are, in many cases, unable to fulfil these ambitions in many project implementation processes. Current management of LIPs seems to be unable to deal adequately with the increased complexity resulting from both external (stakeholder) and internal (technology, rules and legislation) demands (section 1.5).

The management of LIPs is a professional fascination of both of us. In our daily work as managers and consultants we ask ourselves how to improve the management of large infrastructure projects. This goal was the starting point and is the target of this research.

After our first investigation and based on the analysis of this chapter, we formulated to following main research questions:

> *How does the implementation process of large infrastructure projects in Europe evolve, how are the characteristics of complexity visible in implementation of large infrastructure projects, how is this process managed and what are suitable ways to improve the management of the implementation process?*

When we split up this main question into sub-questions we get:

1 What are the current problems, ambitions and challenges within the implementation process of LIPs?
2 What approach can be used to study the management of complexity in LIPs?
3 What characteristics do large infrastructure projects have and how does the implementation of large infrastructure projects in Europe evolve?
4 Are these characteristics and implementation processes similar or different between the studied projects in European countries?
5 Why is complexity and the management of complexity a main issue in the successful implementation of large infrastructure projects?
6 How is complexity defined by project managers and other participants?
7 How is complexity defined in theory?
8 How does this compare to practice?
9 How do managers responsible for the implementation deal with complexity in these projects?
10 What lessons can be drawn on the successful management of complexity in the implementation processes of large infrastructure projects?

The 10 sub-questions give an overview of what needs to be addressed in order to answer our main question. The first question has already been answered in this chapter. How these questions are answered in this thesis, is elaborated into detail in the next chapter in which we outline the methodology used. In the final section of this chapter we provide a short summary and a reading guideline for the remainder of this thesis.

1.7 SUMMARY AND READING GUIDELINE

In this chapter we illustrated that in Europe there is a huge ambition to realise large infrastructure projects. The European Commission calculated an investment of more than € 600 billion until 2020 for the Trans European Networks and Projects. In addition outside the European Commission plans for investing in infrastructure are massive. On the same hand, we noticed that the delivery of LIPs is often disappointing, illustrated by substantial cost overruns, time delays and a general dissatisfaction of the involved stakeholders. To fulfil ambitions, practice needs to improve, otherwise – from a financial perspective – the EC countries will not only need to invest € 600 billion, but much more (i.e. with an average cost overrun of one third: €200 billion more). This is not be easy because the demands on the management and organisations of LIPs are rising: good is not good enough anymore. More and more, the belief strengthens that for the creation of LIPs, we have to cooperate with all kinds of stakeholders, since as we have seen 'No one is in charge'. This requires the utmost of our management. The challenge is enormous and we are convinced that the only way to meet the rising demands is to improve the quality of management.

With this study we don't want to stick to national experiences. We want to meet the growing demand for more knowledge on an international scale and therefore we have researched projects in several European countries.

Based on this analysis we have formulated the following main research questions:

> *How does the implementation process of large infrastructure projects in Europe evolve, how are the characteristics of complexity visible in implementation of large infrastructure projects, how is this process managed and what are suitable ways to improve the management of the implementation process?*

To be able to answer this research question we have formulated sub-questions which are answered in the separate chapters of this thesis. An overview of the issues and chapters is presented in table 1.2

Questions	Ch.	Title
1 What are the current problems, ambitions and challenges within the implementation process of LIPs?	1	Introduction to the intriguing world of cost overruns and delay
2 What approach can be used to study the management of complexity in LIPs?	2	Methodology for studying the management of complexity in LIPs
3 What characteristics do large infrastructure projects have and how does the implementation of large infrastructure projects in Europe evolve?	3	Large Infrastructure Projects – Struggling with complexity
4 Are these characteristics and implementation processes similar or different between the studied project in the European countries?	3	
5 Why is complexity and the management of complexity a main issue in the successful implementation of large infrastructure projects?	4	Managers perception of complexity
6 How is complexity defined by project managers and other participants? How does this compare to practice?	4	
7 How is complexity defined in theory?	5	Scientific perceptions of complexity
8 How does this theory compare to practice?		
9 How do managers responsible for implementation deal with complexity in these projects?	6	Internal and Content focused approach
	7	Systems management – managing detail complexity
	8	Interactive management – managing dynamic complexity
	9	Dynamic management – balancing control and interaction
10 What lessons can be drawn for the successful management of complexity in the implementation processes of large infrastructure projects?	10	Dynamic management – 5 X-factors

Table 1.2: Overview of research questions and chapters of the thesis

Our intention was to investigate LIPs 'from the inside', which is not a coincidence, because we both are active practitioners in the management of LIPs. In our approach we have tried to combine the worlds of science and practice: to develop theory based on empirical research. Based on this theory we have developed guidelines that we feel can assist managers in the management of complexity in large infrastructure projects. This is the foundation to our research methodology which is presented in chapter 2. In that chapter we present the research strategy, the research process, the conceptual model that was used and the research design.

After the methodology we then sequentially address the sub questions which need to be answered in order to answer our main research question. In chapter 3 we show you how the implementation of large infrastructure projects in Europe evolves. This is done by introducing you to the world of our six case projects: Betuweroute, HSL-South, A73-South, Gotthard, Lötschberg and the West Coast Main Line. In this chapter we present the first arguments on why 'complexity' is the central issue in the management of LIPs. We also show why an international comparison of projects is potentially fruitful.

In chapter 4 we then take a practitioner's view on complexity. Complexity is an interesting term and buzz word, but what do practitioners mean by it? Based on our interviews we present a practitioners' framework of complexity comprising six elements: technical, social, financial, organisational, legal and time complexity.

In chapter 5 we then move into a more theoretical approach to complexity. In this chapter we illustrate the characteristics of the complex context in which the processes of implementation evolve. Complexity can be studied and observed using several theoretical perspectives. In this chapter we develop two types of complexity that are key to LIPs: detail and dynamic complexity.
Based on these two types of complexity – detail and dynamic – we present a framework incorporating four management strategies to deal with complexity in LIPs – based on the need to deal with both detail and dynamic complexity. These four management approaches are: the internal and content focused approach, systems management, interactive management and dynamic management.

The four management approaches are then discussed in separate chapters (from 6 to 10). We outline the origins of the approach, the main strategies which form the approach and then present conclusions on their use and their possible success in the management of complexity. The final approach, dynamic management, embodies the approach that we feel offers the best chances of success. This approach involves balancing the strategies of control and interaction (chapter 9) and 'doing the extraordinary' (chapter 10). The final chapter outlines the extraordinary approaches we consider necessary to improve the performance in the management of complexity in LIPs.

2. METHODOLOGY FOR STUDYING THE MANAGEMENT OF COMPLEXITY IN LIPS

2.1 INTRODUCTION

The implementation of large infrastructure projects is challenging, due to the complexity of the demands and activities that have to be applied in order to realise these LIP's. In this chapter we will elaborate the second sub-question of this thesis:

What approach can be used to study the management of complexity in LIPs?

Our approach will be presented and then underpinned. In section 2.2 general characteristics of the research will be explained, in which we will explain main research choices. The research strategy will be presented in 2.3 based on research criteria, followed by the steps in the research process that will be taken in section 2.4. In section 2.5 we will present and elaborate our conceptual model while the design of the practical research activities will be presented in section 2.6. Finally, we will sum up our methodology in section 2.7.

2.2 GENERAL CHARACTERISTICS OF THE RESEARCH

Methodology mainly serves two purposes in this study (based on: De Leeuw, 1993):

1 To choose an appropriate research strategy;
2 To judge the research quality.

Methodology can be seen as a way of thinking about and studying social reality (Strauss et. al., 1990). This definition focuses on 'the way of thinking about research' in general, rather than offering practical guidelines to carrying out research. De Groot (1994) states that "a scientist tries to describe, organise, register, understand, explain, control and influence appearances that come to him through physical experiences". In this respect methodology can be seen as a tool that can be used by researchers to work with appearances that come to them through physical experiences. This is also similar to the viewpoint that methodology: "gives guidelines, rules and tools the researcher needs to conform to, in order to develop reliable knowledge" (Jonker et. al., 1999). All these definitions are related to the two formulated views on methodology that are based on De Leeuw (1993). Other definitions of methodology fit this description as well (i.e: Strauss et. al., 1990; Jonker et. al., 1999; Taylor et. al., 1998; Van Aken, 1996; Volberda, 1999; Van der Zwaan et. al., 1994).

Although there seems at least some basic agreement on the definition of methodology, there is a large amount of discussion on 'What way of thinking in studying reality is the most appropriate?' In this discussion two streams can be identified (Volberda, 1997): 'methodological pluralism' and 'a disciplined methodology'. Some authors argue that there should be one overall methodology that can be put to use in the field of management and organisation (see for example Pfeffer in Volberda, 1997). This would mean one 'disciplined methodology' to execute research, and one set of universal criteria to judge the quality of research. Other authors state that developing such a disciplined methodology is impossible. Instead they advocate 'a methodological pluralism' that could turn out to be more practical. The fundamental idea is that every form of research needs to state and develop its own set of criteria to judge quality (De Leede et. al., 1999).

The researchers conducting this study have chosen to adopt the viewpoint of *'methodological pluralism'* in it. We do not think a universal methodology is feasible or desirable. This means that the research strategy will be fully tailored to the nature of the research question and the characteristics of the subject studied which, in our case, is 'the management of complexity in the implementation of LIPs'.

Our research can be classified as being on the border lines between the field of *'public administration'* and *'management science'*, sometimes also referred to by the term *'business administration'*. The empirical objects studied in this field of study are organisations. In this research the central objects of study are hard to define in clear cut terms. In general we have studied organisations that are assigned by political bodies to execute the task of implementing LIPs. The organisations studied do not usually design and construct the LIPs themselves, this is done by contractors through various contractual arrangements. If you take this role – implementing political ambitions – as a basis, the organisations usually fall in the category of the *'civil principal' and 'project delivery organisations'* that are occupied with the construction of large infrastructure projects. Civil principals and project delivery organisations function in a wider system of stakeholders and can be both private or public enterprises. It is impossible to give a generally accepted definition of the term 'project civil principal' and 'project delivery organisation' within LIPs, since every LIP is organised in a different way. But what we consider to be civil principals and project delivery organisations will be shown in chapter 3, where we introduce our case study projects.

The management of the project delivery organisation is the main focus of our recommendations. The term 'management' has always been very broadly used in literature. We do not think here is the appropriate place to discuss the various definitions used by authors. A more practical viewpoint is better suited for the purposes of this study. That is why we have chosen to use the following definition:

Management is 'every form of result oriented influencing' (De Leeuw, 1982).

The next issue we address is what kind of results can be formulated for the Large Infrastructure Projects (LIPs), which are the main topic of study in this thesis. This question can be answered by drawing from the literature on 'project success'. This question both includes the element of project success and the approach on how to achieve it. In literature several authors state that a possible way to answer the question of how to make projects successful is to develop an overall framework that links the research done on project success criteria to the research on critical success factors (Turner, 1997; Morris, 2000). Combined, these findings from both practice and theory led to the development of the Project Excellence Model. The Project Excellence Model, which is based on the EFQM-model, is designed to link project success criteria and critical success factors into one coherent model. The Project Excellence Model is described in Westerveld et. al. (2001). In this thesis we have chosen to use the success criteria, based on the result areas of the Project Excellence Model, to study the success of strategies in managing complexity. See figure 2.1.

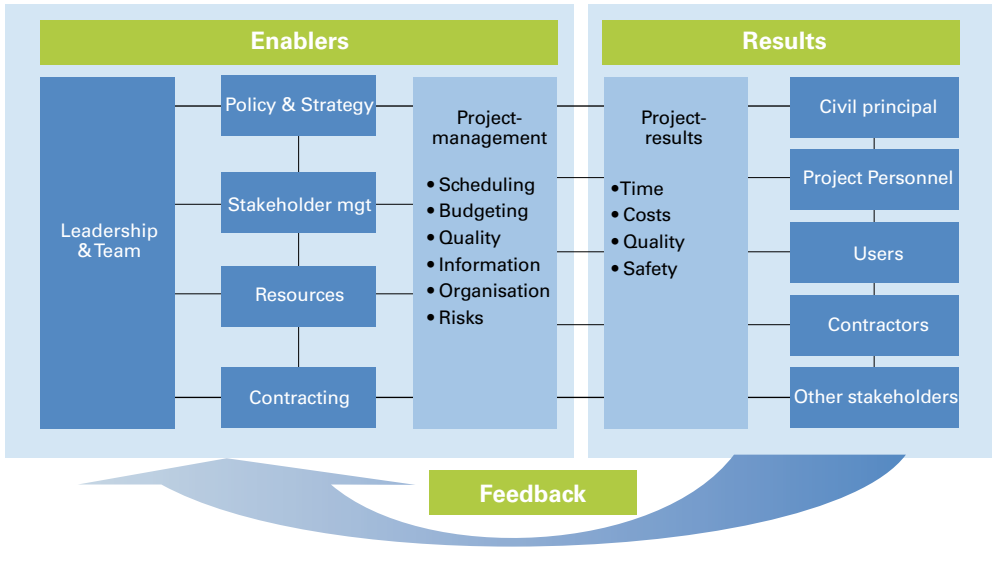


Figure 2.1: Project Excellence Model (Westerveld et. al. 2001)

Several authors have expressed their views on the issue of project success. Early work on success criteria assumed that the main criteria for success were the so-called 'golden triangle' of being (1) on schedule, (2) within budget and (3) and achieving the required quality or functionality. However, the issue of project success turned out to be far more subtle than this. There are more, possibly competing, criteria that can be identified (Atkinson, 1999). Not only is there a larger basket of potentially competing criteria, the judgement of success is made by a wide range of potential stakeholders, over different time horizons. Van Aken (1996) even defines project success as: 'The satisfaction of all stakeholders'. Perceiving project success simply as the compliance with schedule, costs and quality constraints can be qualified as being a more 'narrow' view in this respect.

Research on project success further shows that it is not realistic to strive for a universal checklist of project success criteria that can be applied to all projects. Success criteria will differ from project to project depending on a number of issues (Wateridge, 1998; Bennet, 1991) for example size, uniqueness and complexity. So a less 'fixed' and more flexible approach seems appropriate in studying project success. A more flexible approach to the issue of project success is to develop clusters of possible success criteria – assuming that, while criteria defining project success can be different for each project, a universal clustering of criteria can be formulated to cover the whole issue of project success (Lim and Mohammed, 1999; Wateridge, 1998). The clustering of result areas in the Project Excellence Model, presented in figure 2.1, was used as a basis to assess the results of the management strategies applied to manage complexity in LIPs.

Our research focused on the way that the project delivery organisations manage the implementation process of a LIP within a network of stakeholders – such as the civil principal, local stakeholders and NGO's. The interaction with these stakeholders in particular was our primary focus. This means that we pay less attention to how the project delivery organisation manages its contractors and how the project delivery organisation manages its internal organisation. The reason for this choice is twofold. Firstly that we found out that managing the relationship with principal, local stakeholders and NGO's is the key issue in the management of complexity. Many of the challenges that are faced by project managers within the project delivery organisations fall into this area. This is line with the answers we got on the questions: "What makes your project complex?" (see chapter 4). Secondly we also wanted to narrow our focus in order to improve research depth. Narrowing our focus means that we have chosen to leave related – and interesting – subjects such as the relationship between project delivery organisation and contractors, and internal project delivery organisational arrangements almost untouched.

Research in management science has some specific characteristics (Biemans et. al., 1994). These characteristics place specific demands on the chosen research strategy.

These characteristics are:

- Considering actual empirical objects (in our case the project delivery organisation and other stakeholders within the stakeholder network in a LIP).
- Isolating the studied object from its context is impossible (also found in Van Aken, 1996).
- Examination of the studied objects can only take place in its actual context.

This brings us to another important characteristic of our research. The research is done by researchers that served both as consultants and managers within LIPs. This is a specific case of action research: the researcher is an important part of the studied subject. Action research is an iterative inquiry process that balances problem solving actions implemented in a collaborative context with data-driven collaborative analysis or research to understand underlying causes enabling future predictions about personal and organizational change (Reason & Bradbury, 2001). This means that action research is a process by which change and understanding can be pursued at the same time. It is usually described as cyclic, with action and critical reflection taking place in turn. The reflection is used to review the previous action and plan the next one. In our case this means that many of the concepts developed were discussed and tested with other practitioners and academics in the field of LIPs. Based on these discussions concepts were changed, conclusions were altered and the research set-up sharpened.

Action research challenges 'traditional social science', by moving beyond reflective knowledge created by outside experts (see: Torbert, 1991). The traditional research can be typified as being focused on 'Reflection' instead of 'Action'.

There are several other classifications of research types possible. Verschuren (1988) presents three separate types of research. Research might be focused on:

1 Improvement of operations – enhancing the effectiveness of human action;
2 Development of theory – general knowledge;
3 Learning to do research – the research process is essential.

Other authors make similar distinctions between (1) problem directed research and (2) theoretical directed research. See the table 2.1.

Author	Distinction	Explanation
Swanborn (1987)	Fundamental research	Increase the general knowledge of reality
	Practical research	Contribute to the solution of a practical problem
De Leede et. al. (1999)	Theory directed	Developing general knowledge of a subject
	Practice directed	Solving a specific problem
De Leeuw (1996)	Scientific	The research product contributes to the general knowledge base
	Practical	The research product is useful in solving specific management problems
Van Strien (1986)	Explanative	Studying practice to explain reality
	Problem solving	Using existing knowledge by analysis and diagnosis to solve specific problems

Table 2.1: Different types of research

The main goal of this study is to assist project managers within the project delivery organisation in the management of complexity in LIPs. So the main objective of this study is a practical one. To help in the management of complexity we develop theory. In this sense the study can also be classified as scientific or theory directed. The aim of this study is both *practical and scientific* in the sense that the developed theory will need to be helpful in solving practical dilemmas in the management of complexity in the implementation of large infrastructure projects. The theory will cover the empirical field of the management of large infrastructure projects. So the theory will be *substantive*, as opposed to conceptual (Glaser et. al., 1967).

Within scientific philosophy there is no universally accepted definition of the word 'theory' (Sutton et. al., 1995). So no specific definition of theory will be used during this study. But because of the nature of the studied object, the developed theory is more likely to be consisting of heuristics ('rules of thumb') than algorithms (Vijverberg, 1995). The reason is that when studying a complex object – such as LIPs – with multiple variables influencing each other, finding hard statistical evidence is less likely than establishing some general rules or basics on how to manage complexity.

A 'good' theory has its own set of requirements or quality criteria (Glaser et. al., 1967). For example a theory will need to enable the prediction and explanation of behaviour, to be understandable, to be sufficiently general and to allow its user control over situations. These requirements on theory development were used for the theory developed during this study.

Another canon to judge the usefulness of a theory is the way the theory was generated. This is more a reflection on the research process than it is a judgement of the functionality of the developed theory. Glaser et. al. (1967) state that: "The best suited approach to reach these goals is to build theory from data". So the focus of this study is to develop heuristics based on the collection of empirical data.

In this section we made some first choices in our methodology. As an overview, the main research choices which were described are graphically presented in figure 2.2.

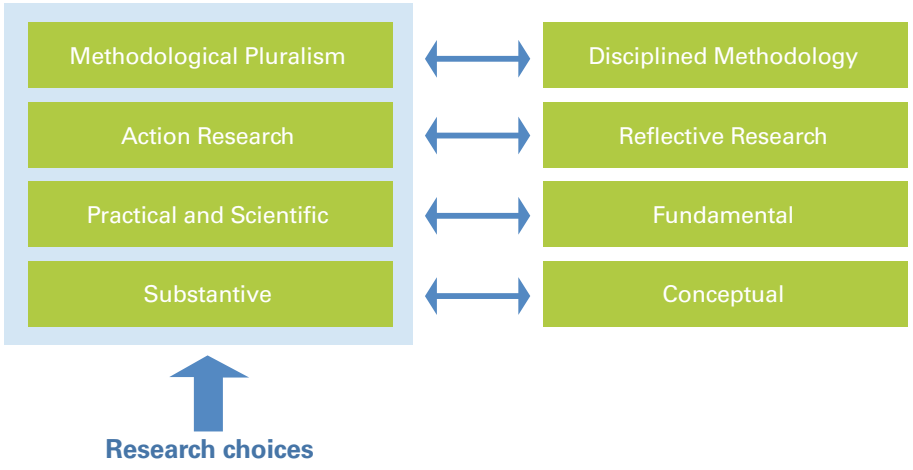


Figure 2.2: Main research choices on studying the management of complexity in LIPs

2.3 RESEARCH STRATEGY AND ACHIEVING RESEARCH QUALITY

2.3.1 Criteria for developing a research strategy

'Choosing the research strategy' deals with the question of how to develop valid and relevant knowledge on the management of complexity in the implementation of large infrastructure projects. In this thesis case studies combined with some of the principles of grounded theory are used as the primary research strategy.

In making choices to determine the research strategy the researcher needs to pay attention to several criteria related to the research context. Since we have chosen to adopt the view of methodological pluralism, the research strategy will need to be tailored to the characteristics of this study.

The criteria to choose the research strategy that was used during this study are (based on Jonker et. al., 1999):

1 Research goal and research question
2 Nature of the studied object(s)
3 Already developed 'sensitising concepts'
4 Nature of the data
5 Personal preference of the researcher(s).

The central criterion to make choices in the research strategy is the stated 'research goal and research question' (Strauss et. al., 1998; also see: Jonker et. al., 1999; Yin, 1989; Biemans, 1994). The essential characteristics of this study were already discussed in section 2.2. In summary this research has a practical focus and takes place at the borderline between business and public administration, looking at project delivery organisations so as to develop theory to help improve the management of complexity in the implementation of large infrastructure projects.

The second essential criterion in making choices regarding the research strategy is the nature of the studied object (Jonker et. al., 1999; Yin 1989; Biemans, 1994). The objects studied are the project delivery organisations executing LIPs (main focus) as well as the stakeholders involved in LIPs (secondary focus). Since these project delivery organisations interact with relevant stakeholders and operate in a highly dynamic field they cannot be isolated from their context. The nature of the studied object is complex and highly interdependent to its context.

Using 'sensitising concepts' means that the concepts yield a meaningful picture to the interested parties (Glaser et. al., 1967). Sensitising concepts can be used to direct the search process for meaningful data but are not set and well defined variables. A main sensitising concept used in this study is 'complexity'. To illustrate this concept we can refer to our interviews. When we asked the interviewees at Betuweroute, Gotthard, Lötschberg and A73-South: "What makes this project complex to you?", only one interviewee initially responded that the project was not complex. However later on in the interview he admitted that several aspects were complex. So complexity appears to be a sensitising, recognisable phrase in studying the challenges faced within LIPs.

The research strategy can also depend on the availability and validity of existing data and of data to be collected. During this study mostly lingual data will be used. This choice is closely connected to the complex nature of the studied object.

Seldom or never is there one best way to solve a specific research question (Van Strien, 1986). The preference of the researcher will and should play an important role in the choice of the research strategy (Swanborn, 1987). Both researchers in this study are active practitioners, working as management consultants within LIPs.

Management consultants can be characterised as practitioners that have been brought into a company to work on problems that concern its management. Consultants seem to use theory in order to contribute to practice while academic researchers seem to draw from practice to contribute to theory (Gummesson, 2000). In this study we will try to combine both perspectives. We will try to develop theory based on empirical research while developing guidelines based on this theory that help to manage complexity in large infrastructure projects.

As management consultants the researchers have another potential advantage that can be used during this study. This is the so called pre-understanding (Gummesson, 2000). This means that consultants have extensive experience in practice within large infrastructure projects that can enhance the quality of the research. An overview of the criteria for selecting a research strategy and how they are applied in this thesis is provided in table 2.2.

Research strategy criterion	Choices in this thesis
Research goal and research question	• How does the implementation process of large infrastructure projects in Europe evolve, how are the characteristics of complexity visible in implementation of large infrastructure projects, how is this process managed and what are suitable ways to improve the management of the implementation process?
Nature of the studied object(s)	• Project delivery organisations, civil principal and stakeholders within LIPs • Complex and dependent on context
Already developed sensitising concepts	• Use of 'Complexity' as central concept
Nature of the data	• Lingual data
Personal preference of the researchers	• Use theory to help address problems in practice

Table 2.2: Criteria for the selection of the research strategy

Based on the characteristics presented in table 2.2, the main decisions concerning the research strategy can be made. In choosing a fitting research strategy the following three core-decisions have to be made (Verschuren et. al., 2000):

1 Breadth vs Depth
2 Qualitative vs Quantitative (Clinical vs Analytical)
3 Empirical vs Desk Research

1 Breadth vs Depth

In developing the research design of this study an approach focussing on depth instead of breadth has been chosen. This choice is based on the nature of the studied object, the research goal and some basic practical constraints.

The goal of this study is to develop knowledge on the management of complexity in LIPs. These projects are often technically and socially complex (Miller et. al., 2000; Hertogh, 1997) – meaning that there are a large number of variables involved, and that their mutual relationships are often hard to determine. Also, during the research, these projects can not be isolated from their context. So in order to develop reliable knowledge that can be used for managing future projects the focus of the research is on in depth study of the selected projects. This means that only a small number of LIPs was investigated. When the studied object is complex, which suggests that a large number of interdependent variables is involved, an in depth and holistic approach seems best suited (Biemans et. al., 1994). A holistic approach is also better suited for the development of prescriptive knowledge (Verschuren, 1998).

2 Qualitative vs Quantitative (Clinical vs Analytical)

The contradiction between qualitative and quantitative research has been a dominant theme in the literature on methodology. Some authors tend to use different, but similar, terms to define both extremes. Here we will first introduce the broader terms clinical and analytical as proposed by Volberda (1997).

The different terms and author that describe differences between two main types of research are shown in table 2.3 (based on Volberda, 1997):

Analytical approach	Clinical approach	Author(s)
Quantitative	Qualitative	Yin (1989), Eisenhardt (1989), Verschuren (2000), Swanborn (1987)
Rational	Interpretative	Weick (1989), De Groot (1994)
Empircal cycle	Regulatory cycle	De Leeuw (1996)
Fundamental	Practical	Swanborn (1987)
Restrictive	Holistic	Van Rossum et. al. (1985)
Descriptive	Presciptive	Verschuren (1999)
Formal theory	Substantive theory	Glaser et. al. (1967)

Table 2.3: Analytical and Clinical Research in Management and Organisation

The analytical and clinical approaches lead to opposite views on how to conduct research.

The analytical approach is based on the empirical cycle (De Groot, 1981). The approach aspires to achieve objective results and the development of universal knowledge based on the use of strict methodological guidelines. Analytical research is mostly monodisciplinary and is traditionally related to the more 'traditional' natural sciences. The analytical approach is linked to the quantitative method of undertaking research. It is difficult to give an unambiguous definition of a quantitative or qualitative approach (Wester, 1991; Jonker et. al. 1998). But it seems that the quantitative approach is more or less linked to the collection of numerical data, statistical analysis and a clear distance between researcher and research object (Van Strien, 1986). Because of its strict and general nature the main problem with analytical research has been the risk of impracticality (Volberda, 1997).

The clinical approach on the other hand is related to the regulatory cycle. The research is based on the subjective dissatisfaction of a specific client – in our case a project manager within a project delivery organisation. The focus is more on a multidisciplinary approach and development of prescriptive knowledge. Historically the clinical approach is related to the human sciences. This research is often termed 'qualitative'. Qualitative research relates to the manner in which knowledge is developed as well as the behaviour of the researchers, the chosen research strategy and the nature of collected data (Jonker et. al., 1998). Some characteristics of qualitative research were stated by Taylor et. al. (1998). Qualitative research is concerned with meanings that people attached to their lives, developing concepts from data, a holistic approach, how people think and act as well as studying all perspectives and craftsmanship. In general, qualitative research is about 'searching for the unknown in systematic ways'. A main problem with the clinical qualitative approach, seems to be the apparent arbitrariness of the applied methodology (Volberda, 1997). 'Qualitative' is often associated with 'muddling through', 'vague', 'non scientific' and 'without starting or endpoint' (Jonker et. al., 1999). Others however argue that, while not similar to the criteria used in analytical research, qualitative research has to follow its own methodological guidelines (Strauss et. al., 1990).

This study has a qualitative focus. The reason for this choice is that qualitative research seems to be better suited for the development of theory (Jonker et. al., 1999). Since the goal of this study is to develop theoretical insights on the management of complexity in large infrastructure projects this would make an inductive approach, where theory is developed from data, the most fitting (Taylor, 1998). A qualitative approach is also fitting when the studied object is highly complex and when little is known about the studied object (Strauss et. al., 1990). And – although there has been plenty of previous research on projects, project delivery organisations, and infrastructure projects – a study of the management of complexity in these projects cannot be found.

While the dominant focus is qualitative, this does not mean that quantitative techniques were not used, for example, to collect and analyse data. The qualitative focus can be found more in the attitude of the researcher in approaching the research questions. Some guidelines that we have used during this study, also based on the synthetic approach from Volberda, are given in table 2.4 (Volberda, 1998; Jonker, 1999)

Term	Application
Exploring	The researcher is not an expert but an explorer that tries to discover effective ways in the management of complexity.
Context related	Studying large infrastructure projects in their natural context.
Interactive perspective	The research is conducted together with the stakeholders and personnel of large infrastructure projects. Results are discussed with respondents and possibly adapted based on these discussions.
Holistic	Focussing on depth rather than breadth. The Betuweroute project was used as the main case for this research. In depth document analysis and various interviews were used to construct the case analysis.
Interdisciplinary	Using more perspectives to study the management of large infrastructure projects. Trying to involve various perspectives on complexity and the management of complexity.

Table 2.4: Guidelines used during the research

3 Empirical vs. Desk Research

Based on the previous statements, it is clear that the focus in this study is on e*mpirical research*. This is because the nature of the studied object – and the goal of building theory on the management of complexity in large infrastructure projects – requires such an approach. This does not mean that desk research was not used during this study. But literature was used to enhance rather than constrain (see also Biemans, 1994 and Strauss et. al., 1998). Desk research was not the central element of this study but was used as an enhancing tool to develop sensitising concepts, formulate questions and to enrich and analyse the founded empirical data.

We conclude, in short that our study focuses on in depth analysis, a qualitative approach, and has an empirical basis. Based on these choices we selected an appropriate research strategy which is a 'case study approach combined with elements of grounded theory'.

2.3.2 Choice of the Research Strategy

Several distinctions can be made as between research strategies. While authors often make similar distinctions there are always some small differences. For this study

we used the classification of strategies described by Verschuren et. al. (2000) and Swanborn (1987). Verschuren distinguishes the following strategies:

1 Survey
2 Experiment
3 Case study
4 Grounded theory approach
5 Desk research

Swanborn (1987) mentions six similar research strategies. He places both the case study approach and grounded theory under the title 'field research' and adds simulation and psychological test as specific strategies. Also it needs to be stressed that although these strategies can be distinguished as independent basic forms of research, combinations will often be used in practice (Verschuren et. al., 2000).

We will not extensively describe the strategies mentioned. It is more fruitful to relate the five strategies to the three core-decisions made on the aspects in the previous section: breadth vs depth, qualitative vs quantitative and empirical vs desk research. This relationship is shown in figure 2.3.

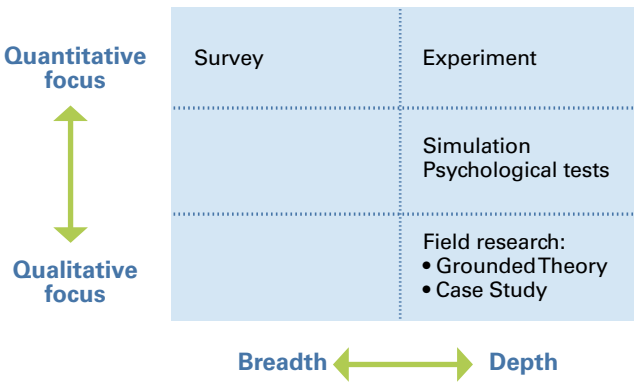


Figure 2.3: Available research strategies related to the core decisions (all empirical)

Desk research cannot be found in figure 2.3, since it is the only non empirical strategy and is often applied in addition to one of the empirical strategies. So it can be used for research with a qualitative or quantitative focus.

Based on our core decisions, where we argued that the focus should be on qualitative and in depth research, figure 2.3 shows that the most fitting research strategy is 'field research'. Field research contains both the case study approach and grounded theory approach. We have chosen to use a combination of these two approaches. A combination has the advantage that it will enrich the data collection and analysis

so improving the validity of the study. The case study approach served as the basic research strategy and was enriched with some of the elements of grounded theory for example the development of the sensitising concept 'complexity'.

Case study approach

A case study research is to do research by executing one or more case studies. A case study is researching an actual, empirical object within its natural context (Biemans et. al., 1994). Or, as stated by Yin (1989): "a contemporary phenomenon within its real-life context". A case study is an adequate research strategy when (Van Hutjes et. al., 1992):

1 Dealing with a complex situation
2 Isolating the research object is difficult
3 The number of research objects is low but the factors concerned high.

All three circumstances apply to our study. Several types of case studies can be distinguished. Based on Yin (1994), Van der Zwaan (2000), Kjellen et. al. (1980, in Gummesson, 2000) the following six types are mentioned:

1 Descriptive – attempts to describe events
2 Exploratory – attempts to derive questions and hypothesis for future research
3 Explanatory – attempts to explain the course of events
4 Generate theory – attempts to develop new theory based on cases
5 Test theory – attempts to test theory within a (number of) cases
6 Initiate change – attempts to initiate change during the research process.

However these types cannot be seen in isolation since more often than not strategies will be combined within a research strategy. This research will be based on an *explanatory approach* to theory generation. This means that this study is performed in the context of *discovery* where the aim is to construct new theory from practice. Often this type of research focuses on exploring a field of study without a sharply defined research question or problem (Dijkstra et. al., 1999). It is better is to state that the research question during of this study is regarded as 'open ended' – meaning that the research question was specified and sharpened during the course of our study. Verschuren et. al. (2000) call this approach 'iterative research'. In our study the research started off with the very general and broad research goal of 'how to improve the management of LIPs'. This question was made more specific by adding the sensitising concept 'complexity'. In our first interviews with project directors in the management of LIPs complexity emerged as a central theme and this became more of a focus for our subsequent studies. This illustrates the iterative approach used in this study.

Some advantages of the case study approach (Verschuren et. al., 2000) are the integral

holistic viewpoint, the flexible approach and the high chance of the acceptance of conclusions by respondents. The main disadvantage of the case study approach is the low external validity (Gummesson, 2000). One way to enhance the external validity of the research is by using a multiple case study approach. The results in this type of case study research can be improved by working with a comparative element. This can be done by comparing results with the results of other cases (Van der Zwaan, 2000). In this thesis we have adopted this *comparative case study* approach, by using 6 studied case projects as opposed to 1.

Grounded Theory

During this research, in studying multiple cases in practice we tried to generate theory on the management of large infrastructure projects. Here is where the elements of 'grounded theory' played an important role. Grounded theory is an approach focussing on generating theory based on empirical research and was initially established by Glaser and Strauss (1967). A theory is derived from data systematically gathered and analysed through the research process. Data collection, analysis and eventual theory stand in close relationship to another. The researcher does not begin a project with a preconceived theory in mind (Strauss et. al., 1990). The main ingredients of the research process in grounded theory are a) asking questions and b) making comparisons (Strauss and Corbin, 1990). Another important viewpoint is that the researcher can become convinced of his own theory but this does not mean his analysis is the only plausible one that could be based on his data (Glaser et. al., 1967).

Some of the main characteristics of grounded theory are (Verschuren et. al., 2000):

- Searching attitude of the researcher.
- Comparative approach: empirical concepts and theoretical concepts, with primary or secondary data and theory.
- Use of extensive procedures, tools and techniques.

Grounded theory (GT) can be used when the purpose of the research is to elaborate and extend existing theory. It is valid to use GT when little is known about the research topic, it is a new field and when researching complex matters (Strauss et. al., 1990). All this, to a certain extent, holds true for this study. Concepts of grounded theory that are especially relevant in the case study research are the use of theoretical sampling and saturation. These approaches were used to select our cases. Theoretical sampling means that the selection of cases is based on provisional findings and theory. Added cases should be maximised on comparable characteristics and minimised on comparability (Hakvoort, 1995). Saturation means that the actual number of cases will be based on the added contribution of each case. When the value of an additional (sub-)case approaches zero no new cases will be added. Both theoretical sampling and saturation help to enhance the external validity of the case study approach. From this view it becomes clear that theory can be built on a limited number of cases since additional evidence is not so crucial in developing a new theory (Gummesson, 2000). In this thesis we have developed theory based on 6 cases and 14 detailed sub-cases. The sub-cases are visualised in table 2.5.

No.	Project	Sub-case
1	Betuweroute	Tunnel Technical Installations (TTI)
2	Betuweroute	Scope and cost development
3	Betuweroute	Preparation of operation
4	Betuweroute	Organising
5	Betuweroute	Pannerdensch Kanaal/Gorinchem/Barendrecht
6	Gotthard/ Lötschber	Referenda
7	Gotthard/ Lötschberg	Canton Uri
8	Gotthard/ Lötschberg	Frütigen
9	A73-South	Political Agreement
10	A73-South	Tunnel safety (TTI)
11	A73-South	Environmental compensation
12	HSL-South	Bos Alternative
13	HSL-South	Noise screens (birds)
14	West Coast Mainline	History

Table 2.5: Sub-cases studied

While grounded theory plays an important role in the research strategy certain procedures and tools will not be applied. For example in the initial presentation of grounded theory the general notion was that theory should not play any role in the data collection process. In later work this view was revised (Strauss et. al., 1990). There are various examples of research where theory was used to enhance data collection (in example Denison, 1990). The researcher cannot be a 'tabula rasa' but will always need some sort of experience to draw upon. This view has been widely accepted by those working with case studies (Eisenhardt, 1989). The a priori specification of constructs can help to shape the initial design of theory building research.

2.3.3 Research Quality

We now turn to the subject of research quality. When performing a study one has to pay attention to the criteria for judgement of the quality of scientific research (definition 2 of methodology in section 2.1). So in order to judge the outcomes of our study we will need to state the relevant criteria in advance. Important decisions made in the research design can be related to these stated criteria.

The dominant term we used to judge the quality of this research is 'usefulness' (De Leeuw, 1996). De Leeuw also provides a transparent view of the relationships between the components of usefulness. Other authors simply state a number of criteria – although sometimes very similar to those stated by De Leeuw – without specifying relationships (for example Dijkstra et. al., 1999; Swanborn, 1987).

To improve the research quality, and stimulate the 'usefulness' of our developed theory, we used the following approaches:

1 Triangulation
2 Sensitising and analytic concepts
3 Inter-subjectivity
4 Client based research
5 Chain of evidence – case study protocol
6 Pattern matching and explanation building

1 Triangulation

Triangulation relates to the use of more sources of data, applied methods and researchers (Verschuren, 1999). Triangulation can help to improve the internal validity of the results of research (Swanborn, 1987) of the results by looking from different viewpoints and so minimising the chance of errors in the interpretation of collected data. The term 'triangulation' derives originally from surveying where it is used to describe a method of determining the location of points by using several different viewpoints (Hakvoort, 1995). Where possible, the concept of triangulation of methods, researchers, data sources and theory was used during this study. But with hindsight it is arguable that the best measure of triangulation was the fact that this research was performed by two different researchers – each with their own view and opinion. By combining and discussing these sometimes opposing views, the quality of the end product has without doubt been improved.

2 Sensitising and analytic concepts

Concepts developed within a theory should be (Glaser, Strauss, 1967):

- Analytic: sufficiently generalised to designate characteristics of concrete entities.
- Sensitising: yield a meaningful picture (for those interested).

Qualitative research is not working with pre-developed theoretical concepts but working with, at most, sensitising concepts (Jonker, Pennink, 1999). Working with sensitising concepts can improve the validity of the research. During the execution of the research these concepts will be adapted in order to yield a meaningful picture. On the other hand this does not mean that the researcher should start without any concepts at all. The researcher should at least explicitly state how concepts used were developed and improved (Hutjes et. al., 1992). The main sensitising concept used in this study is 'complexity'.

3 Inter-subjectivity ('inter-judge reliability')

Research should strive to be objective although subjectivity should not be regarded a disturbing factor (De Groot, 1994) – when working with complex material it could be that no objective measures can be found. In that case the researcher should strive for 'inter-subjectivity' which is also called 'inter-judge reliability' (De Groot, 1994). In eliminating subjectivity the researcher can (De Groot):

- Build in loops
- Reduce complexity by applying fewer measures
- Eliminate other aspects
- Eliminate different interests.

Inter-subjectivity is an approach used in empirical (practical) research that is often preferable when objectivity cannot be attained (Swanborn, 1987). Others state that inter-subjectivity is the highest achievable goal in scientific research (Dijkstra et. al., 1999). This is in line with the iterative research approach mentioned earlier, where continuous reflection from the researcher regarding his results is a dominant aspect. Techniques that also fit into this approach are 'peer debriefing' and 'peer examination' (Hutjes et. al., 1992) which involve the control of research results by colleagues – which is similar to the method of triangulation described earlier.

4 Multi-client use of scientific research

First of all we formulated an ambition to write a doctoral thesis, aiming to satisfy the scientific community. At the same time however, the study was performed to serve several clients. Main clients were Rijkswaterstaat (the department of public works of the Ministry of Transport in The Netherlands), ProRail, BAV (Swiss Federal Office of Transport), DfT (Department for Transport, UK), the European Commission (NETLIPSE) and Transumo.

The Ministry of Transport commissioned the initial investigation of 3 LIPs in The Netherlands and asked us to compare the management practice in these project to the management of the Swiss Gotthard and Lötschberg projects. The outcomes of this study were also presented to the European Commission and led to the NETLIPSE initiative in which the management of LIPs within the European Commission was researched. This research was completed in June 2008 with the book: 'Managing Large Infrastructure Projects'. Transumo (TRANsition SUstainable MObility) is a Dutch platform for companies, governments and knowledge institutes that cooperate in

the development of knowledge with regard to sustainable mobility. Transumo has stimulated this PhD research by providing knowledge and financial support. BAV, ProRail and DfT supported the research by making interviews possible and delivering the required data. We had interesting discussions with these organisations that sharpened our findings.

Additional clients of this research have been the project directors of the projects investigated. During our study, clients participated in a specific steering committee where progress was reported and practical relevance was safeguarded. The position of the client in this study improves the usefulness of this study by relating outcomes to specific problems 'in practice'. In addition the validity is improved because the clients, as insiders in the world of large infrastructure projects, can be used to check the collected data and analysis in line with the 'member checks' method as mentioned by Hutjes (1992). A steering committee can perform this role in a practical or client based study (Brasters, 2000). Several steering committees have followed the presented research and reflected on the outcomes.

6 Improving validity: pattern matching and explanation building

Pattern matching is an approach where patterns found in the empirical case data are compared to expected patterns drawn from theory. This helps to enhance the internal validity of the case study. Another approach used to enhance internal validity is 'explanation building' (Yin, 1989) which is a strategy where hypotheses are developed to explain the evidence found in a case study. Pattern matching and explanation building were both used in the set up of the case study protocol.

In the following sections we show how the measures taken mentioned are reflected in the research process, conceptual model, and research design.

2.4 RESEARCH PROCESS

The main research strategy and measures to improve research quality formed the input for our research process shown in figure 2.4. This process was not only straightforward (in the figure start from the top, read to the bottom), but had several iterative loops, as was mentioned in the previous section.

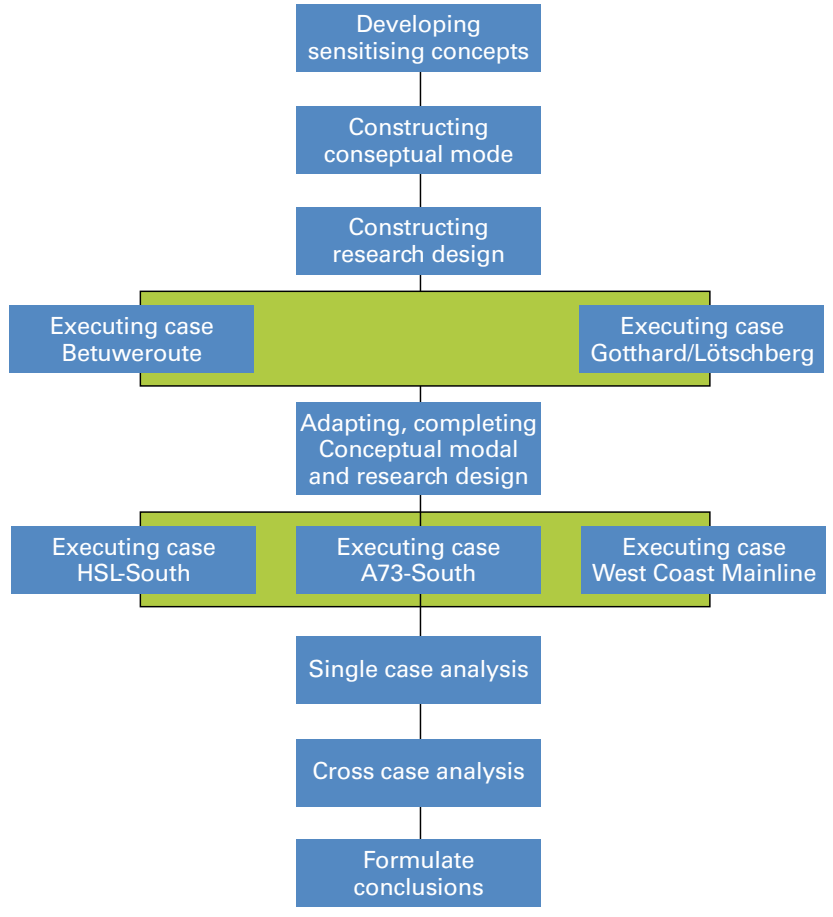


Figure 2.4: The applied research process

The first step was the development of sensitising concepts, illustrating our 'grounded' approach. This was done by conducting talks with key players in LIPs in The Netherlands and conducting a study of literature on the management of LIPs. Combined with a reflection on our experience in practice, this led us to several sensitising concepts that were used. These concepts were also discussed in various

settings with colleagues, practitioners and other researchers thereby improving the inter-subjectivity. Examples of these are:

- Project team discussions with members of the project organisations of the Betuweroute, A73-South and HSL-South.
- Steering committee discussions with the project directors and managers of the Betuweroute, A73-South and HSL-South.
- Research team discussions with members of the ETH Zürich and Erasmus University.
- Essay in which preliminary findings were presented to the steering committee.
- Workshop held for employees of Rijkswaterstaat on the management of complexity.
- Peer briefing discussions with fellow consultants at AT Osborne.
- Direct link with the work done within NETLIPSE and Transumo.
- Discussions during the NETLIPSE research with the four knowledge teams of this research project.

The most important sensitising concept was that of 'complexity' as mentioned earlier. The first version of the conceptual model was based on these sensitising concepts regarding complexity. The conceptual model (see the next section) forms the theoretical framework for execution of the case studies. Next the conceptual model was translated into an approach describing the collection of data and analysis: the research design. This research design contained, for example, the questionnaires that were used in the interviews.

Because of a desire for flexibility we chose to use two case studies as first batch. The execution of this batch was based on the research design in place at that point. Based on the findings in the first two cases the conceptual model and research design were refined and adapted.

In the initial set-up, it was planned to investigate only 5 case projects. Later we decided to add the case of the West Coast Mainline (WCML) as a 6th case. The addition of this case was done to add a third country to the European comparison – a measure to enhance the validity of our conclusions. On the other hand, our experiences with NETLIPSE had already shown us that the WCML would provide us some very interesting additional insight. So it is also an example of theoretical sampling and saturation.

During the investigation it proved to be impossible to conduct a large number of interviews for the HSL-South project. At that time (around 2004), the project was the subject of a parliamentary enquiry and other investigations. As a result we mostly used material that was largely available – documentation, own experiences, interviews and experiences from NETLIPSE and discussions with members of the project organisation, as the basis for our analysis.

After all cases were completed, the final analysis was started. This started with the single case analyses, and was completed with the cross case analysis. Finally the outcomes of the analyses were used to formulate the answers to the posed research questions and to draw the final conclusions. We will now illustrate the set up of the conceptual model.

2.5 CONCEPTUAL MODEL

The conceptual model is constructed to answer the primary research questions 'How does the implementation process of large infrastructure projects in Europe evolve?, How are the characteristics of complexity visible in implementation of large infrastructure projects?, How is this process managed? and What are suitable ways to improve the management of the implementation process?' The central element in the research questions is the term 'complexity'. The theory, and practice, of complexity and management was studied in order to develop the conceptual model.

The conceptual model is based on the study of the management of complexity in literature and the research on practice. For large infrastructure projects, there are two main questions to be answered in this study:

1 What is complexity?
2 How to deal with complexity?

1 What is complexity?

The theory regarding the first question was constructed by combining two approaches. The first based on practice (presented in chapter 4). We distinguish six complexities: technical, social, financial, legal, organisational and time complexity in what we called 'the practitioners" view.

The second is based on theory (chapter 5). In particular, the pair detail and dynamic complexity concepts turned out to be useful to study complexity at LIPs. We have chosen to use two separate approaches in order to enhance the *triangulation* by offering more definitions of the studied phenomenon. Based on merging theory and practice we distinguish two main types of complexity: *detail complexity* and *dynamic complexity.*

2 How to deal with complexity?

Our research can be positioned between project management and public administration sciences. At the case studies, we used the method of storylines to investigate how the organisations deal with complexity. As a result, we also analysed the implementation processes of LIPs.

We found that the theory of project management is especially appropriate for the internal management of LIPs and is focused on the technical content of the task at hand. As a representative of 'project management' we used the theory of *systems management* (chapter 7). We also used another management strategy for the management of complexity and this was based on public administration. We called this theory 'interactive management' (chapter 8).

It is interesting to note that during the execution of our research we found that two other strategies, not part of our initial conceptual model, could be added to provide a full overview of the management of complexity in practice. The first is the *Internal and Content focused approach* (chapter 6), in fact an approach that is suited for projects with low complexity. However, we observed that it was frequently used for higher levels of complexity and, needless to say, led to poor results. On the other side we recognised an approach that is best suited to managing complexity: we call it *dynamic management*. With dynamic management the benefits of systems management and interactive management are combined (chapter 9). That is to say a combined approach is needed for the successful management of complexity, systems management as well as interactive management is needed . How to combine these two is illustrated in chapter 9. Finally, in our analysis we found that for successful management of LIPs at critical moments, it is often necessary *'to do the extraordinary'*. Apparently, extraordinary projects need extraordinary approaches when the going gets tough (chapter 10). This element *extraordinary approaches and solutions forms* the second part of our dynamic management approach.

The conceptual model is based on these two main questions 'What is complexity?' and 'How to deal with complexity? and has been graphically worked out in figure 2.5.

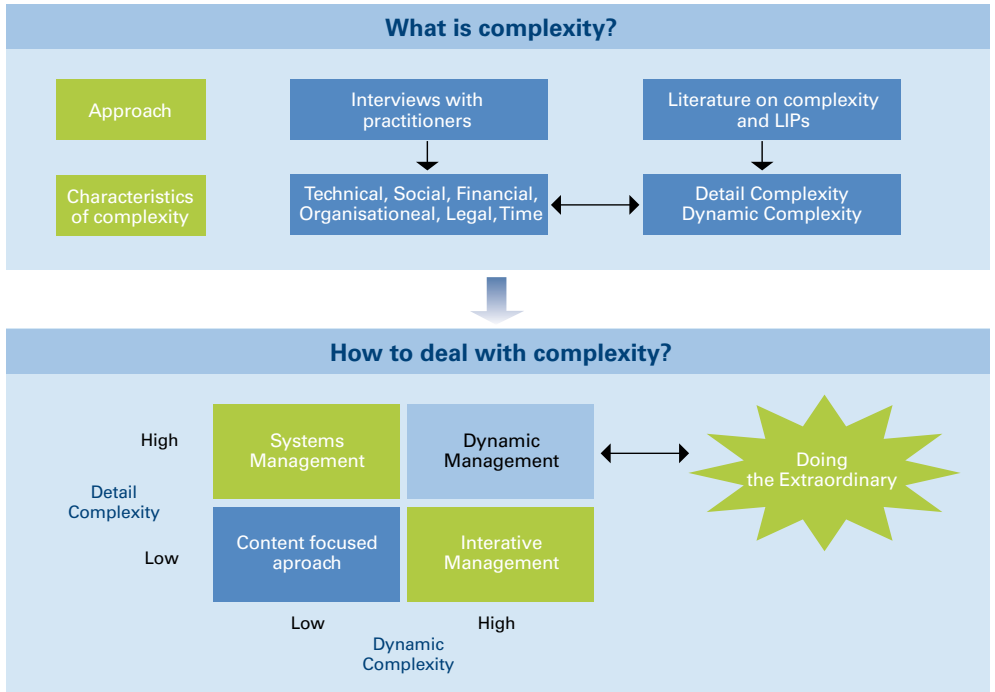


Figure 2.5: Conceptual Model

2.6 RESEARCH DESIGN

This study has used a case study approach, combined with grounded theory, as the main method to collect data so as to answer the primary research question on how to manage complexity in LIPs. In this section the method of data collection and analysis is described.

The first aim of our study was to investigate the nature and perception of complexity. As described in the conceptual model, various views of complexity can be applied. In our study we have constructed a theoretical framework to find out how these views relate to the perception of complexity of project participants of project delivery organisations and of other stakeholders. The approach chosen was to study the cases and look for possible sources of complexity (document study). In addition, in the interviews held with employees and stakeholders, we asked them what made the project complex from their point of view.

In order to study the management of complexity, 'situations' have to be identified in order to make an analysis possible. In our research we used the term 'critical

events' or 'important themes' to identify such situations. Events were identified in the interviews mentioned. We asked respondents to identify important events in their projects. Our basic assumption behind this was that critical events were events that had the characteristics of complexity such as found in the conceptual model.

Before the first two cases, historical analyses were made using the 'rounds model'. This historical analysis was based on a document study. During the first two cases (Betuweroute and Gotthard/ Lötschberg) the document analysis and interviews were used to identify 'critical events' to study the management of complexity. The most often mentioned themes and events were then, in the form of sub-cases, analysed in depth using the 'rounds model'. After the execution of the main batch of interviews we tried to cluster the sub-cases into several themes. The construction of the themes was done in a meeting with the academic project team containing researchers Prof. Teisman (Erasmus University) and Prof. Schalcher (ETH Zurich). The following themes were identified:

1 Political support
2 Technology and Legislation
3 Finance and Scope
4 Principal and Parent
5 Local stakeholders

These themes were then used to tailor the final 3 case studies. This meant that events were identified on the themes that could be studied in the case at hand. Next the themes to be studied were chosen before starting the interviews. This enabled a better focus in the the second batch of interviews and a better selection of interview partners. It also helped us in selecting those most interesting sub-cases by use of the criteria of 'saturation' and 'theoretical sampling'. In the selection of themes we have selected at least two main sub-cases for each of the five themes. In addition we have identified several supporting sub-cases for each of the themes to test and expand our findings.

For our main sub-cases on the themes, we have used a storyline description. This storyline is based on the 'rounds model' which can be used to present public decision making (Teisman, 2000). We introduce the rounds model in chapter 3.

The further analysis focused on how complexity was dealt with in the cases studied. The case descriptions of the studied themes served as the basis to answer this question. In addition, specific questions were posed to employees and stakeholders so as to collect additional data.

In our analysis of the types of management we used the theories of systems management, and of interactive management as our basis. We analysed how the approaches found in theory relate to the behaviour of respondents in each 'round' of our main cases. After looking at the specific behaviour of respondents the next step was to look at the results achieved with this behaviour. Results were estimated for the following aspects (see figure 2.2 on the Project Excellence Model):

- 'Hard results': on the aspects Time, Costs and Quality.
- 'Soft results': on the satisfaction of respondents with the outcomes.
- 'Soft results': on the satisfaction of respondents with the process.

The final step was to link the behaviour of the respondents to the results so as to check if a relationship between approach and results could be identified.

Interviews were used as one of the primary methods to collect data on the cases. Each interview contained general and more specific questions. General questions were asked of all respondents, specific questions were asked to several selected respondents based on the theme or critical event defined for study during the interview.

Data was analysed mainly using two techniques:

1 Pattern matching
2 Inductive analysis.

For pattern matching purposes, specific tables were developed to classify the 'complexity' and 'management' views that were applied in each of our main sub-cases. Each element of research sought to establish which type of complexity was dominant in a specific round and what management strategy was used.

In addition, collected data for each interview and each case has been analysed by looking for patterns occurring. These are patterns emerging from the data itself and not present in a previously formulated hypothesis. This technique is called inductive analysis. Patterns found, based on inductive analysis, will after the execution of the case studies be compared to theory and the opinion of experts from the field.

2.7 SUMMARY AND CONCLUSIONS

In this chapter we outlined the methodology of this thesis. The main research questions in this thesis are 'How does the implementation process of large infrastructure projects in Europe evolve, how are the characteristics of complexity visible in implementation of large infrastructure projects, how is this process managed and what are suitable ways to improve the management of the implementation process?'. The main 'sensitising' concept used in this study is 'complexity'.

To answer the main research question 'list' we have chosen to adopt the viewpoint of *methodological pluralism*. This means that the methodology is specifically tailored to answer this question and no universal methodology has been applied. The research can be classified as being on the border line between the field of public administration and management science because the central objects of study are the 'project delivery organisations' and 'stakeholders' that are concerned with the implementation of large infrastructure projects. In addition to studying these entities we have described and analysed the implementation processes of LIPs.

Since the researchers are active practitioners in the field of LIPs, the research is a specific case of action research. This means that the researchers are an important part of the studied subject.

The aim of this study is both practical and scientific. It has the goal to develop 'substantive theory'. This theory will need to be helpful in solving practical dilemmas in the management of complexity in large infrastructure projects. The theory will contain heuristics to be used by stakeholders in the field of LIPs – based on the collection of empirical data.

In this thesis comparative case studies combined with some of the principles of grounded theory will be used as the primary research strategy. This research will be based on an explanatory approach to generate theory. This means that this study has been performed in the context of discovery where the aim has been to construct new theory from practice.

In the research design of this study an approach focussing on depth instead of breadth was chosen and a qualitative focus was predominantly applied. However this does not mean that quantitative techniques were not used to collect and analyse data.

Concepts of Grounded Theory that were used are mainly theoretical sampling and saturation in the selection of the case projects.

The dominant term we used to judge the quality of this research is 'usefulness'. To enhance the usefulness or findings the following methods were used: triangulation, sensitising and analytic concepts, inter subjectivity, client based research, measures improving reliability (chain of evidence, case study protocol) and measures improving validity (pattern matching and explanation building).

For this research a case study protocol was used to structure the research. This protocol contained the conceptual model and the research design. The conceptual model contains the theoretical framework used to collect and analyse the case study data. In order to answer our primary research question, six cases were studied. These are introduced in the next chapter.

3. THE PROJECTS – STRUGGLING WITH COMPLEXITY

In the first chapter an introduction was presented as to what problems occur in the practice of LIPs and which parties experience these problems. In the second chapter we outlined a methodology on how to develop meaningful knowledge so as to deal with the challenges, resulting from complexity, faced in LIPs today. In this chapter we move forward by introducing our case projects. This means we answer the following questions: "What characteristics do large infrastructure projects have, and how does the implementation of large infrastructure projects in Europe evolve? Are these characteristics and implementation processes similar or different between European countries? And what similarities and difference do we observe between the studied projects?".

The studied projects originate from several European countries and all have their specific characteristics. However they definitely have one major element in common: the enormous complexity that the management of these projects needs to deal with. The projects in this chapter are used to give a first view on how this complexity can be observed in every day practice. In addition we take a first look at the demands this complexity places on the project delivery organisation and other stakeholders active in LIPs.

The six case projects are:

1 Betuweroute (The Netherlands) (3.1)
2 High Speed Link South (The Netherlands) (3.2)
3 A73-South (The Netherlands) (3.3)
4 Gotthard (Switzerland) (3.4)
5 Lötschberg (Switzerland) (3.4)
6 West Coast Mainline (United Kingdom) (3.5)

In general, each of the cases is introduced in a separate section. However, because the Gotthard and Lötschberg project are tightly connected we describe them in one section, section 3.4. In the separate sections we show how our six studied infrastructure projects evolve in different European countries and what the problems are that managers, responsible for implementing these projects, are facing. The projects appear to be 'struggling with complexity'. In the introduction to our cases we opt for an approach in which we present the characteristics both in terms of facts & figures as well as an historical overview of the implementation process. Afterwards we look for main similarities and differences (section 3.6).

Each of the projects is first described based on facts and figures where we provide the details of the project in terms of size, stakeholder constellation and contracting structures. Secondly we describe each project from a historical perspective. The first perspective allows us to see the project as a more or less static facility by presenting the overwhelming size mainly in terms of the number of stakeholders, scope to be built, organisation structures and work to be completed.

The second perspective allows us to deploy a more dynamic view on LIPs by showing their implementation processes over time. Various approaches can be used to provide this dynamic perspective. A common dynamic perspective used to describe projects is the 'phasing model'. Projects go through certain specific phases from initiation to completion. Project phases can for example be: initiation, feasibility, planning, execution and closure. However this phasing model assumes a more or less sequential and linear progression through these stages. Because LIPs do not seem to follow the characteristics of linearity in problems and solutions, the 'rounds model' ('rondemodel', Teisman, 2000) is used to describe the implementation process of our studied LIPs. The rounds model is a method to describe the project history by distinguishing specific rounds of decision making and development. The rounds model examines the decision making processes in terms of a series of interacting decisions taken by several players. Demarcation of a round is done by identifying crucial changes in the constellation of stakeholders – such as the entrance of new key players – as well as critical events that change the course of the project. This means the rounds model allows for more flexibility and insight in studying especially the non linear development of LIPs that is observed in practice.

Within the rounds model, the historical descriptions are not presented as a strict timeline of events but have the characteristics of a storyline. The storyline concept enables us to present the history of the projects in a qualitative way. It serves to identify key events and interventions of players in the system (see Haynes, 2008). In this sense the storyline is a qualitative approach of presenting a case history as compared to a more quantitative approach in which only a timeline is presented. In the storyline we focus on demonstrating the complexity of LIPs and the struggle of stakeholders – mainly principal and project organisation – to deal with this complexity in the management of LIPs.

3.1 BETUWEROUTE

The first project which was studied concerns the bringing into use of the Betuweroute, the 160 kilometres long dedicated double-track freight railway between the Port of Rotterdam and the German border that was opened in June 2007. It will become the backbone of Dutch freight rail transport and extend considerably connections with the European freight rail network.

3.1.1 Project Facts & Figures and stakeholder constellation

The Betuweroute is a 160 kilometres long double-track dedicated freight railway line between the Port of Rotterdam and the German border at Zevenaar-Emmerich. The route alignment, as built, is shown in figure 3.1

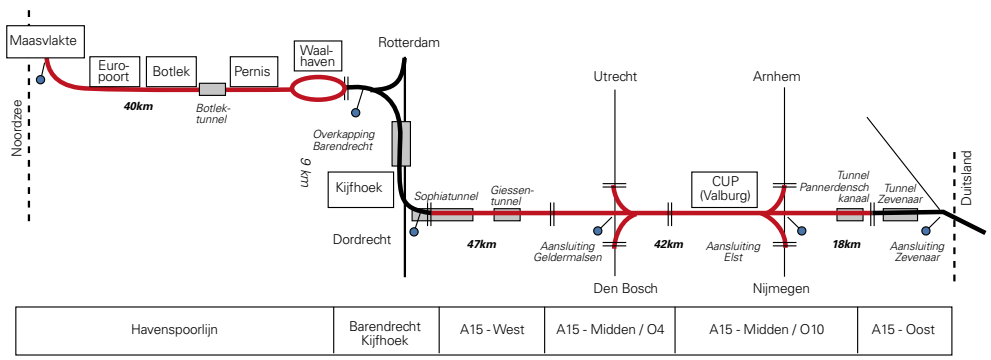


Figure 3.1: The Betuweroute

In brief, the Betuweroute was planned to deliver to following benefits [Projectbeschrijving ProRail, 1995]:

- Environmental: Bring about a sustainable solution for freight rail transport while relieving road capacity overload;
- Economic;
- Improve the competitive position of Rotterdam harbour;
- Offer a financially attractive opportunity for freight rail transport.

Table 3.1 provides some key facts and figures on the Betuweroute project.

Key Betuweroute Facts and Figures	
Original budget	2,53 bn. € (price level1995)
Costs	4,7 bn. € (price level 2007)
Yearly revenues	Unknown (operation started in 2007)
Houses and other property removed	Over 400
Parallel length alongside highway A15	95 kilometre
Length of noise screens	160 kilometre
Electrification	25kV
Safety system	ERTMS/ETCS
Length of lowered track	7,5 kilometre
Number of bridges and viaducts	130
Length of bridges and viaducts	12 kilometre
Number of switches	155
Number of 'ecological crossings'	190
Number of tunnels	5

Table 3.1: Key facts and figures

The project planning process started in 1990, the formal Route Decision – generally seen as the GO decision for the project – was taken in 1996. The Betuweroute was opened by Queen Beatrix of The Netherlands on the 16th of July 2007.

The Betuweroute was built by the use of government funds and a small contribution from the European Union and ProRail. During the early phases (1995) of the Betuweroute however, it was the intention partly to finance the construction of the Betuweroute with private funds. The idea was that a private contribution of approximately 20% of the capital costs of construction was feasible, and that the investor would see this repaid by a share in eventual track access receipts. Later on during the project, it turned out to be impossible to attract private funding to cover any of the construction costs.

The Ministry of Transport, Public Works and Water Management – Ministry of Transport in short – serves as the civil principal of the Betuweroute project. The responsible politician for the execution of the project is the Minister of Transport. The Minister reports on the project to the House of Representatives ('Tweede Kamer') by publishing a progress report every six months. This progress report, together with other project issues that require political decisions, is discussed in a separate Council of the House that deals with issues concerning the Ministry of Transport.

ProRail, the Dutch company responsible for the capacity, reliability and safety of the Dutch railways, has been commissioned by the Ministry of Transport to oversee the construction of the railway line. Within ProRail a specific department was set up to execute the Betuweroute project called 'The project organisation Betuweroute' – headed by a special Project Director. The Project Director Betuweroute reports on the progress of the project to the overall ProRail Director. The ProRail Director then discusses progress with the Ministry of Transport. In addition there is an informal working meeting to prepare decision making between the project director of the Betuweroute and the main office within the Ministry.

The project steering mechanism used since 2003 of the project is shown in figure 3.2.

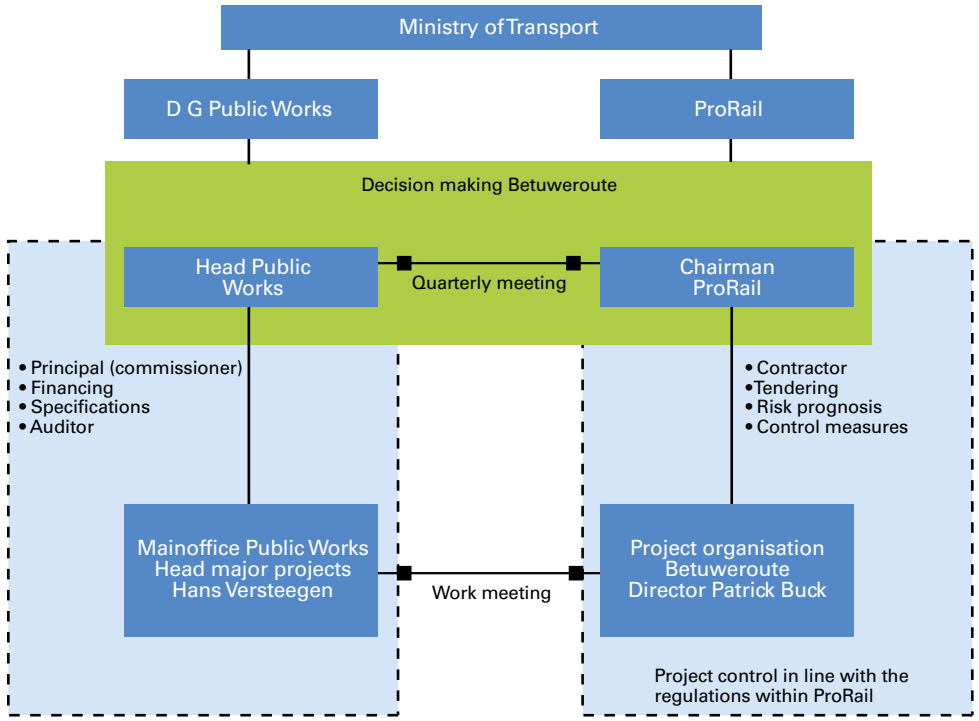


Figure 3.2: Principal – commissioner relationship at the Betuweroute

Apart from being responsible for execution of the project to the Ministry, ProRail is currently (2007) also involved in developing a plan for the maintenance and operational preparation of the track. This has been described in a 'position paper' which was published in April 2006. In addition, ProRail participates (50%), together with the harbour 'exploiting' companies of Rotterdam and Amsterdam, in the newly formed company that will operate the Betuweroute between 2007 and 2012. This company is called Keyrail.

The main local stakeholders of the Betuweroute have been the separate communities along the line as well as the Provinces of Zuid-Holland and Gelderland. These local stakeholders, especially those in Gelderland, had a major influence particularly during the early stages of the project – until 1995 – as will be shown in the project storyline.

Other relevant stakeholders include environmental protection agencies and the fire brigades.

3.1.2 Storyline Betuweroute

The round model has been used to distinguish three separate rounds of decision making for the Betuweroute. Each round is separated by one or more major event causing a dramatic turn in the project. The three phases that have been distinguished are:

1	Round I	Reaching a mature scope	1990-1995
2	Round II	The continual story of ongoing cost overruns	1995-2000
3	Round III	A 'contaminated project' realised within its budget	2000-2007

The storyline of the Betuweroute is based on the report written by the 'Technische Commissie Infrastructuur (TCI) in 2003, publicly available progress reports (PR) on the project, as well as interviews with the participants in the project.

Each of these three rounds will now be described in more detail.

Round 1 Reaching a mature scope 1990-1995

As early as the mid 1980s, ideas existed to build a new railway line to improve the connection of Rotterdam harbour with Germany. To investigate the transport of goods by rail, the Minister of Transport (Kroes) established a special committee: the Van der Plas Committee. The report of the Committee was published in July 1989. In the conclusion, the importance of an 'East-West corridor' for goods transport by rail was stressed. "To improve this corridor, the existing Betuwelijn will need to be improved".

With the conclusions of Van der Plas as one of the main inputs, the 'Betuweline' was presented as a main axis for goods transport in the policy document 'SVV2', published in 1990 by the Ministry of Transport. The project was focused on upgrading an existing regional passenger line. The estimated costs were estimated at around 1,134 bn. euros. The approval of this policy document by Parliament was seen by the Minister as the start of the execution of the Betuweline project.

Traditionally rail infrastructure was developed by NS ('Nationale Spoorwegen N.V'), the Dutch Railways. So the Betuweline project execution was mainly a task for the Dutch Railways, the only organisation that had the required technological know-

how. The Ministry of Transport funded the project, but had no direct influence on the organisation of projects by the Dutch Railways. NS undertook project execution, including the main spatial planning documents, but NS interpreted their task much more broadly than that. A project manager of NS told us:

> *"Ironically, we from the Dutch Railways initiated the discussion about the benefit and necessity of the Betuweroute, while this should have been a job for the Ministry of Transport. At that time, the Cargo department of the Dutch Railways, NS Cargo, wanted a Betuweroute because of the employment it would bring. Dutch Railways wanted to speed up the initiative."*

The Dutch Railways (NS) and the Harbour Authority Rotterdam supported the project. The Dutch Railways wanted to strengthen its position on the freight market and the Harbour Authority wanted to enhance transport modalities with its German hinterland.

The Ministry of Transport assigned responsibility for project execution to Dutch Railways (NS). In 1990 NS formed a project organisation for the preparation of the 'Startnotitie', the starting document as a first step in the procedure for environmental impact report (m.e.r) for the Betuweroute. The focus was on the technical design of the project and speed was a key consideration. As an illustration of the sense of urgency, evidence is provided by a clock in the of the NS project director's room. After it broke, he set it at 5 to 12, saying:

> *"For this project, it's always 5 to 12.",*

...and he didn't want it to be repaired!

In 1991, problems arose when the project organisation of NS organised information evenings along the line, where the new track of the rail freight line was shown. This was the first time that many inhabitants and cities were confronted with the line and the planned route. Some people realised from the drawings that the planned track went straight through their houses, because the maps used by NS didn't take the latest spatial developments into account. The way the Dutch Railways communicated the plans basically created commotion, but these information evenings were not the only factor.

A former deputy of the Province of Gelderland illustrates the character of the talks with the Dutch Railways concerning the Betuweroute (BR):

> *"In the beginning there was no possibility of talking with the project director, although later this became possible. During the first meeting the objective was simply to give information. There was no interaction between those attending the meeting. It was predominantly presented as a fixed plan that was very beneficial for the whole country. You could say they did everything they could to organise their own resistance. And they have really succeeded."*

Within half a year, twenty eight pressure groups were active. The Province of Gelderland that was previously in favour for the Betuweroute, switched its opinion to severe opposition to the line. Until 1995 the Betuweroute was one of the most important topics on the front pages of the newspapers. We have referred to a detailed scientific analysis to the TCI (report about reconstruction of the Betuweroute) and for a more personal tale to the book 'Slag om de Betuweroute' (Battle on the Betuweroute) by Hans Boom, who was at that time the project director of the Betuweroute at the Ministry of Transport.

Looking back, the focus in these early stages was mainly on the national stakeholders. There was hardly any interactive contact with local government and Provinces. Neither was there much attempt to build-up societal support – and only passive support from national environmental organisations.

The national government followed the formal procedure of 'the Key Planning Decision (PKB)' to structure the spatial planning process. The PKB3 on the Betuweline was published in May 1993. The total costs of project execution were estimated at € 2,832 bn. The higher cost estimates stemmed mainly from scope-expansion (the project now included the improvement of the Harbour-line connecting the existing passenger line with the Rotterdam harbour area) and change of scope (the project had been transformed from the upgrading of the existing passenger track into a new dedicated freight railway line). This change was symbolised by a new name: 'Betuweroute' (we will use 'BR' as abbreviation) instead of 'Betuweline'. Furthermore a lot of additional measures concerning environmental aspects were included: noise screens, measures avoiding the fragmentation of the 'community landscape', measures to protect soil, water and nature. Various demands from local stakeholders in the Provinces of Zuid-Holland and Gelderland however still had not been addressed in the revised project – measures needed to address their demands were said to be too expensive. In the Province of Gelderland especially, the local politicians did not accept this view. As a result they continue to urge the Ministry, politicians and project organisation to take additional mitigating measures.

The National Parliament discussed PKB3 in various sessions. Their amendments led to further scope changes and, in parallel, to further increasing cost estimates.

Added project elements like the Kortsluitroute (a connection with existing track in the Rotterdam area), a tunnel at Zevenaar, lowering the track at Schelluinen, and building a tunnel-roof at Barendrecht caused a cost increase to € 3,239 bn. However amazingly, there was no discussion about the line as such – a discussion on whether the line should be built at all was apparently regarded as neither necessary nor opportune. The final version of the PKB (number 4) was approved by Parliament in April 1994. In May 1994 PKB4 for the BR was published in the official journal for government announcements ('staatscourant'). The execution of the Betuweroute could formally begin.

In 1995 a new government was elected. It had serious doubts on the added value of the BR in relation to its cost. Political parties that previously opposed the project now became part of the government coalition. As a result of negotiations leading to the formation of the government it was decided to reconsider the decision to execute the project. To investigate the matter an independent research committee, the 'Hermans' Committee' was set up.

The Hermans Committee recommended that the line should be built but that several additional requirements needed to be met. One of these requirements was that several additional measures ('flankerend beleid') needed to be taken to stimulate the use of the new track. The decision to build the line was seen as 'strategic', a connection of Rotterdam harbour with Germany and to achieve a modal shift from road to rail. The initial goal to focus on 'economic return' was discarded by the Committee. The report was published in January 1995 and, based on the report, the new government concluded that it was necessary to increase stakeholder support ('draagvlak') for the BR. This was to be done by taking further measures to meet local stakeholder interests.

Based on the report of the Hermans Committee major additional scope changes such as a tunnel at Giessen and the Pannerdensch Kanaal were proposed by Parliament and accepted by the Minister. It was also decided that the route would not contain 'same level' crossings with other infrastructure. The cost estimate rose to € 3,744 bn. It is interesting to note that during the discussion of these scope amendments in Parliament, the Minister set the € 3,744 bn. as a maximum budget, with parliament to decide on what elements the additional budget would be spent.

The Hermans Committee marks a key event in the history of the project. Not only did the overall goal of the project shift from 'economic return' to 'strategic investment' but, with the discussion in the Parliament, the conflict between the local stakeholders and the government now seemed to come to an end. The main stakeholder 'arena' of the project shifted to that containing the Ministry of Transport and ProRail.

Round 2 The continual story of ongoing cost overruns 1995-2000

Based on the new decision of the government, the Project Plan ('Project beschrijving') was published in November 1995. Even before this was published there was a discrepancy between estimated costs and the allocated budget. The project budget was handed to the Ministry of Transport while the cost estimates were made by the project organisation within ProRail, a newly formed public body responsible for the management of rail infrastructure. ProRail is one of the separated parts of the former Dutch Railways (NS). ProRail was responsible for the execution of the project. Within the Ministry of Transport a separate unit was set up to control the execution by ProRail. The starting budget for the BR was € 3,744 bn. The BR project was also selected as a 'major project' which meant it would need to follow new specific guidelines in future communication with Parliament. For example, the project needed to present a six monthly progress report to the House of Representatives.

In April 1996 the BR project manager within ProRail reported to the Ministry that the costs were expected to be € 425 mln. higher than the allocated budget. The difference resulted from unprocessed price level increases, unapproved changes in scope, approved scope changes and extra costs for archaeology and cleaning of soil contamination. During the next years the difference between cost estimates and the budget grew quickly. The 'cost overruns' became a permanent topic of discussion between the ProRail BR project organisation and the Ministry of Transport. Various attempts were made to resolve these financial problems.

The first attempt to resolve the problem, called re-calibration ('herijking'), took place in 1998. In April a new cost estimate was presented by the project organisation. The project now would cost € 4,506 bn. The approved budget at this point, which was used as a reference, is € 4,138 bn. (PR4). This meant an outstanding deficit of € 368 mln. The Ministry and ProRail decided to develop an 'Action plan' to tackle this problem. Both parties tried to define "A final and definitive scope definition" (PvE) and "A final cost estimate" based on this scope.

During the discussion with ProRail the Ministry's position was that it would only accept cost estimates at or below the current budget of € 4.138 bn. They considered the budget as a fixed ('taakstellend budget'). The fixed budget approach was a key issue for Minister (of Transport) Netelenbos. She reasoned that such an approach would stimulate infrastructure project organisations to find alternative solutions when overruns occurred. Another reason to stick to the budget was that she wanted to introduce a more formal steering relationship between the Ministry and ProRail, since ProRail was now an independent – but still government owned – company. However if the budget is fixed, large cost reductions and scope decreases are the only options left open to provide relief. After negotiations between the Ministry and the project organisation, an agreement on cost reduction was signed in October 1998. This

agreement is generally referred to as the 'Malle Jan' agreement, named after the hotel it was signed. This document covered the agreement between the Ministry and ProRail on the fixed budget of € 4,138 bn. The agreement is based on 'a sober design'. None of these design changes however were reported to Parliament even though some were a change in the project functionality which was subject to approval – and formally only can be changed – by parliament. Apparently, the fact that the budget had remained fixed, was seen as more important than the decreased functionality of the new line.

However the process of increasing costs did not stop. In September 1999 the sponsor of the BR within the Ministry sent a letter to his Minister reporting this. The new budget deficit was € 180 mln. Asking for more money in Parliament was not regarded as a feasible option, because the Betuweroute already had a reputation as a 'major budget overspender'. Instead the Ministry and ProRail stated that a lot of apparent additional costs for extra price level increases, the booming construction market, effects of new jurisdiction, changes in legislation, slower procedures for permits and spatial planning and opposition of citizens, were uncertain but were likely be covered by the current budgets.

By October 1999 the estimated costs were € 4,479 bn. while the budget was € 4,281 bn. Again a large part of the deficit resulted from scope changes. But this time the budget and scope changes were reported to the House of Representatives in August 2000. The new measures agreed, tightened the budget constraints on the project even further because the budget for unforeseen costs was partly applied and the price level for Engineering Administration and Supervision (EAT) and for unforeseen costs was fixed. However at the start of the project the budget for unforeseen costs was meant to serve as a buffer to deal with the construction costs and not to fund 'scope' additions. The former project director within ProRail commented on the project budget:

> *The budget for unforeseen costs of 10% was meant to manage changes in the contracts for contractors and not to fund scope changes. The strange thing was that the original cost estimates used a margin of +/- 20%, but these margins were never added to the budget. There was never any budget to deal with 'external developments'. This meant the budget was basically very tight from the beginning.*

The new budget tension was resolved in a new agreement between the Ministry and ProRail. This agreement is generally referred to as the construction budget ('Aanlegbegroting'). The new agreement also contained the new master plan, with a completion date of July 2006. The budget increases and scope changes were reported in PR8 which was published in August 2000 .

In the public debate since 1993, BR has become almost a synonym for cost increases in relation to scope-changes. Several scope changes have been reported to Parliament, combined with requests for additional budget. Other changes, such the functional reductions to stay within the budget and the use of financial reserves have not been reported to, nor approved by Parliament.

Reviewing this round we see that the public management of the project was facing severe pressures. Externally driven scope changes as well as an immature project control in this period of the project together created a large upwards pressure on the budget. At the same time there was a clear tendency to put new demands on the project, without providing additional funds. These two pressures on the policy system of complex project development came into conflict at the interface between the Ministry of Transport (as sponsor of the project) and ProRail (as project director). The quality of this interface had to be exceptional to deal adequately with these pressures. In this case two agreements, 'Malle Jan' and 'Aanlegbegroting', were used to deal with these tensions. The agreements are somewhat ambiguous: ProRail did not feel committed to several measures taken to reduce the cost increases, because the measures are seen as impossible to realise. The Ministry however assumed that ProRail was fully committed to the fixed budget. The project director within ProRail on these agreements:

> *The tension became so high we needed to do something. We developed a plan containing measures to stick to the original budget. I thought that was a good objective and I was willing to do everything possible to accomplish this. That is why I signed the agreements. On the other hand I realised that these measures were very ambitious, so I could not promise anything.*

The different perceptions clearly are related to the position of both parties in the policy field. ProRail had to build the line and felt the effects of a fixed budget. The Ministry still had to propose unwanted budget increases to Parliament which were unlikely to gain support. The upside of the agreements, however is that the project was allowed to continue. It is clear to all parties that a further delay would have led to more additional cost increases. This however will be different in the third and final round. In this round the clashes in the various arenas of stakeholders are 'damp squibs': the project can finalise its work in a relative quietness. At the same time however, the negative public image of the project as a synonym for a cost and planning disaster remains present.

Round 3 A contaminated project realised within its budget 2000-2007

In the six monthly reports of ProRail to the Ministry in 2000, ProRail used its own estimate of the project costs. By doing so, ProRail questioned the reality of a fixed budget. As result the Ministry ordered ProRail to make a plan to resolve the new incompatibility between budget and estimated costs. There was intense discussion between Ministry and ProRail. The deficit however reached € 272 mln. by the end of 2000. Some of the causes include extra costs resulting from EAT ('Engineering Admistratie en Toezicht'), market changes influencing the costs of the superstructure, and Tunnel Technical Installations (TTI).

In July 2001 a report of AT Kearney on the budget tension at BR was presented. The conclusion was that there is still a deficit of € 348 to 443 mln. Several measures of cost reduction were proposed. For example the sponsorship of the BR was to be transferred from the Policy Department to the Department for Public Works and Water Management (RWS). RWS has a long history of project directorship and contracting out, that is why they were considered a capable and qualified sponsor for the project.

In July 2002 a new national government was formed. A new budget overview for large infrastructure projects was undertaken including the BR. Within the Ministry it was decided to propose the creation of a combined risk reservation for the projects BR and HSL-South. After risk analysis on both projects it was suggested to make a reservation of € 985 mln. This proposal led to intensive discussions in Parliament in October 2002. Even though the reservation was described as "unacceptable" by the House, the Minister of Transport decided to proceed with the decision.

During the following months and years, after the introduction of the risk reservation, the attention given to the costs and scope of the BR diminished. The project was controlled well, disturbing external events were absent and as a result, the budget increases only came from regular yearly price level updates and minor additions. Furthermore the project management was facing the happy circumstances of economic recession, which led to a quieter market in the building industry. The tender procedures resulted in lower cost contracts. From 2004 on ProRail was able to refund part of its budget to the Ministry. Expenditures were under control, thanks to the improved project management, the absence of major scope changes and favourable market conditions. The risk reservation was used for only one major change: costs of the Tunnel Technical Installations. The budget refunded by ProRail had risen to € 350 million in 2007.

The only other topic concerning the BR that remained an issue in the public debate was the preparation of the operational phase: who should operate the track? After various changes it was decided that a consortium called Keyrail will operate the track for the first five years. The consortium comprises ProRail and the Harbour companies of Rotterdam and Amsterdam.

In 1995 the budget was € 3,744 bn. The actual costs in 2007 were € 4,663 bn. This implies a cost overrun of € 919 mln. Most increases can be explained by regular price increases and approved scope changes. The amount of real cost increases is below 5%. This could lead to the conclusion that the project has largely stayed within budget since 1995 (Westerveld and Flyvbjerg, NRC, 2007; Flyvbjerg, 2007). In large sections of politics, the media and society, however, the project is still regarded as a financial disaster. This is curious and becomes even more curious if we see another project facing much more cost overruns such as the High Speed Line South.

3.2 HIGH SPEED LINE SOUTH

The first project, the Betuweroute, is the biggest freight railway project ever undertaken in The Netherlands. The second project we will now describe, the High Speed Link South (HSL-South), is the biggest passenger railway project ever undertaken in this country. We will outline the project history and show some of the main historical events that the management of the project needed to deal with over time. The facts and figures are largely based on the NETLIPSE report on the HSL-South. The storyline is largely based on the TCI report, interviews and our experiences as consultants working with the project delivery organisation.

On a strategic level the HSL - South is considered to be of great importance to The Netherlands by providing a fast and comfortable train connection with other European countries and as being necessary for the sustainable development of The Netherlands. A high-quality link of The Netherlands to the European network of high speed rail tracks was felt to be indispensable. As the official Key Planning Decision document (PKB3) on the HSL states:

> *"The completed high speed connection will accommodate growing mobility and will contribute to the transfer of road and air traffic to rail traffic."*

The HSL-South project's scope consists of the building of a high speed railway line from Amsterdam to the Belgian border with stops at Amsterdam, Schiphol and Rotterdam. Part of the project comprises a shuttle connection between The Hague and Breda. At the Belgian border; the HSL connects to the Belgian and European network of high speed lines.

3.2.1 Project Facts & Figures and stakeholder constellation

The High Speed Line – South (HSL - South) is a two track high speed railway line that runs over 125 kilometres. 85 Kilometres of the line is newly built high speed rail track, the other 40 kilometres utilises existing track. The new tracks are built using high grade technology for the foundation, electrification and signalling of the track. The design and use of this technology makes it possible for high speed trains (HST's) to travel along the track at speeds of 300 km/h and above. Unique to the project is its construction on soft soil and the 170 civil structures such as tunnels, bridges, flyovers, dive-unders and aqueducts that enable trains to travel at high speed.

The track of the HSL-South is shown in figure 3.3.

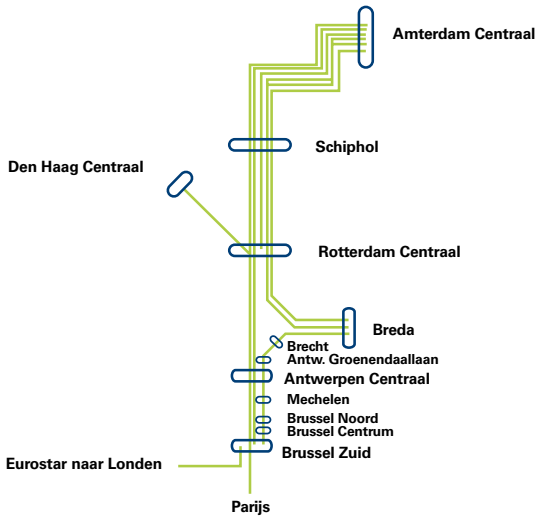


Figure 3.3: The HSL-South

The Ministry of Transport serves as the civil principal of the HSL- South project. The responsible politician for the execution of the project is the Minister of Transport. The Minister reports on the project to the House of Representatives ('Tweede Kamer') by publishing a progress report every half year.

In 1996, the Minister of Transport decided to create a relatively autonomous project organisation for constructing the line. The Project Organisation HSL – Zuid as it was called, was part of the Directorate General Passenger Transport (Policy) within the Ministry of Transport. As of 2001 the HSL – South project was split. The substructure contracts were managed by the Directorate General Rijkswaterstaat which is the department responsible for public works. The infraprovider (infrastructure provider) contract and the transport contract remained with the Directorate General Passenger Transport. In 2007 this was changed again: now full responsibility for the whole project is with Rijkswaterstaat.

The project director of the HSL-South within the Ministry has full responsibility for the realisation of the project. For the turn-key delivery of the line, the project organisation is responsible for safety, access and system integration, which means – making sure that a functioning transport system, which is able to run passenger transport, is completed. During the construction phase, the project organisation managed the contracts with all subcontractors, the building consortium 'Infrarail', the smaller contracting firms that build the connections to existing tracks, and the superstructure contractor 'Infraspeed'. As the construction of the substructure and superstructure has been completed, different parts of the organisation have been merged and others have been shut down. The Project organisation 'HSL' is shown (figure 3.4) as between 2002 – 2004, while the line was being constructed.

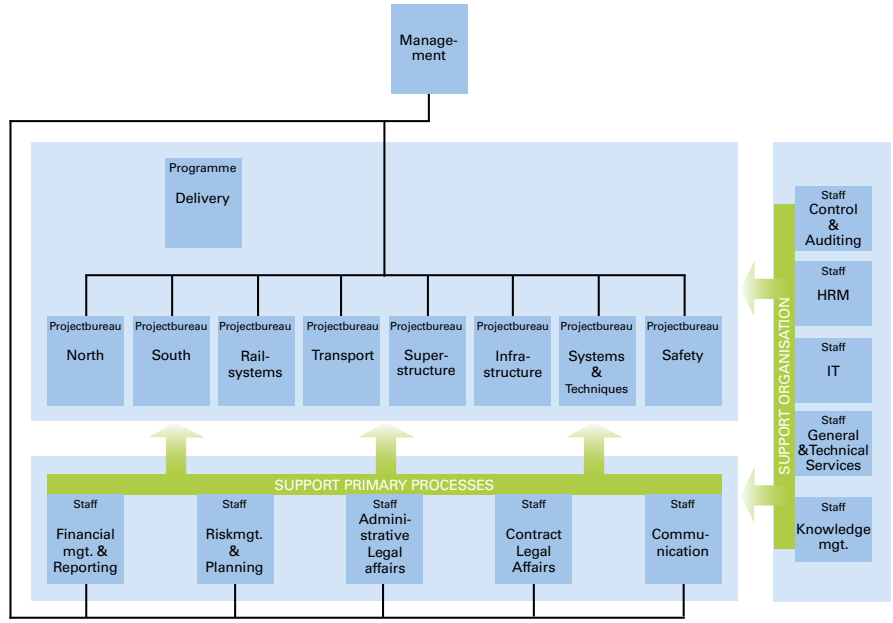


Figure 3.4: The HSL-South Project Organisation (2002-2006)

There a wide variety of stakeholders represented in the HSL-South project. The main stakeholders are shown in figure 3.5.

Figure 3.5.: Stakeholder network at the HSL-South

One of the strategies within the HSL – South project delivery organisation was to replace the traditional way of contracting large infrastructural projects by innovative ways of contracting such as Public-Private-Partnerships (PPP). The model for contracting has been heavily influenced by the policy paradigm of working closely together with the private sector (market). For the different parts of the project, such as construction, maintenance and transport, different types of contracting were used: Design & Build (D&B) and Design, Build, Finance & Maintain (DBFM). As a result of this philosophy a contracting model was developed. The model is shown in figure 3.6.

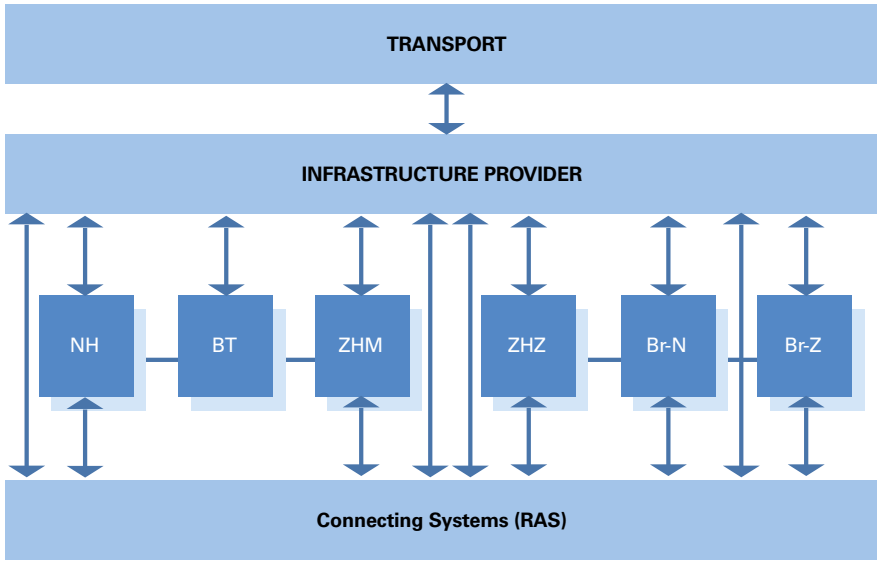


Figure 3.6: Contracting model HSL-South

The Ministry of Transport chose to divide the construction of the substructure into six Design & Build contracts, and one contract for the connecting systems (RAS). For the entire superstructure, a Design, Build, Finance and Maintain contract was awarded to the consortium Infraspeed after a public call for tender. Infraspeed is paid a performance fee and needs to design and construct the superstructure within 5 years. In addition they are responsible for 25 years of availability of the HSL infrastructure. During this time they have an obligation to guarantee 99% track availability.

The transport concession agreement has been awarded by the Dutch government to Hispeed (formerly the High Speed Alliance) after a public tender, for a period of 15 years. This PPP-contract is the second largest ever agreed in The Netherlands. Hispeed is an alliance of the Dutch Railways (NS) (90%) and KLM (10%). The carrier has an obligation to take care of national as well as international high speed passenger transportation. For the use of the infrastructure the carrier will pay a user fee to the state each year. International train operating companies such as SNCF (France) and NMBS (Belgium) using the HSL infrastructure pay an access fee to make use of the line. By contract agreement, Hispeed is responsible for business preparation (including rolling stock procurement and admission) and the state is responsible for timely provision of infrastructure and capacity allocation.

Infrastructural management for the HSL is undertaken by the state owned railway infrastructure management company ProRail. Management tasks are the provision of administration services, capacity management, traffic management and traffic control.

Part of the project is connecting the HSL-South to the Belgian High Speed Line (which the Belgians call HSL- North). To be able to undertake this, a technical coordination group has been set up. In this way a cross border technical harmonisation process is facilitated.

In contrast to the Betuweroute project the local communities and the Provinces have been mostly co-operative towards the project. But this does not mean that mitigating measures were not discussed and approved by the House of Representatives during the planning phase. Negotiations took place on how to adapt the new line to fit the existing landscape. But it is important to note that during these discussions little political controversy occurred – certainly in comparison to the BR project described in the previous section. Possible explanations for this are:

1 The added value of a passenger railway compared to a freight railway is more easily recognisable to the general public;
2 The HSL-South does not cross the politically sensitive 'river area' but is bundled with the A4 and A13;
3 The BR served as a distraction from the HSL-South proposals.

We now present the storyline of the HSL-South.

3.2.2 Storyline HSL-South

The idea of a high-speed rail line for The Netherlands was first mentioned in 1973. At this point (January 2008) the scheduled project completion date is October 2008. In the storyline the project is described by using seven distinguished rounds. In each of the rounds the area of interest and the involved stakeholders change. The storyline of the project runs to 2004.

Round 1 European ambitions *1973 - 1988*

The first round of the project mainly takes place in the European arena. The Dutch cabinet's international ambition was translated into national policy documents. As we

saw with the Betuweroute project, preferences stated during the very early stage of the project, such as the decision to build new infrastructure and not use existing one, will turn out to be very influential in the later rounds.

The idea of a high speed rail line for The Netherlands was first mentioned in 1973 when the Ministries of Transport, Public Works and Water Management (Ministry of Transport in short) and the Ministry of Housing, Urban Development and Environment established a working group which was asked to develop a proposal for a high speed rail track between Amsterdam, Rotterdam and the Belgian border, with the possibility of a stop at Schiphol. As a result of this, the so-called AmRoBel-report was published by the working group in 1977.

In 1979 the Ministry of Transport published its first national traffic and transport scheme (SVV1). The report stated: "when a West-European network of high speed rail is completed, the Dutch cabinet judges a link connecting The Netherlands to this network to be desirable." And: "The option to provide a high speed rail connection between Amsterdam-Rotterdam-Belgian border and beyond and Amsterdam/ Rotterdam Utrecht-German border and beyond, will be kept open". A high speed train could provide an alternative to airplane traffic and road traffic.

In 1984 the PKBA (Paris, Köln, Brussel, Amsterdam) project was set up. This was a collective initiative of The Netherlands, France, Germany and Belgium to establish a HSL network, which was supported by the EU. The PKBA working group presented a feasibility study in 1986 in which four possible alternatives for connecting the cities were presented and compared. The European Commission supported this initiative. It is important to note that the comparisons showed that building new infrastructure north of Brussels was not expected to be very profitable.

In 1987 the Minister informed the House of Representatives by letter of the results of the PKBA project. The letter confirmed the intention to build a HSL line. Although the decision on which type of track to build was not taken, it was clear that newly build infrastructure was the preferred option. In this letter the Minister also informed the House that work on the Starting Document ('Startnotitie') would begin. Later during 1987 the Starting document for the HSL was published. With the publication of this document the formal decision procedures for the HSL started which would include the Key Planning Decision ('PKB'), the Route Decision Procedure (Tracéwetprocedure), including an Environmental Impact Assessment ('MER').

Round 2 A false start to the planning process *1988 - 1992*

During the second round, the national planning process for the HSL-South was started. But the first activities, mainly concerning the planning of the route, turned out not to be very successful since they met a lot of resistance in public debate. During this round, tension becomes visible between the Cabinet's international ambitions and the local interests of municipalities and civilians. This conflict finally results in a new start to the planning process.

In the second national traffic and transport scheme (SVV2), on which discussion started in 1988 and which was approved in June 1990, the building of an HSL is confirmed. The cabinet's international ambition is thus confirmed by the Dutch Parliament. Shortly afterwards, the European Union decided that – based on the PKBA study – further research would be needed to define the optimal routing and suitable financial and legal structures. This was to be done by co-operation between the national railway companies. Private funding was regarded a serious option in the financial plans for the projects. The co-operation between the railway companies started with difficulty because both SNCF (France) and DB (Germany) wanted to chair the study. In addition, SNCF wanted to fund, construct and operate all new track in France which made co-operation more difficult. The results of the study showed that the return on investment for the Dutch and Belgian parts of the track is low compared to the return on investment for the connecting tracks in France and Germany. Based on the report, the EU Ministers of Transport agreed on a phased execution of the projects. For The Netherlands this meant that only a new line from Antwerpen to Rotterdam would be built, with a new track between Rotterdam and Amsterdam being constructed at a later stage. The 'intended' design speed of the track to Rotterdam is 300 km/h. The cost estimates (in SVV2) for the new line are around € 1,15 bn. of which 50% was planned to be financed by private funding.

The draft Key Planning Decision ('Ontwerp-PKB') was published early 1991. In PKB1, four alternative track options were presented. One alternative was using the existing track. This alternative was regarded as non viable however because it would not be able to compete with the timings of air services. The government supported the alternative of building a completely new line including a new connection between Rotterdam and Amsterdam. One of the reasons for including a new track for this part was a connection to Schiphol Airport. Apparently the rationale of a high speed connection to Amsterdam had changed. Now the preferred option was to build a high speed line to Amsterdam instead of stopping at Rotterdam. This resulted in higher estimated costs for the project. Within the government there was a large degree of support for building the new infrastructure with a high speed design. Only the Minister of Finance stated that the necessity of building a new HSL line was not sufficiently demonstrated. However the council of Ministers decided to approve PKB1, including the connection to Amsterdam. The estimated date of completion of the project was to be 1999 and the costs were estimated a little over € 1,36 bn. Just € 1 bn. would be publicly funded, the additional money required being funded by government loans and/or private investment.

PKB1 was not well received by the public stakeholders. Most criticism was focused on the lack of justification for building the line and the impossibility of making an accurate comparison between the preferred alternative and the alternative of using the existing track between Amsterdam and Rotterdam (via The Hague). At the same time there was still no agreement between The Netherlands and Belgium on the preferred routing for the southern part of the route. Based on these two developments the Minister of Transport decided to restart the PKB procedure. This meant a large part of the planning procedure would need to be done again which caused a major delay in the project.

Round 3 Silent preparation *1992 - 1994*

During 1992-1994 the project HSL-South was not visible in the political arena. The Ministry of Transport's focus during this period was on writing a new draft PKB1 document. The procedure was undertaken much more thoroughly than previously. A separate project organisation was formed and a communication plan was developed.

Main topics addressed in the new PKB were:

- The business case (including forecasts of the number of passengers)
- Negotiations with Belgium about the routing

External studies, commissioned by the Ministry of Transport on the business case, showed that the alternative with a completely new track had the highest return on investment but without providing much added value in comparison to other alternatives which needing less investment – such as building a connection only as far as Rotterdam. In addition the reports confirmed that much of the benefits of a completely new track would be realised in Belgium and France.

In the period 1992 to 1994 there were intensive negotiations with Belgium on the preferred routing. The Netherlands favoured an alternative in which the HSL was aligned parallel with the A16 motorway. The Belgian parties (Flemish government, NMBS/SNCB and the federal government) preferred a connection through the Antwerp harbour area which was shorter and therefore cheaper to build. To break the deadlock in the negotiations, the Dutch stakeholders investigated possibilities to meet other Belgian desires such as the deepening of the Westerschelde, in order to encourage Belgian co-operation with the Dutch preferred HSL route along the A16.

In March 1994 the government decided on the preferred routing (alternative 'A1' for the Northern part and 'F' for the Southern part). The new routing was largely similar to the one presented in 1991, but important improvements had been made to meet the demands of citizens, landowners and environmental protection groups. These changes made it necessary to raise the budget to € 2,67 bn. The PKB also described the importance of separating the financing, building and operation of the high speed line.

In 1994 a new government was formed. The government declared it 'confirmed the plan to build the HSL and the preferred route'. This small sentence was a firm statement of support for the project. It also somewhat conflicted with the PKB procedure which forms the legal framework for the decision making process, aimed at protecting the rights of the stakeholders. The PKB-procedure was not completed at the time the government issued its declaration.

Round 4 Debating the project scope *1994 - 1996*

The new PKB1 was sent out to the public in May 1994. After this, a broad public debate including the public, governmental advisory boards and other organisations was started in the period 1994-1996. At the same time there were talks and negotiations with local stakeholders such as communities and Provinces which were affected by the new line. This led to additional research on possible alternatives.

In this subsequent round of consultation, the public still doubted both the economic viability of the line and the strategic decision to build a completely new track. However the governmental advisory boards were more positive on this issue: it seemed obvious and essential to connect the Dutch railway network to the European high speed network. On the other hand the advisory boards did not agree with the preferred route for the track north of Rotterdam.

Further research was mainly focused on the northern part of the route. New possible alternatives were investigated such as the 'Bos alternative' (developed by a private citizen) and an alternative developed by Delft University of Technology. The Ministry of Spatial Planning and Environment (VROM) within the public side of the project was the prime mover in stimulating the search for alternatives. The main reason for their doing so was that the VROM was unhappy that the northern part of the railway was planned through the so called Groene Hart ('green heart') area. This area is a main area for nature and landscape protection between the major cities of Amsterdam, Rotterdam, Utrecht and The Hague.

The 'Bos alternative' was developed by a member of the public in the early 1990s and had the advantage that it avoided the Groene Hart by using a route along the existing highway A13 and A4. Wim Bos submitted his alternative once again in the public consultation of 1994. The Committee for Environmental Impact Assessment (Commissie m.e.r) strongly supported investigating this option further. The further investigation was carried out by the HSL project organisation.

After this detailed investigation, the Bos alternative was publicly supported by the Minister of VROM because it provided a different, more environmental friendly, crossing of the Groene Hart. Because of this support, the alternative was 'additionally' entered into the PKB procedure, which meant that a supplemental EIA was executed

and additional public consultation took place. This late entrance of the alternative into the procedure was not appreciated by the Ministry of Finance who were greatly worried about the much higher costs (the expected added costs for the Bos alternative were € 540 mln.). The alternative did not gain significant public support as evidenced in several public hearings.

The reason for the lengthy public debate (2 years) about the Bos alternative was that until final negotiations were complete with Belgium the final routing of the track could not be decided. The fact that negotiations on the agreement took a lot of time, gave plenty of opportunity to discuss the pro's and con's of the Bos alternative.

Finally, in 1996 Belgium agreed that the track from Rotterdam to Antwerp would be aligned with the A16 motorway. Belgium would receive € 380 mln. (excluding interest) as financial compensation for additional costs incurred. The financial compensation, as well as the routing decision, was included in the 'HSL treaty', signed by both Belgium and The Netherlands on December 21st 1996.

Round 5 Public decision making *1996*

After the publication and consultation on the PKB1, the government and House needed to reach a decision on the project. This decision making process can be separated into two phases. In the first phase it was decided if the extra studies provided enough argumentation to revise the previous government point of view – which selected alternative A1 to cross the Groene Hart. During the second phase the complete PKB would be discussed within the government and finally with the House.

The idea of crossing the Groene Hart with a tunnel became a serious option in early 1996. Just like the Bos alternative, the tunnel alternative was supported by VROM who wanted to preserve this area. The tunnel alternative had a further advantage in comparison to the Bos alternative – travel times would be much shorter.

In March 1996 the government met to formulate its view on the route. In this meeting the Minister of VROM and the Minister of Transport presented opposing views on the preferred route. The Minister of VROM supported the Bos alternative, the Minister of Transport the original planned route.

A few days after the government meeting, the alternative of a tunnel was publicly mentioned as a possible solution by Prime Minister Kok. In a second government meeting the tunnel option was then selected as the preferred routing which caused the expected cost to increase by € 380 mln.

Intermezzo: the further story of the Groene Hart tunnel
The bored tunnel decision for the Groene Hart became the topic of further discussion within the House of Representatives in 1998. In the period between 1998 and 1999 the alternative of a shorter tunnel was seriously investigated. However mainly because of practical arguments – the tender process had already been completed and a change would mean a delay – the original decision was maintained. The final decision on the matter was communicated to the House in July 1999 – the final debate on the matter, the Groene Hart tunnel was to be built.

The extra € 240 mln. for mitigating measures and extra 380 mln. € for the tunnel mean that the budget had now reached a level of € 3,4 bn. This is, according to the Prime Minister, the 'absolute budget ceiling' for the project. It was at that moment still unclear how the additional budget would be financed. After the separate government discussion on the northern part of the route, the whole PKB3 was approved by the government on May 20, 1996. Shortly afterwards PKB3 was sent to the House of Representatives. At that same time the Flemish administration had formally approved the routing between Antwerp and the Dutch border. This confirmed the agreement between The Netherlands and Belgium.

Because the House of Representatives felt overloaded with information it decided that before the political discussion on PKB3, a quick study of the proposed alternatives needed to be made by an independent party. This study showed that the alternatives were often hard to compare and that none of the proposed alternatives could be described as the 'best alternative'.

The PKB was first discussed in the House on October 28th 1996. During the debate, more information on the financing of the project was requested from the Minister – to make a comparison of the proposed investment with other possibilities possible. The financing of the project was not a major issue in the second discussion in November 1996. But in the following years, the financial consequences of the HSL would be heavily felt by other planned projects. In the discussion on PKB3 the majority of the discussions related to the proposed preferred route alternatives.

One of the discussions in the House concerned the design speed. One of the members of the House argued that a design speed of 300 km/h is not needed for parts of the track such as in the Groene Hart tunnel. Her arguments appeared valid but did not lead to a different Ministry view. The original preference – see round I – a design speed of 300 km/h – on a newly built track appeared to be fixed and not debatable.

The main topic of discussion remained the preferred route between Rotterdam and Amsterdam. The discussion focused on comparing the preferred A1 alternative

(including the Groene hart tunnel), the Bos alternative and the alternative that made use of the existing track between Amsterdam and Rotterdam.

The political parties in the House were completely divided on the issue. A majority seemed to support the Bos alternative. So did several important public organisations. This support did not convince the Minister of Transport. After the first debate in November, a period of negotiations within the government took place in which proposed amendments of the House were discussed. The outcome of the discussion was that the A1 alternative would be chosen and that only limited additional House amendments would be approved, the total budget for the project remaining the same. Basically the government opted to follow its own preferred alternative, causing large dissatisfaction among the members of the House. It looks as if the government used political pressure, often not visible to the public, to convince certain parties to change their opinion. The House seemed to have a very limited room for manoeuvre in trying to change the preferred government alternative. Based on the adapted government view the final debate took place on December 16, 1996. At the end of the debate, PKB3 was approved by the House which meant that the project would enter its next round.

Round 6 Project preparation *1997-2000*

After PKB 3 was adopted, a new judicial procedure called the Route Decision ('Tracèwet') commenced. This procedure was meant to decide on the exact horizontal and vertical alignment of the HSL. Preparation started in 1997. At the same time work was started on preparing the operational phase of the track (i.e developing the business model), technical preparations and the setup of a project organisation.

The route decision, which did not have to be approved by the House, was taken in April 1998 by the Ministers of Transport and VROM. In the route decision almost none of the proposed amendments of the House can be seen.

In regard to the project delivery organisation, it was decided in January 1997 to combine the highway reconstruction of the A16 and HSL-South into one project. A discussion was held about who was to be responsible for delivering the project. Alternatives were the Dutch rail infrastructure manager RIB (currently named ProRail), the department for public works ('Rijkswaterstaat'), or a special HSL-South project organisation within the Directorate of Passenger Transport (DGP). The final decision was that a separate department, with its own project director, would be responsible for the project (see facts & figures). This decision meant that the project organisation would require a high number of external consultants to man the project organisation (on average around 90%).

In June 1998 concerns arose regarding the financial control of the project. This concern resulted in separate investigations. The reports which were published, based on these investigations, contained heavy criticism on the quality of project control. Later, in April 1999 an external audit performed by AT Kearny confirmed that the project could not be completed within budget and or the set time schedule. According to the report, the main risks to the project included the steering relationship within the Ministry, as well as co-operation with parts of the former Dutch Railways (NS) such as RIB. Based on this report the decision was taken to split the organisation of the HSL-South into a 'policy part' – responsible to the Directorate General Passengers (DGP) within the Ministry of Transport and an 'execution part' – responsible to the Department for Public Works (RWS). In addition a steering committee was set up to monitor large infrastructure projects. As a result of the split, responsibility for contracts for superstructure and transport passed to DGP while the contracts for the substructure were managed by RWS.

During this period, the new Minister of Transport employed the policy of working with a fixed budget ('taakstellend budget'). The first report on a potential cost overrun concerned the costs of the planning procedures up to PKB3. These costs of € 45 mln. were not part of the project's cost estimates. This does not lead to a budget change however. Actually in the years of preparation (1997-2000) the progress reports (PR) for the HSL-South show no budget increases apart from the annual price indexation. PR5, mentions a 'budget tension', a Dutch phrase for a difference between cost estimates and the approved budget. Nothing is mentioned on the extent of the tension. In discussion of PR6 the Minister states that the tension is around € 91 mln.

In the year 1997 work starts on the preparation of the operational phase and the formulation of a contracting strategy. An important goal of the contracting strategy is achieving the highest possible amount of private funding for the project. To achieve this, the project organisation looked at experiences in the UK with Private Finance Initiatives (PFI) and starts with the requirements definition of the HSL transport system. The first goal of the Minister and project organisation is to tender the whole transport system so as to attract private funding. The market is tested in a consultation round. The conclusion of this consultation of market parties is that there is not much interest in investing in the total transport system because the perceived risks are too high. Instead market parties seem to be more interested in a contracting model in which the several parts of the transport systems are split. According to market parties the central government will need to play an important role as a 'principal' for each of these projects. Basically this also means that the government is responsible for the interfaces between the various contracts.

In January 1999 the project organisation presents an ambitious strategy to the House of Representatives regarding the involvement of market parties in the project. The strategy is to transfer responsibilities and risks to the market parties by using innovative contracts:

- A Design, Build, Finance and Maintenance (DBFM) contract for the superstructure;
- A concession agreement for the transport;
- Several Design and Build contracts for the substructure.

Tendering the whole transport system in one PFI-contract is not regarded as feasible.

The tender procedures for all contracts are started in February 1999. It will be the largest tendering of projects ever undertaken within The Netherlands. As a consequence, the stakeholder arena shifts once again, this time towards the relationship between the Ministry and project organisation on the one side, and the contractors on the other side.

Round 7 The contracting issues of a mega project 2000-2004

In 2000 a new phase was entered in which the project was built. One of the key challenges turned out to be the management and tendering of the contracts and above all managing the key interfaces between the various contracts. The arena of importance was mainly occupied by the Ministry of Transport, project organisation, contractors, and – at a distance – the House of Representatives. The main discussions during this round concerned the 'mega' contracts on substructure, superstructure (infraprovider) and transport.

Of the three main contracts, the substructure was the one which was prepared and tendered first. Later the 'infraprovider' contract and transport contract were tendered and awarded. To provide a better overall view, we use an approach in which we describe each type of contract separately.

1 Substructure

The conditions for tendering the substructure are not too favourable in early 2000. This was due to several factors: a period of economic growth which raised prices, because of labour shortages; at the same time various other large contracts were also tendered – such as the Betuweroute. In addition the size of the contracts meant that only limited competition in bidding was possible. These and other factors led to bids in September 1999 that are far above the previously calculated cost estimates for the contracts (in total 43% higher). A special task force is formed to develop an action plan to deal with the disappointing results. The taskforce investigates the possibilities for stopping the tender procedures and restarting them. Also the possibility of tendering the scope of work in a more traditional way is investigated.

An analysis of the high bids shows that the cost estimates were accurate regarding direct building costs. The main reason for the increase in bids lies in the overhead percentages ('staartkosten') that are calculated for indirect costs, risk pricing, price increases and profit. The contractors state that these costs are higher than usual because of the transfer of risks.

The high bids were not directly reported to the House. In the PRs it was only stated that

the tender process for one of the contracts had been stopped because of unacceptable bids. The enormous potential budget overrun was not referred to.

Afterwards, informal discussions are started with contractors. At the same time the project organisation investigates solving the disputes by means of arbitration. However, after a first lower bid for the total amount of the contracts, the project organisation sees a possibility for reaching an agreement. Because of this, the planned meeting on arbitration is postponed in November 1999. Instead two day sessions are planned with senior delegates of the contractors and the project organisation to discuss the possibilities of lowering prices. These sessions fail to meet the requirements of the project organisation because major cost savings are still hard to achieve. As a result the informal negotiations are stopped. The dispute will now to be resolved with arbitration.

The arbitration ruling is that the project organisation will need to restart the negotiation for the contract of 'Noord Holland'– which was previously stopped because the bid was too high. After further negotiations the contractors send in their new bids, for all substructure contracts, in February 2000. These still amount to € 363 mln. more than budget. On some contracts there has been only minimal progress. Both contractors and project organisation however are keen to make a final deal – which should use an incentive structure to optimise the building process and achieve the best results. With this in mind, a special working committee is set up with members from both sides. The committee appears to be the key to success: a final deal is made on a total budget of € 1,88 bn. The 'intention agreement' between contractors and the Dutch State is signed in March 2000. The final estimated costs are still € 250 mln. higher than estimated, excluding 'moved scope' from substructure to infraprovider contract.

The next step is to translate the overall agreements into agreements on the separate contracts. This turns out to be a very difficult because according to the project organisation the contractors were reluctant to reach optimisations needed to meet the target in the agreement. Finally the total costs turn out to be € 2,0 bn. This agreement is signed on 16 July 2000. Because of the high time and price pressure to reach an agreement, the project organisation is not fully aware of the contracted scope, costs and risk distribution.

During the construction phase, pressure on the completion date of the project increases. This can be attributed to cash flow problems as well as delays in the tendering process. The potential delays are at odds with the strict agreement with Belgium that mean that a late completion will have large financial consequences. Finally the pressure becomes too much to maintain the original completion date of December 31st 2005. In PR8, the delay in start of the superstructure contract is mentioned and the final delivery date slips six months.

The budget increase, which was modest in the preparation phase, increases rapidly in the building phase. In PR7 (10-10-2000) the budget increases by € 1,24 bn. This is the

result of overruns on the substructure contracts (€ 600 mln.) as well as budget increases that result from increased scope on reconstruction of highways in the project. With these increases in scope it is not always clear however why they emerge at such a late stage and what the content of the added scope is. The House responds to these cost overruns by asking questions on the quality of estimates and proposes to investigate the quality of the project control.

2 Superstructure (infraprovider)

The superstructure contract for the HSL-South is one of Design Build Finance Maintain (DBFM). This means that a large part of activities and risks is transferred to the contractor. The superstructure (infraprovider) contract is the largest DBFM contract ever in The Netherlands and at that time was also novel in its contract format. At the end of 1999, the Ministries of Finance and Transport have strong ambitions and high expectations in the field of Public Private Partnerships (PPP). This ambition is reflected in the intention of DBFM for the HSL infraprovider contract. The basic idea is that the provider invests in the superstructure and will be paid based on the availability of the infrastructure with an annual fee. This means that the infraprovider is responsible for a large part of the risks during design, construction and maintenance. To calculate the potential added value of the DBFM contract, a Public Sector Comparative (PSC) study is used.

The invitation to tender for the contract is sent out to five consortia in November 1999. This results in three bids that, at first analysis, show disappointing PSC results. After some major modifications that result in lower bids, it is decided to continue the tender procedure. In a subsequent analysis the disappointing bids are attributed to high risk pricing on the contractor side, as well as flaws in the PSC calculations.

In June 2000 the two best bidders are invited to start negotiations with the State. The negotiations have the result that the State takes back several risks that it feels it can best control. The final bids are received in March 2001 – however still above PSC values. After some new negotiations in which efforts are made to lower the bids, the 'Infraspeed' consortium is selected as the preferred bidder. The price level is now comparable to the PSC value. Based on this price a memorandum of understanding and later the final contract is signed with Infraspeed. The basic agreement is that the Infrastructure provider 'Infraspeed' gets paid a maximum fee of € 117 mln. per year based on 99% availability.

Later analysis by the Audit Office shows that questions can be asked about the added value of the new contract form in comparison with a traditional contract format. Another element of criticism is the high number of external experts needed to manage the contracting process.

Although the DBFM contract means that some major risks are carried by the Infraspeed consortium, important risks remain with the State such as the risks inherent with the major interfaces with the substructure and transport contract. These risks later turn out to cause major problems for the project organisation. In addition significant problems will arise with the commissioning of the ERTMS signalling system.

3 Transport

The transport contract is the most important contract with regard to the stated project goals. It is meant partly to finance the budget of the construction project and it is essential in achieving the transport objectives.

In this regard the Ministry faces a dilemma. There is large political pressure to grant the transport contract to the Dutch Railway while on the other hand this might not be the best party to achieve maximum financial benefits and meet the demands for fair competition. The discussion regarding the transport contract is dominated by the tensions between the Dutch Railways (NS) and the Ministry of Transport. The NS sees the operation of the HSL for a prolonged period of time as a necessity to safeguard its future privatisation. The Ministry sees the HSL concession agreement as an opportunity to test its new 'client-contractor' relationship with NS. This tension is one of the main reasons explaining a highly difficult tendering process which takes more than two years.

The basis of the tender process is the initial financial goal to offset € 816 mln. of the construction project. The initial intention is to have an open tender for the contract in which the NS has the option to make an exclusive bid for the operation of national trains. International operation will be tendered publicly in which the NS will have a special position. The NS immediately protest against this tender process because they feel it puts them at a competitive disadvantage. Despite this protest the tender procedure is continued during which the Ministry tries to reach a compromise that NS will cooperate with the international tender, in return for getting the rights to operate national train services. But the NS opts for a strategy of confrontation with the State which leads to a non compliant bid for the national services in July 1999. The NS bid is for both national and international services as one complete package. By doing this, the NS signals that they only want to negotiate on the complete package because operating the national services alone will not be profitable. This bid is turned down by the State in October 1999. The State's intention is to start the tendering process for both national and international services. However, as a political concession, the NS is given one final opportunity to change its mind and three options are provided:

1 Accepting the contract for national services and continuing the original procedure;
2 Withdrawing from the public tender for the complete package but getting the right to participate on even terms (50%) with the winning bidder in the to be formed company operating the track;
3 Join the public tender for the complete package without a preferred position.

The NS decides to turn down all presented options. After being informed, the House of Representatives is completely dissatisfied with the tendering process and asks the Minister to start negotiations with NS again on the complete package and stop the current tender procedure. This is highly unwelcome to the Minister because of the high legal risks and the potentially lower than expected income.

After intense discussions it is decided to restart the tendering process by investigating the possibilities for 'level playing field competition' between the potential bidders for the contract. The new start enables relations with NS to be improved over the next months. The new investigations show that both a public tender and exclusive negotiations with a consortium of NS, Schiphol and KLM ('Oranje combinatie') are feasible. On the other hand, both options present some major pitfalls and risks concerning tendering legislation. The Minister decides to start exclusive negotiations with the Oranje Combinatie, a decision which is opposed by the Ministry of Finance. After some more investigation of legal matters the Ministry shifts again: the transport contract will publicly be tendered. Four consortia are invited to tender in December 2000. Three bids are received in May 2001. After judging the bids, one is turned down because it does not meet requirements. In addition the bid of NS and KLM (High Speed Alliance –HSA) turns out to be by far the most financially attractive. Negotiations with HSA are started and an agreement is reached in October 2001 in which a fee of almost € 148 mln. per year will be paid by HSA. The agreement is broadly supported by the House.

After the signing of the contract discussions start on fare restrictions. The House wants to influence the price level of travel but this is directly related to the profitability of the HSA. Because of this, a clause is entered in the contract describing the financial consequences of a restriction on fares imposed by the government. Some members of the House support this measure but not the Minister of Transport. In April 2002, the House decides not to impose the restriction but discussions surrounding the subject remain. A new debate is started in December 2002. During this debate there seems to be a majority supporting a restriction but again the (new) Minister is not convinced. Even HSA now publicly supports using the possibility of imposing the restriction, since apparently this option is beneficial to the consortium. The final decision is reached that the restriction will not be imposed in February 2003. The importance of the subject in the public debate declines.

3.3 HIGHWAY A73-SOUTH

The third project which is presented is a somewhat smaller example of a LIP but nonetheless a very interesting one: Highway 73 South. In contrast to the first two project described this project has a local origin. We will show however that despite the more regional focus, it can still have similar symptoms of complexity as the Betuweroute and HSL-South.

In the first two cases we mostly focused on identifying the elements of complexity. In this case we will supplement that by looking more at the management side of complexity.

3.3.1 Project Facts & Figures and stakeholder constellation

Project Purpose and Project Definition

The A73-South is a highway, with a length of 42 kilometres in the Province of Limburg in the South-East of The Netherlands. It connects the A73-North that runs from the city of Nijmegen to Venlo, and which opened in 1997, with the A2 in the south at Echt-Susteren. A73-South will relieve the busy provincial roads N271 on the west bank and N273 on the east bank of the river Maas. The intention is to improve road safety, accessibility and 'liveability' – the citizens' quality of life. The decision to locate the A73-South on the east bank was taken after years of discussions by parliament with a majority of only one vote in 1995.

The A73-South is part of 'Via Limburg'. Via Limburg is a co-operation between 'Rijkswaterstaat' and the Province of Limburg. Rijkswaterstaat (RWS) is the implementation organisation of the Ministry of Transport, Public Works and Water Management. Together they had planned to construct five new roads in Limburg: A73-South, A74, N280-Oost (N280-East), N293 and N273 Haelen.

The A74 would solve a congestion problem in the city of Venlo, because it is the four kilometre long missing link from Highways A67 and A73 to the highway BAB61 in Germany leading to Mönchengladbach. The N280-East would provide a link at a regional level between the middle of Limburg (from Roermond) to the German Ruhr-Rhein area and is 3 kilometres long. The N293 (Oosttangent Roermond) is 1,5 kilometres long and would connect the A73-South with the industrial estates 'Keulsebaan' and 'Heide Roerstreek'. And in addition, the city of Haelen on the left bank of the River Maas (Meuse), would get a diversion of 1,5 kilometres to free its centre from busy traffic and unsafe conditions. It was scheduled to open for traffic in May 2004. All roads have 2x2 lanes.

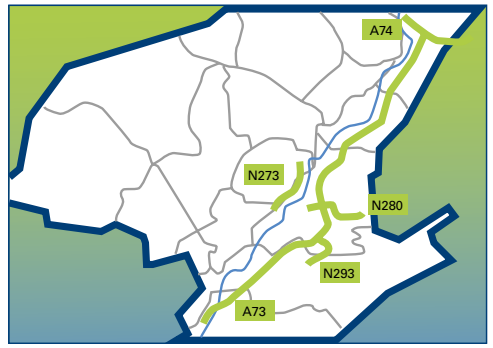


Figure 3.7: Map of A73-South and related projects

The project consists of the following elements:

- Construction of 42 km highway, 2 x 2 lanes, maximum speed 120 km/h, for tunnels 100 km/h.
- Roermond Roerdal Tunnel 2,4 km
- Swalmen Tunnel 0,4 km (including access roads 1 km)
- Tegelen open tunnel 0,8 km
- 41 viaducts, bridges and ecoducts (wildlife passages)
- 185 ha environmental compensation

Finance

Decided in 1999, the budget and the funding were set up in the following way:

Budget:

Project	Budget (millions)
A74	€ 57
A73-South	€ 593
N280-East	€ 27
N293	€ 14
Total budget	€ 691

Financing:

Financier	Budget (millions)
Ministry	€ 646
Province	€ 45

Source: Political Agreement: Ministerie van Vekeer en Waterstaat en de Provincie Limburg, Bestuursovereenkomst aanleg Rijksweg 73-Zuid, Rijksweg 74, N280-Oost en Oosttangent Roermond, 1999.

These costs included approximately € 70 million for environmental compensation and € 55 million for specific fauna compensation, including wildlife crossings.

At the end of 2007, the total costs of Via Limburg are approximately € 850 million.

Planning

In 2003 and 2004 Rijkswaterstaat started the construction of the tunnels, the project elements with the longest construction time. From Spring 2006 construction work had been completed. 1 January 2008 the A73-South opened for traffic. At that time four of the five roads of Via Limburg had been open for traffic, with only the A74 left for completion.

Organisation

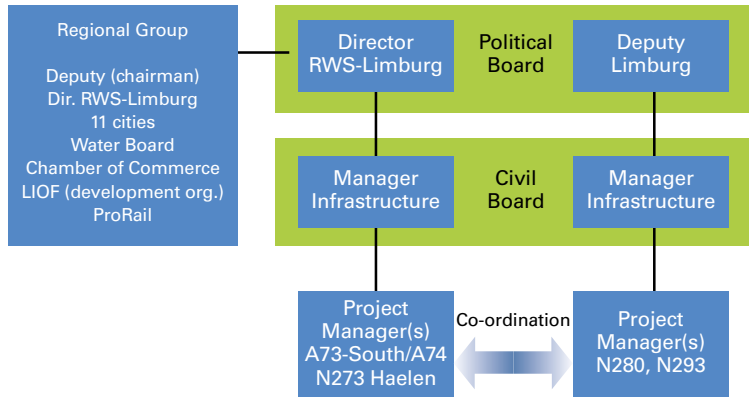


Figure 3.8: Organisation of the A73-South

The Political Board is the 'formal' client, the Civil Board the 'authorised' client. The Regional Group is an advisory body for the Political Board. The function of the Regional Board is the exchange of information and deliberation, looking at scope for agreements. The focus is on progress, coordination and regional support.

Rijkswaterstaat Limburg was responsible for the construction of the A73-South, as well as the A74. The head of the project organisation of the A73-South was the project director.

Stakeholders: internal and external

Apart from Rijkswaterstaat and the Province of Limburg, important stakeholders were the cities along the highway, of which Roermond is the biggest. The cities were represented in the Regional Group, which met formally periodically. Also the regional fire brigade was particularly important for tunnel safety aspects, for which a special working group was formed.

For the citizens in the neighbourhood of the new highway, the intention was that communication was a joint process between local politicians, civil servants and

Via Limburg. Via Limburg opened an information centre in Roermond, organised information evenings, and published a news letter every quarter (information bulletins) as well as launching a website.

In every Province of The Netherlands individual ecological interest organisations join together in provincial ecological federations. These individual organisations make use of the knowledge and network of the federations and they are thus able to 'tune' their activities. The provincial federation in Limburg is the 'Stichting Milieufedratie Limburg' (MFL), an important stakeholder. Apart from this federation, the specific ecological interest group Das&Boom (literally 'Badger and Tree') had been active in opposing the decision to build the highway on the east bank. MFL was also against this decision, but in contrast with Das&Boom, they decided to cooperate with Via Limburg to fight for ecological compensation.

3.3.2 Storyline A73-South

Round 1 Heavy discussions about ecology versus economy *1985 – 1997*

The need for a new Highway A73-South wasn't controversial, but the whether it should be built on the west or the east bank of the river Maas definitely was. Already in 1985 the Minister of Transport had taken a route decision ('Tracébesluit')[1] for a highway on the east bank of the river Maas. But this decision was cancelled in 1992, because of new European guidelines for environmental effect assessment. Rijkswaterstaat started a new project initiative document ('Startnotitie') with environmental effect report and finished this in 1993. After intense discussions in the region and in parliament, in March 1995 the Dutch parliament finally decided to construct the A 73-South on the east bank of the river Maas by a majority of one vote, thus ratifying the 'Tracébesluit'. The decision was adopted by the government. During the debate, the discussion was mainly as between arguments on ecology and economy. The ecologists were the defenders of the west bank route, in order that the highway wouldn't affect the ecologically more valuable and vulnerable east bank. Moreover, on the west bank was the existing north-south connection, the 'Napoleonbaan', approximately 15 kilometres shorter than the eastern alternative. The supporters of the east bank route, such as the Chamber of Commence and the provincial employers' federation, focused on economical and safety arguments. They stressed the importance of the connection with the city of Roermond and the fact that most industry was located on the east side. Also the existing road N271 on the east bank was very unsafe ('the killing road'), with a total of 39 fatal road accidents from 1993 to 2001 (almost 5 every year). An A73-South on the east bank should reduce traffic through cities, thus enhancing safety.

[1] The route decision ('Tracébesluit') is the final decision of the Minister of Transport, Public Works and Watermanagement in together with the Minister of Housing, Spatial Planning and Environment about the justification and the location of the infrastructure. Appeal is possible at the Council of State. The Council of State advises the Dutch government and parliament on legislation and governance and is the country's highest administrative court.

Round 2 Political Agreement *1997-2000*

In 1997 the Minister of Transport Mrs. Annemarie Jorritsma postponed the project to 2000 for funding reasons. In 1998, the new Minister Mrs. Tineke Netelenbos established that there were far more commitments and plans for the whole country than could be afforded. She needed to cut back the ten year programme of infrastructure and transport (MIT) of the Ministry. One of the measures she took was to postpone the A73-South in the MIT with construction delayed until after 2006 at a budget of € 536,8 million. This budget was higher than the 1995-budget, due to higher cost estimates that had been influenced by the extra costs of other projects, especially the Betuweroute.

These delays annoyed both the Province of Limburg and the regional department of Rijkswaterstaat[2], RWS Limburg. The Province and RWS Limburg were agreed that the situation was too urgent in terms of mobility (economy) and road safety to allow delay. After the second postponement, the Province and RWS Limburg seized the initiative. The Region wanted the Minister to keep her promises to it. But they also understood that it was necessary to present a reasonable, acceptable plan to the Minister, because they knew that in the meantime the cost estimations of the A73-South had been rising. What was to be done?

The Province advocated the A73-South, but the Delegate knew that this new 42 kilometre long highway alone couldn't solve the whole region's mobility problem. The Province suggested taking the opportunity to put forward one set of measures, a package deal, including the improvement of the unsafe traffic situation. Together with RWS Limburg, the Province developed a new plan in which they increased the scope to the following programme: Highway A73-South, Highway 74, two provincial roads (N280-East and Oosttangent Roermond/N293). "The projects are close to one other", the delegate mentioned.

By focussing on the whole issue of mobility, with particular regard to three junctions (two in The Netherlands and one in Germany at 35 to 40 kilometres from each other), it was possible to make efficiencies by avoiding certain costly constructions at the three junctions concerned (the Province mentioned savings of about € 220 million). Co-financing by the Region was part of the plan, and this demonstrated their serious intent and commitment. In addition, the linkage of the project with German mobility issues, made room for co-financing from the European Union.

[2] Rijkswaterstaat is the implementing organisation of the Ministry of Transport, Public Works and Water management and works to protect against flooding and to provide sufficient clean water for all users. RWS also promotes the rapid and safe flow of traffic on national roads and waterways.

The Province of Limburg was highly committed to the project and its Delegate was active in arranging meetings with the local cities, the Minister of Transport and other ministries. The result was that the Region became an active partner: a new role for the Province. Traditionally the emphasis of the Province had been on controlling, but by then they aimed for full responsibility for the N280 and N293. The Province and the cities co-financed the plan and the Province took a leading role.

The Province and RWS Limburg had long discussions about the content of the plan in order to get the acceptance of the Minister. How much was needed to get her acceptance? Would she be enthusiastic about the scope broadening to a package deal and would she accept that the agreements will be binding for all parties involved? They knew the Minister had insufficient money for all of the projects, but by combining they realised cost savings and the revised bid to the Minister now included co-financing from the Region. The Region's condition for co-financing was that the agreement had to be obligatory on all parties

> *"Complexity increased during the negotiations, but after the decision realisation was more simple"*

as the project director of RWS Limburg mentioned. They stipulated that a central point was "the commitment to consider this agreement as an end result of the discussion and therefore on this basis take on the construction". The project director of RWS Limburg:

> *"We spent days in isolation to determine: what is an acceptable proposal in terms of money and staging (pre financing) to propose to the Minister?"*

The Minister judged the proposal as a feasible plan. The Cabinet and Parliament agreed to the package deal. Interestingly the Minister had an important additional reason: she described the initiative with co-financing as an example for other regions, so she hoped this example could help her to solve other problems. 2 December 1999 (3 days before the feast of St Nicholas) the Minister signed the package deal with the regional stakeholders with a fixed budget and a regional contribution (€ 45 million). So the Minister could also demonstrate success.

Four years after the one vote majority in parliament, the region had a definite legal decision from the Minister: the final 'go' ahead for the project – an important moment for the Deputy, the aldermen and the director and the project director of RWS Limburg.

Summarising, the main characteristics of the plan were:

- Increasing the scope to a programme with:
  A73-South (including the Haelen traffic diversion) and A74, under responsibility of the Ministry
  N280-East and Oosttangent Roermond/N293, under responsibility of the Province; later on the diversion of Haelen was added.
- Fixed budget: € 691 million (f 1.522 million), price level 1998.
- Province fund € 45 million (f 100 million) of which the municipalities funded 50%, because of the improvement of the road-safety and stimulus to the local economy.
- Time schedule: completion 31 December 2007.
- The mutual acceptance that the agreement was the end of discussion and that the implementation had to begin. The key factor was the end result commitment ('resultaatverplichting') of the Province and the Ministry.

The budget was a fixed target for all partners. Of note is that the Political Agreement between the Minister and the region had arrangements in case of a financial surplus at a (sub)project that could be used to cover a deficit in another (sub)project by means of a budget transfer within the overall project. But in total a deficit of the whole programme was not possible. The total budget had been capped.

The Province and RWS Limburg added additional commitments in the 'Realiseringsovereenkomst' (Realisation agreement), 23 February 2000, in terms of tasks, responsibilities and competences, finance, co-operation and planning. Rijkswaterstaat and the Province had clarity of responsibilities. The delegate mentioned:

> *"Within the agreement, we could play our own role."*

After the signing, Rijkswaterstaat and the Province established a joint venture: the project organisation 'Via Limburg' for the construction of the package. The mutual interest and co-operation in the region continued. For example, the Province wanted to introduce environmental 'quiet' areas next to the highway, but RWS Limburg calculated that this would lead to 8 meter high noise screens. RWS Limburg suggested the use of extra sound absorbing asphalt and the Province was able to adapt this within their planning permits, which solved the problem.

Round 3 Building a new highway 2000-2007

The political agreement marked the start of the design and realisation phase. The results of this phase are encouraging. The opening of the highway was 1 January 2007, in line with the initial time schedule. The market situation helped the partners, because the tendering process was successful with positive financial results.
During the design and realisation phase, there were still some important issues to be

dealt with. We mentioned the issue of the west and east bank routes that remained until the decision of the Council of State in November 2002 and the compensating measures for environment, e.g. environmental compensation and fauna crossings. But also intense discussions took place concerning tunnel safety (see section 4.2) at the Roermond and Swalmen tunnels. Here we will concentrate on ecology.

Ultimately, as previously mentioned, the decision was made to build on the east bank. But this didn't finish ecological discussion. Because of the fragile environment, the 73-South needed sufficient ecological compensation and required an exemption from 'priority animal species regulations' from the Dutch Ministry of Agriculture, Nature and Food Quality (LNV), within the framework of the nature protection law, the 'Natuurbeschermingswet' (NBW). Rijkswaterstaat Limburg (RWS Limburg) had developed a compensation plan, including mitigating measures, based on investigations of independent consultants of the actual ecological values and the damage the highway would cause to the environment. The central topic in considering the exemption was – again – whether there is an alternative route that from strictly environmental and ecological reasons is better than the eastern alternative – and if so, that there is an overwhelming social interest to justify building on the east bank[3].

The exemption of the NBW for animal species, such as the zeggekorfslak, was drawn from the actual ecological inventory conducted on the east and the west banks in 2000, with mitigation and compensation on the basis of field-research. The application (request) was ready for submission in June 2001. LNV considered 'east vs west', the degree of mitigation and the degree of compensation.

LNV decided that more measures were needed, with an increase in cost from about € 23 million (f 50 million) to € 36 million (f 80 million). This was, for The Netherlands, a very large amount. The total area of ecological compensation for A 73-South is 185 hectare (the total for the four projects of Via Limburg is approximately 250 hectare).

Environmental organisations, such as MFL and Das+Boom, opposed the proposal at the Council of State. Unfortunately for them, the Council of State decided on 13 November 2002 in favour of the east bank solution in the zoning plan of the city of Swalmen. This removed any hope that the highway would be build on the west bank.

[3] Letter 20-09-2001 to Minister Netelenbos from her civil servant.

3.4 GOTTHARD AND LÖTSCHBERG

The first three projects described were of Dutch origin. The two next ones are located in Switzerland. The facts and figures described are drawn from research investigations in co-operation with the ETH-Zurich and the Ministry of Transport (UVEK) over the period 2002-2005. Over 15 interviews were held to investigate the project. In addition the NETLIPSE case reports on the Gotthard Base Tunnel (Schalcher et. al., 2008) and Lötschberg Base Tunnel (Schalcher et. al., 2008) was used as a basic reference, as well as the very infomative articles of Friederike Schlumbom in Swiss Traffic (2003-2004).

3.4.1 Project Facts & Figures and stakeholder constellation

The Gotthard Base Tunnel and the Lötschberg Base Tunnel are part of 'NEAT': the New Rail Link through the Alps. Apart from the two large tunnels, NEAT consists of the Ceneri Base Tunnel and the Zimmerberg tunnel, which both belong together with the Gotthard Base Tunnel to the 'Gotthard axis' and furthermore to the connection of the eastern part of Switzerland.

The NEAT-Concept, given in the Federal Resolution concerning the construction of the Swiss rail link through the Alps, highlights the following points:

- Making Switzerland a hub of the European high-speed passenger rail network.
- Integrating intermodal goods traffic into the European rail corridors.

NEAT creates inter-operability and enables time-saving. The GBT will establish a shorter and faster north-south rail link for passenger and freight transport. By constructing the NEAT, Switzerland integrates itself into the growing European high-speed network. Train journey times will be reduced significantly. The construction of the GBT creates a more level rail link whose highest point is at 550 meters above sea level.

NEAT improves competitiveness and facilitates the transfer of traffic from road to rail – e.g. it is expected that large amounts of trans-alpine freight traffic will transfer from road to rail. The NEAT will provide the required capacities. Thus, the competitive position of rail freight transportation will be enhanced. This meets the demands of the 'Alps Initiative' which was accepted in a public vote in 1994. Before describing the highlights of the Gotthard and Lötschberg, in this section we will outline the organisational structure, because at the top level this is the same for both projects

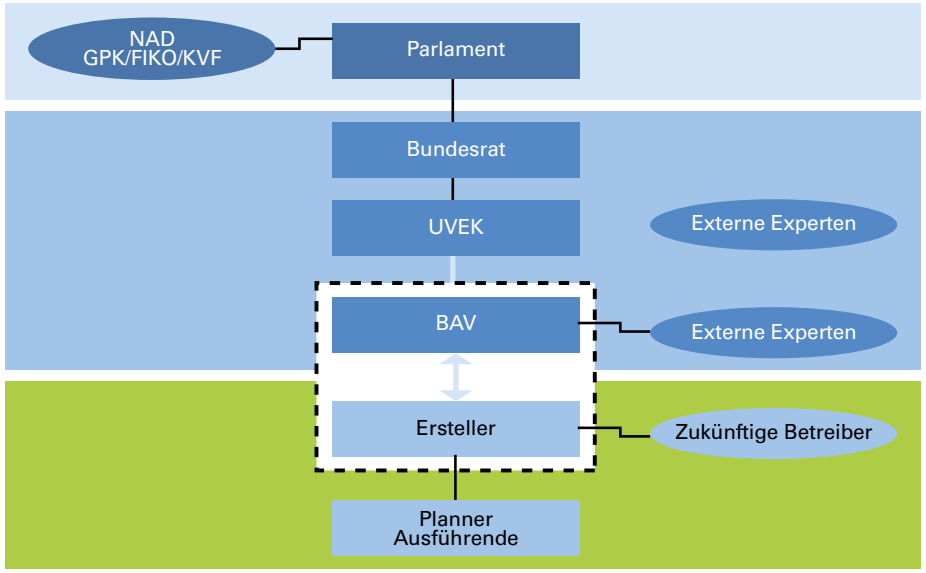


Figure 3.9: Organisational chart Gotthard and Lötschberg

Switzerland has a bicameral parliament at federal level: the Federal Chambers, which together constitute the United Federal Assembly. The National Council represents the overall population and the Council of States the cantons. The decisions of the United Federal Assembly establish the legal foundations for the financing and realisation of the NEAT. On October 4th 1991 the Parliament decided in favour of the NEAT. A referendum brought the decision to the public vote on September 29th 1992, where it was clearly accepted.

The function of the Federal Council ('Bundesrat') is strategic control of the project. It can release credits and free reserves. It can decide about credit enhancement for covering rises in prices, VAT and building elements.

The Federal Department of Environment, Transport, Energy and Communications (UVEK) is the 'principal' of the NEAT. It established the NEAT Controlling Regulation ('Neat-Controlling-Weisung' abbreviate 'NCW'), which defines the processes for the reporting, supervision and controlling of the project. Furthermore, the UVEK prepares, together with AlpTransit Gotthard Ltd., contracts concerning specified performances and date of fulfilment.

The Federal Office of Transport (BAV) represents the biggest portion of the Federation's responsibilities, related to the realisation of the NEAT:

- The operational supervision at public authority level is incumbent on it. Its field of responsibility begins with the controlling of planning and ends with the operating approval.
- It controls and co-ordinates the works of the constructor and develops in co-operation with the future user implementation principles.
- It monitors the tendering procedures.
- Controlling of and reporting on the level of authorities: it prepares documents and papers for the department UVEK, the federal council and the parliament.
- It keeps the NAD (NEAT-Aufsichts-Delegation, or Delegation for the Supervision of the NEAT) informed about the state of the project. It publishes the half-yearly progress reports.
- It manages the funds for large railway projects.

Finance

Both the Lötschberg and Gotthard Base Tunnel are fully financed by a fund obtained from a tax on oil, a capacity-rated heavy vehicle tax, and a value-added tax percentage. The people of Switzerland approved this plan for the construction and financing of the public transport infrastructure (Finöv) on the 29th of November 1998. The origin and the use of the financial resources are illustrated in figure 3.10.

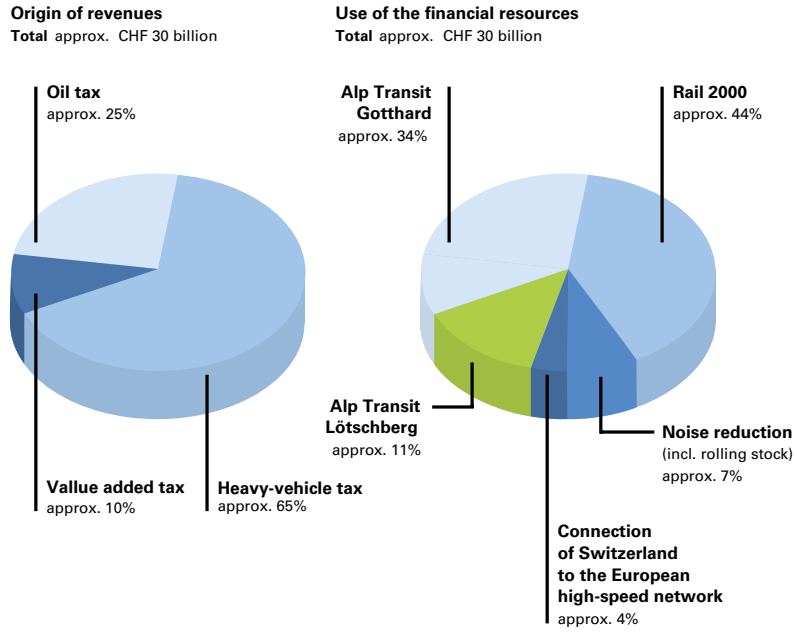


Figure 3.10: The origin and the use of the financial resources (© AlpTransit Gotthard Ltd.)

Gotthard Base Tunnel

The Gotthard Base Tunnel (GBT) is a 57 km long railway tunnel between Erstfeld in the Canton of Uri and Bodio in the Canton of Ticino. It consists of two single-track tunnels which are linked to each other by connecting galleries. The construction of the GBT creates a relatively level rail link whose highest point is at 550 meters above sea level.

General project scope

The general project scope of the GBT is fixed in the 'sectoral plan Alptransit' of March 15th 1999. Thus, it is constructed with two single-track tunnels. The north portal is located at Erstfeld in the Canton of Uri. The south portal is located at Bodio in the Canton of Ticino. Intermediate headings at Amsteg, Sedrun and Faido divide the GBT into five sections: Erstfeld, Amsteg, Sedrun, Faido and Bodio. Double tracked connections to the main lines of the Swiss Federal Railway (SBB) will be constructed in Altdorf/Rhynächt and in the area of Giustizia. Furthermore, two overtaking sections in the areas of Altdorf/Rynächt and Biasca are included within the fixed scope. The track is visualised in figure 3.11.

Figure 3.11: Map of the Gotthard Base Tunnel (© AlpTransit Gotthard Ltd.)

Capacity

The GBT is designed to allow a maximum speed of up to 250 km/h for passenger trains, and up to 160 km/h for qualified goods trains. The baseline allows freight trains travelling on the flatter route to be longer and to pull up to twice today's weight (4000 tonnes instead of 2000 tonnes). From an estimated 140 million tonnes of alpine-crossing freight traffic per year in 2020 (rail and road), the proportion of the GBT is expected to be 40 million (29%). This means up to 210 goods trains per day, which is a doubling of today's capacity. From an estimated 100 million alpine-crossing passenger trips per year in 2020 (rail and road), the proportion of the GBT is expected to be 8 million or up to 60 passenger trains per day.

Construction concept

The concept for the GBT is to drive five separate sections of different length simultaneously. For the construction project, two alternative approaches were developed using two methods of driving: tunnel boring machines or drilling and blasting. From a total of 153.5 km of tunnel, galleries and passages, nearly two thirds are driven by tunnel boring machines.

AlpTransit Gotthard will be equipped with the new standardised European Train Control System (ETCS) Level 2 which will also be introduced on other European railway networks at the same time.

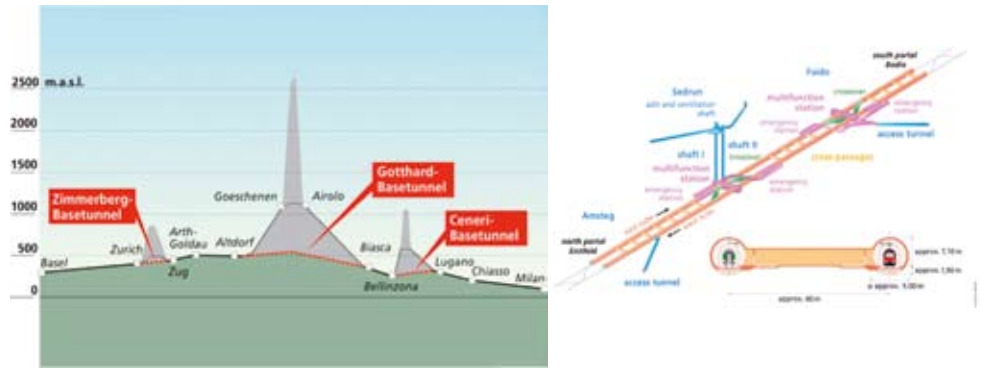


Figure 3.12: Two cross-sections of the Gotthard Base Tunnel (© AlpTransit Gotthard)

Costs

According to the progress report of June 30th 2001, the estimated final costs would have amounted to 6.579,2 mln. Swiss Francs (approx. € 4.078,9 mln.). By June 30th 2006 the estimated final costs amount to 8.139,1 mln. Swiss Francs (approx. € 5.045,9 mln.). This means an increase of 24% respectively 29% in comparison to the original cost basis (compare figure 3.13).

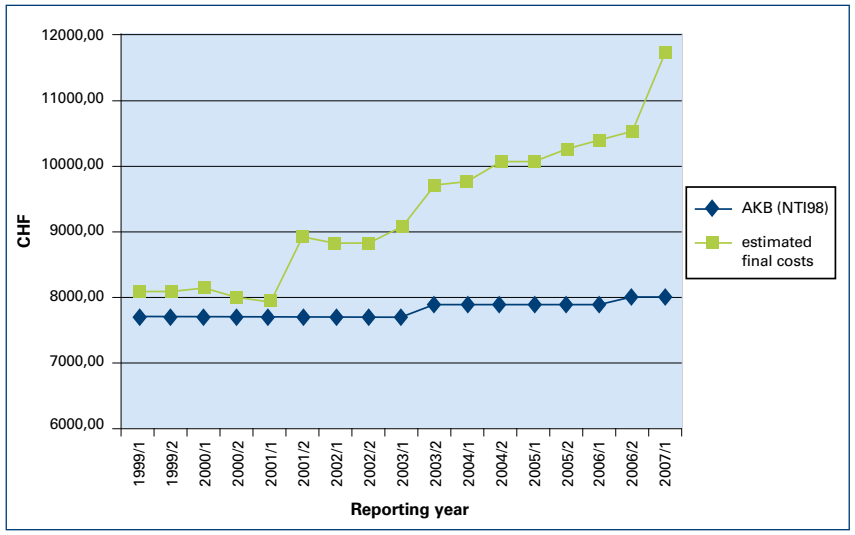


Figure 3.13: Estimated costs of the Gotthard Base Tunnel (AKB = Original Cost Basis)

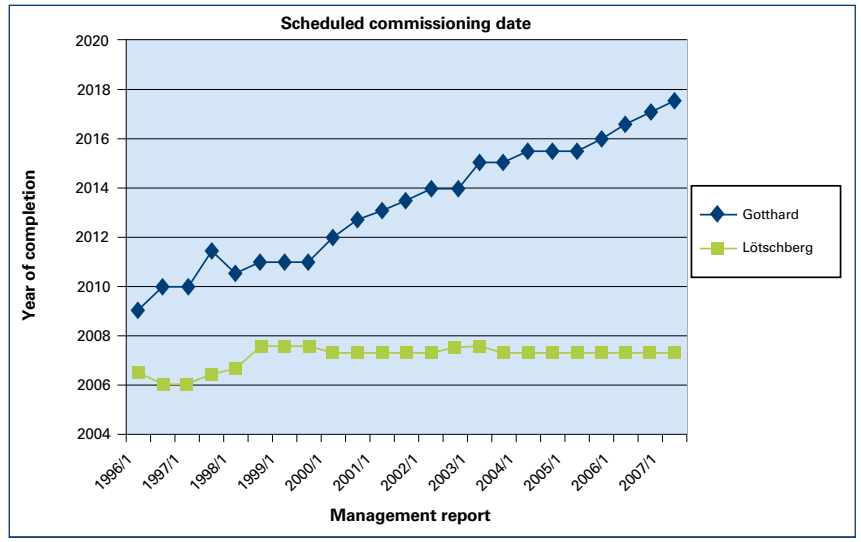


Figure 3.14: Scheduled date of completion for the Gotthard Base Tunnel and Lötschberg Base Tunnel (Wadenpohl, 2008)

Contracting

While the planning is carried out by the constructor AlpTransit Gotthard Ltd. (ATG) itself, the construction works are carried out by different general contractors. The tender is based on different constructions projects for each subsection of the new Gotthard Line. The basis for the contracts is the work-breakdown-structure, which is fixed in the controlling-directive for the NEAT (NCW). Though ATG legally appears as a stock company which follows entrepreneurial principles, for the tendering it appears as a contracting authority.

Status and time schedule

According to the state of the progress report from June 30th 2006, the project is planned to be completed by the end of 2016. Originally, (in the first management report from June 30th 1996) the plan was to complete the project in 2009 (compare figure 3.14) (Wadenpohl, 2008).

Organisation

AlpTransit Gotthard Ltd (ATG) is the constructor of the Gotthard axis of the New Rail Link through the Alps with base tunnels through the Gotthard, Zimmerberg and Ceneri (see figure 3.15).

ATG was founded on May 12 1998. It is a wholly owned subsidiary of Swiss Federal Railways (SFR) with headquarters in Lucerne and branch offices in Altdorf, Sedrun, Faido and Bellinzona.

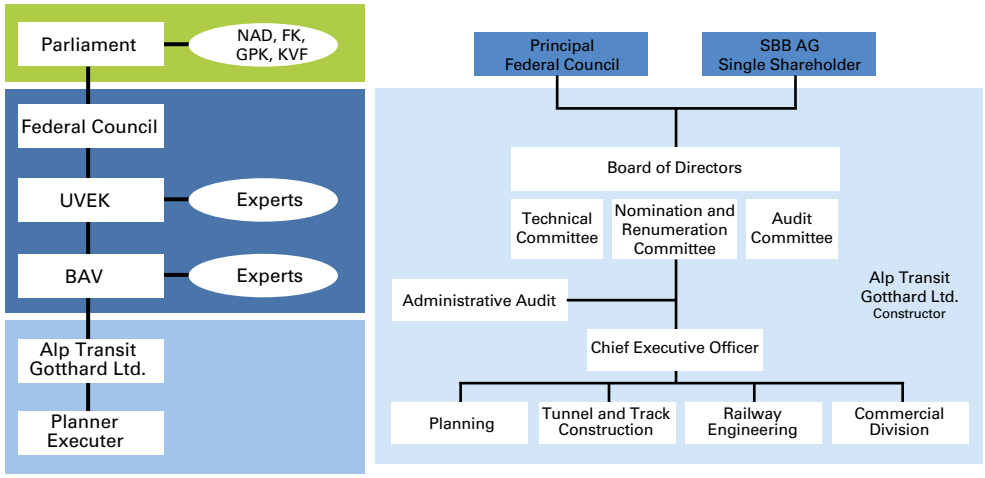


Figure 3.15: Overall Organisation Chart (left) and Organisation Chart ATG (right)

Local stakeholders of the GBT exist at three levels; cantons, communities and neighbourhoods. The directly affected cantons are Uri, Graubünden and Ticino. While the cantons Graubünden and Ticino always supported the project or caused no resistance worth mentioning, the canton Uri became the ATG's biggest opponent. Line choice and design of the open track raised hackles. Citizens' action committees like 'NEAT in den Berg' were founded. The building permit for the section in Uri was granted as late as March 5th 2004 and therefore became the last to be given – five years after construction work began at the GBT.

On November 8th 2006 the Federal Council decided that the Swiss Federal Railways should be the carrier of the GBT. Thus, arrangements for implementation were made.

Non-governmental organisations

Currently there are 25 national organisations in the field of environmental protection listed in Switzerland.

To focus the work and different opinions, eight of the bigger organisations formed an alliance and appointed one single person to be their representative (see figure 3.16). In the interviews we noticed that both parties, ATG and the stakeholder representative, have found the co-operation to be fruitful.

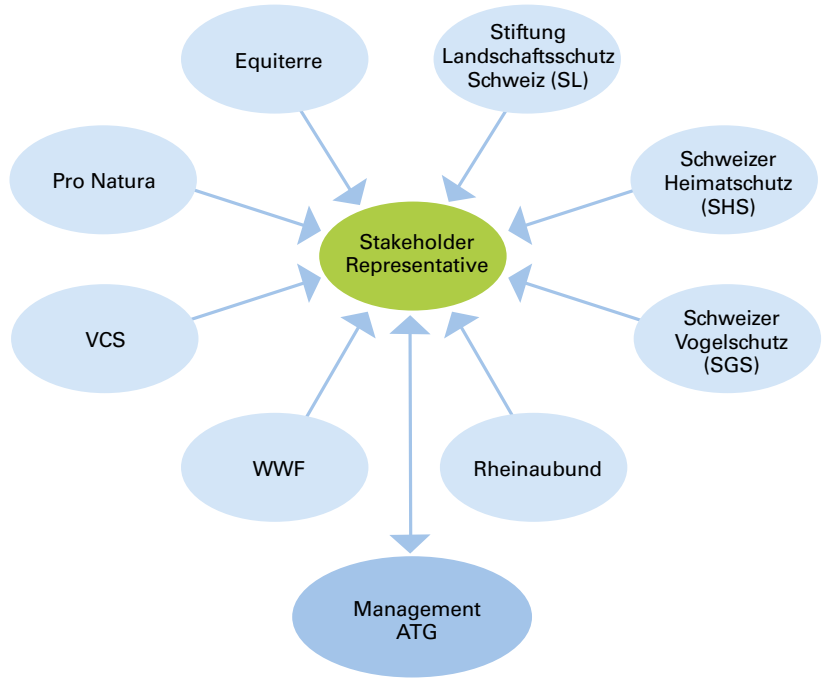


Figure 3.16: The stakeholder representative of eight national environmental protection organisations.

Lötschberg Base Tunnel

Project Facts and Figures

The Lötschberg Base Tunnel (LBT) is a 34,6 km long railway tunnel that runs from Frutigen in the Kandertal to Raron in the Valais. To the south it links up with the Simplon line. It was officially opened on the 15th of June 2007.

Planning for the Lötschberg Base Tunnel has been in progress since 1988. Today's route is the result of several years of optimisation, including several preliminary studies, major and detail variants. The early involvement of municipalities, planning regions and cantons ensured an open planning process. The main criteria in the evaluation were technical feasibility, environmental compatibility, construction time and construction and operating costs.

General project scope

The Lötschberg is designed as a tunnel system with two separate one-way single-track tubes. In the first phase, however, only one tunnel tube will be constructed between the north portal of Frutigen and the project service station in Mitholtz. Here, the Kandertal exploration tunnel, runs parallel and performs the function of a rescue and emergency tunnel. To the south of Mitholtz, as far as the southern portal in Raron, two tunnel tubes are envisaged. Initially, the technical railway infrastructure will be installed only between Ferden and Raron. This meant that at the opening in 2007, only one third of the tunnel will have two operational tubes. This phased approach to the Lötschberg AlpTransit project is the result of a decision by the Federal Council on 24 April 1996 to re-dimension NEAT for reasons related to costs. Depending on the costs, a further development phase will be subject to a policy decision by the Federal Council or parliament.

Figure 3.17: Map of the Lötschberg Base Tunnel (© AlpTransit Gotthard Ltd.)

Capacity

The LBT will carry both passenger and freight trains. Depending on the type, freight trains will travel through the tunnel at speeds of 100 to 160 km/h whereas passenger trains will travel at up to 200 km/h (or even 250 km/h for tilting trains). The journey time from Bern to Upper Valais will be halved. A daily total of 110 trains on the base line is foreseen: 30 will be passenger trains and 80 freight trains, including long freight trains (loads up to 4,000 tonnes, and up to 1,500 m long).

Construction concept

The Lötschberg base line and base tunnel were to be constructed simultaneously from five construction sites. The tunnel was sub-divided into sections and thanks to three lateral access points, which served as intermediate working points, the tunnel could be opened in 2007 (construction time of 8 years). 20% of the base tunnel would be driven by tunnel boring machines. The remaining 80% would use conventional blasting techniques. Especially in areas with variable geology or rock, tunnel boring machines are less suitable.

LBT will be equipped with the new standardised European Train Control System (ETCS) Level 2 which will also be introduced on other European railway networks.

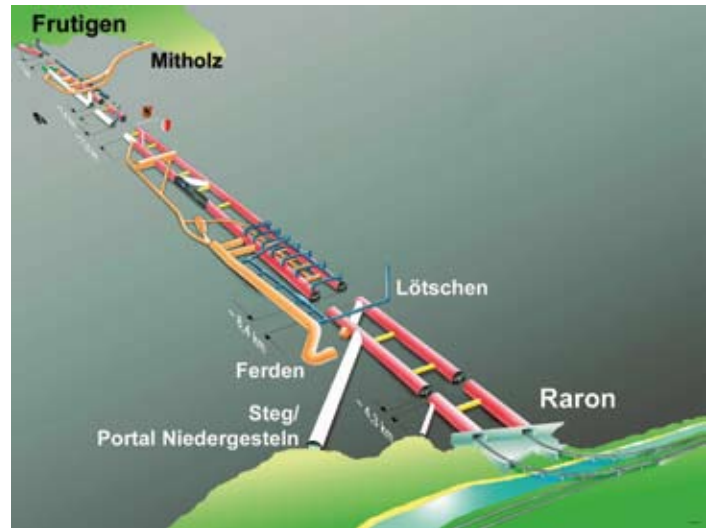


Figure 3.18: Cross-sections of the Lötschberg Base Tunnel

Costs

The costs were estimated at 3,2 bn. Swiss Francs in 1998. The Swiss Federal Council estimated cost overruns of 34% (2007) and total costs of 4,3 bn. Swiss Francs. 67% of the additional costs are due to changes in the plans and geological risks. With inflation and interest accumulated during construction, the tunnel cost 5,3 bln Swiss Francs.

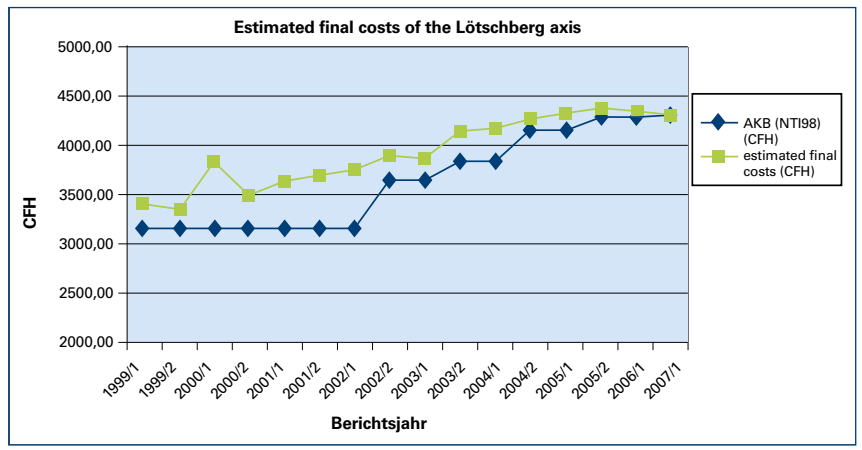


Figure 3.19: Estimated costs of the Lötschberg Base Tunnel (Wadenpohl, 2008), (AKB = Original Cost Basis

Status and time schedule

The base tunnel was under construction from July 1999. In 2007 the tunnel, the first new transalpine rail axis, has begun to carry traffic. The tunnel was opened on 15 June 2007, after eight years of construction time. Full scale operation started in December 2007.

Organisation

BLS AlpTransit AG bears sole responsibility for design and construction of the Lötschberg base line. The client is the Swiss Confederation. During the project and construction phase, BLS Lötschbergbahn AG represents the operators' interests on behalf of the Confederation. The prime concern of BLS AlpTransit AG is to implement the project on time, within budget and with due consideration of future requirements.

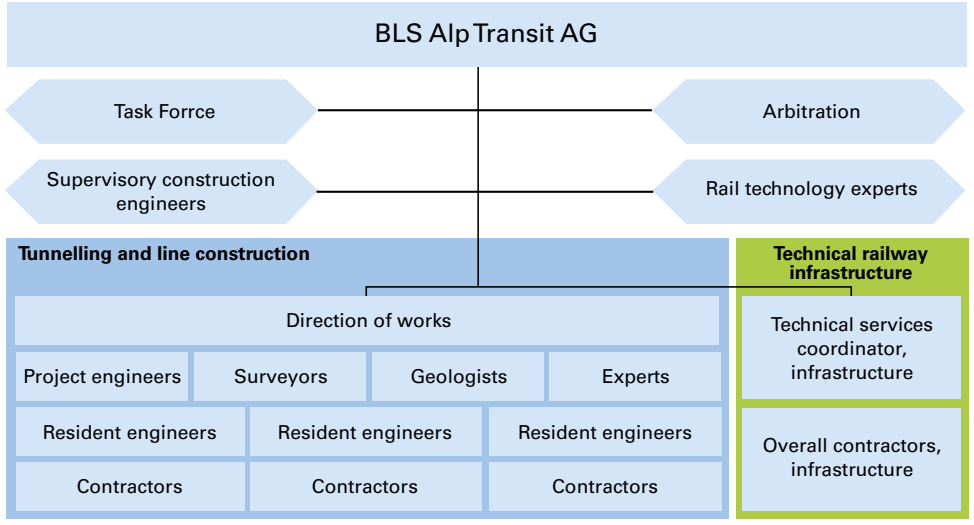


Figure 3.20: Organisation Chart BLS AlpTransit AG

3.4.2 Storyline Gotthard and Lötschberg

Round 1 Decision for NEAT and the Referenda of 1987, 1992 and 1994

After the Second World War, trans-alpine traffic increased heavily and the capacity of road and rail needed to expand. In particular, mobility increased dramatically after 1960 associated with the success of private motoring with the first traffic pinch points emerging on rail and road in the early 1970s. In the 80's the ever increasing trans-alpine traffic caused more and more problems and the rail corridors through the Swiss Alps were running near capacity, and in the densely populated Swiss Midlands were running near or at capacity. Swiss roads became more congested. Rail 2000 ('Bahn 2000') was designed to revitalise the existing rail network that had remained virtually unchanged for over 100 years. The goal was to provide faster and more frequent services to meet the needs of travellers in the 21st century. Rail 2000 aims to offer at least half-hourly frequencies on major routes, a 15% cut in journey times between major cities, new trains and improved station facilities. The Rail 2000 concept was approved at the ballots in 1987.

Vote on Public Transport Funding				
Date	Subject	Turnout:	Yes:	No:
06.12.1987	Rail 2000 concept 1)	48%	57.0 %	43.0 %

1) Official name: 'Bundesbeschluss betreffend das Konzept BAHN 2000'.

As part of the revitalisation of rail since the 1960's, serious studies had been undertaken into tunnels crossing the Alps in a north-south direction. This crossing was identified as the most expensive part of the revitalisation. An example is the establishment in 1963 of 'die Kommission Eisenbahntunnel durch die Alpen' (Committee for a railway tunnel through the Alps), KEA, by the Federal Council (Bundesrat). In 1970 they recommended the building of a Gotthard Base Tunnel and converting the old Lötschberg tunnel to double track. In the next decade study also continued, undertakenby SBB (Swiss National Railways). But in the meantime politics seemed still to be more concerned with road.

In 1988 the new Minister (Departmentsvorsteher) of Transport and Energy, Adolf Ogi, advocated the extension of railways, including two new base tunnels through the Alps: Gotthard and Lötschberg-Simplon. In May 1990 the Bundesrat presented a plan to the Parliament, which in 1991 decided in favour of 'NEAT': the New Rail Link through the Alps. It is important to note is that NEAT was not a part of Rail 2000. NEAT embraced the St. Gotthard (57 km), and the Lötschberg base tunnels (Simplon axis, 34 km), the Ceneri Base Tunnel and the Zimmerberg tunnel, and the integration of the Eastern part of Switzerland. In the discussions which led to this event, several

reasons were advanced in favour of this package: the increase in European transport generally, the integration of Switzerland in the modern European traffic system, national and economical benefits, the need to modernise the rail infrastructure and the environmental protection of the Alps. This parliamentary decision was subject to potential objections.

That was the case. A committee disagreed with the parliamentary decision of 1991 and tried to hold a referendum about NEAT. Members of this committee were the Green party, a committee from Urn and a car journalist from Basel. The committee had the feeling that the benefits would not be reached, for example the reduction of road freight transport and environment, indeed they were afraid about the impact on the environment. They also had doubts about the financing. The committee needed a minimum of 50.000 signatures for a referendum, and they succeeded with 50.051 valid signatures, after re-counting.

The referendum was held on 29 September 1992. Swiss people decided in the public vote to accept the NEAT-submission, including the Alptransit-decision concerning the building of the Gotthard and Lötschberg lines, the decision on the global credit at a value of CHF 14 bn. (approx. € 8,7 bn.) and the federal decision about the integration of east Switzerland (CHF 850 mln. / approx. € 527 mln.). This established the basis for the planning and building of the Gotthard and Lötschberg lines, and the connection of east Switzerland to the high-speed network; as well as the financial framework. The financing concept planned to cover the costs with earmarked fuel duties covering 25% of costs, as well as taking on debt (75%) by means of capital market loans, which had to be paid back with interest over a period of 60 years.

Vote on Public Transport Funding				
Date	Subject	Turnout:	Yes:	No:
27.09.1992	Alp transit decision 1)	46 %	63.6 %	36.4 %

1) Official name: 'Bundesbeschluss über den Bau der schweizerischen Eisenbahn-Alpentransversale (Alpentransit Beschluss)'.

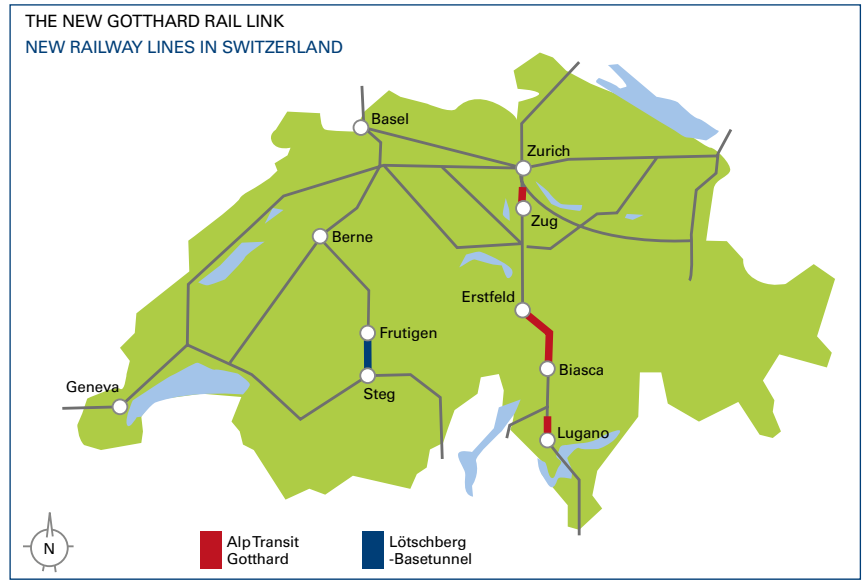


Figure 3.21: Overview of Gotthard and Lötschberg

In the meantime, the European Union wanted to increase the efficiency and competitiveness of the rail sector, in order to change the trend where rail was loosing more and more ground to road transport. To this end, in 1991 the guideline 91/440 was signed. Of particular importance in this guideline were to be the commercial independence of railway companies and the mutual accessibility of member states to individual countries' railway networks. In the Maastricht Treaty in 1992, the EU declared that borders were to be opened for a free exchange of persons and goods. These developments illustrated the need for of a more integrated European transport system. Switzerland noted these developments, and didn't want to become an island within Europe, where – although it was the shortest route in distance – transportation of goods would by-pass Switzerland, because the route was not fast enough and had too many administrative difficulties.

The European Union itself opted for road transport for the crossing of the Alps, which threw doubts on the need for NEAT but also would lead to a negative impact on the local environment. Adolf Ogi tried to persuade his colleagues of the European Ministers of Transport by showing them the narrow valley in Canton Uri and the need for trans-alpine rail transport instead of by road. An important issue was that in Switzerland the maximum weight for lorries was 28 tons, whereas the European Commission wanted a 40 tons transit limit. Finally in 1992, an agreement was signed where Switzerland committed themselves to build a corridor for lorries on freight wagons ('Huckepack Korridor') at Lötschberg and to build the two NEAT base tunnels. In return, the EU accepted a 28 ton limit for lorries.

In January 1993 Parliament released the financing for the project clearance and building preparations for the Gotthard line. On 22 September 1993 Minister Ogi of the Department of Transport and Energy gave the starting signal in a ceremony for site investigation of the Gotthard tunnel at Tessin. The rock conditions at Faido were expected to be one of the most critical construction factors.

Alpine Initiative 1994

On 20 February 1994 another referendum took place. This was about the 'Alpine Initiative', an NGO for the protection of the mountains, founded in 1989, that still exists in 2007. The scope of the referendum wasn't the need for NEAT, but 'The Article on the Protection of the Alps'. This Article was to be seen as an objective, and "it is up to the Federal Council (the Swiss Cabinet) and the Swiss Parliament to take measures to implement the text", as they stipulated on their website. The Article in reference to Alpine Transit stated[4]:

(1) The Confederation shall protect the alpine regions from the negative effects of transit traffic. It shall limit the nuisances caused by such traffic to a level which is harmful neither to people, animals and plants, nor to their environment.
(2) Transalpine freight in border-to-border transit shall be carried by rail. The Federal Council shall take the necessary measures. Exceptions are only permitted if they are unavoidable. They must also be specified by a law.
(3) The capacity of transit roads in the alpine regions may not be increased. Bypasses to relieve the pressure of through transit traffic in towns and villages are excluded from this provision.

The Alpine Initiative was adopted by the Swiss people with 954,433 votes, which meant a small majority of 52%. 19 of the 26 cantons adopted "the first popular initiative originating in the Alpine region", as is mentioned by the Alpine Initiative itself.

Vote on Public Transport Funding				
Date	Subject	Turnout:	Yes:	No:
20.02.1994	Alpine protection initiative 1)	41 %	51.9 %	48.1 %
20.02.1994	Continuation of heavy vehicle charge 2)	41 %	72.8 %	27.8 %
20.02.1994	Introduction of heavy vehicle charge 3)	41 %	67.1 %	32.9 %

1) 'Eidgenössische Volksinitiative 'zum Schutze des Alpengebietes vor dem Transitverkehr.'
2) 'Bundesbeschluss über die Weiterführung der Schwerverkehrsabgabe.'
3) 'Bundesbeschluss über die Einführung einer leistungs- oder verbrauchsabhängigen Schwerverkehrsabgabe.'

[4] Article 36.6 of 1994 was renumbered in 1998 in the new constitution of the Swiss confederation and became article 84. The issuing of legally binding acts in the form of ordinances is now provided for all legislating decisions of the Federal Council in article 182, paragraph 1 of the Swiss constitution and is therefore no longer mentioned in the Article on the Protection of the Alps.

The Alpine Initiative couldn't have led to abandoning NEAT, but it is important for the design and construction of the NEAT. It can be seen as 'a watchdog' on the environmental impact of NEAT. One of the initiators of the Article was Andrea Hämmerle, member of Parliament and a former President of the 'NEAT-Aufsichts-Delegation' (NAD), the parliamentary committee for supervision on the NEAT.

Swiss Minister for the Environment, Transport, Energy and Communications, Moritz Leuenberger, mentioned about the Alpine Initiative on their website (2007):

> *"It tirelessly spurs us all on, so that nobody forgets the mandate for transferring traffic from road to rail and so that the green laurels of 1994 never wilt. … But in 2004, rail freight transit traffic grew faster than road freight transit traffic, proving the fruit has at least begun to ripen. And, so that we can pick it as soon as possible, the association will continue relentlessly to make its presence felt. This is absolutely necessary, because without its gnawing pain we will probably never be able to savour the sweet fruit of the transfer of traffic from road to rail."*

Around this time, the responsible politicians and civil servants became more and more aware of the environmental importance of NEAT and it reshaped its purpose. To express this thinking, the slogan "The biggest environmental project in Switzerland" had been developed and used since then.

Round 2 Debates about finance, the two referenda in 1998 and negotiations with EU

After the positive outcome of the referendum in 1992 in favour of NEAT, new obstacles emerged. Although the Federal Council (Bundesrat) mentioned at the Referendum of 1992 that the NEAT was financially attractive, doubts arose. In Summer 1992, words of the Minister of Finance (Departementsvorsteher) Otto Stich cast doubt in public on the financing and profitability of the project – in particular the need for two tunnels: why build both the Gotthard and the Lötschberg? It was clear that he wanted to cut the Lötschberg. Minister Ogi of the Department of Transport and Energy, emphasised that the NEAT was a massive investment in all of the regions of Switzerland. He also would not consider building the Lötschberg later, because that would not lead to any savings, moreover it implicated longer construction times and therefore higher costs. These were very critical moments for the NEAT. In 1994 the Federal Council voted for the solution approved by the plebiscite of 1992 and rejected a split approach.

In the Autumn of 1994 the consultants Coopers & Lybrand were asked to undertake an economical study. In February 1995 they concluded that NEAT was unprofitable and that supportive measures ('flankierenden Massnahmen') were needed. By then a politician of the Schweizerische Volkspartei (SVP) found that his time had come. He repeated his doubts about the need for two tunnels and again proposed to just build the Gotthard,. The discussions reopened and led to an even more fierce discussion than the year before. However, the Bundesrat decided to stick to the two

tunnel approach, without a 'spread in time', and started a study on the financing and optimisation of the track. They suggested extra taxes (fuel, road tax and heavy transport) and 16 new variants for the track. But although several associations and Cantons wanted to change the alignment, they couldn't agree about the variations, because of conflicting individual interests.

In the intense discussions between the Ministers and parliament in 1995, a solution for the financing emerged: a special fund. This gave the opportunity to cover all the large infrastructure projects in a single parliamentary bill that could be embraced within one decision. For this a special fund had to be established – the FinöV-Fund – for project construction and financing. The projects included were: NEAT, High speed connection West and East Switzerland, noise protection measures and Bahn 2000. The new Minister of Transport and Energy, Moritz Leuenberger supported this FinöV-Fund.

On 24 April1996 the Federal Council took the decision on the building and financing of the NEAT. Out of the overall project, in accordance with the plebiscite of 1992, on the Gotthard line only the base tunnels at the Zimmerberg, Gotthard and Ceneri were to be built. The connecting track in the cantons Schwyz, Uri and Tessin were abandoned; however the alignments were to be safeguarded in land use planning. The SBB was assigned to prepare projects for the construction of connection tunnels to the main lines. For the Lötschberg Base Tunnel this decision meant that in fact, in phase 1 (opening in 2007), only one third of the Lötschberg Base Tunnel will have two operational tubes, for cost related reasons.

The Director from BLS AlpTransit stated:

> *"In the cost benefit analysis we have noted that this is impossible. For the combined construction of Gotthard and Lötschberg the maximum expenditure is 30 milliard CHF. This meant we had to modify the construction plan of the Lötschberg Tunnel. Else we would not have the chance to complete both projects"*

On 26 September 1996, the Federal Council adopted the Bill "Building and Financing of the Infrastructure of Public Transport" (FinöV-Fund) for consideration by Parliament. The investment program of 30 bn. Swiss Francs, approx. € 19 bn. covered three further large-scale public transport projects beside the NEAT concept.

Finally on 20 March 1998, the FinöV with a modified schedule of work and financing was adopted by the parliament and became law. The National Council and Council of States approved the investment extent of 30 bn. Swiss Francs, approx. € 19 bn. for all large-scale projects. Included were the four base tunnels of the Gotthard, Lötschberg, Ceneri and Zimmerberg, as well as the connection to the Lake Zurich area . The money originated from the heavy vehicle tax (LSVA[5]) (55%), 20% from the increase of value added tax (VAT) and from 0,1% and 10% from a mineral oil tax. The remaining means are made available by interest-bearing and repayable loans from the capital market (to a max. 25% of the costs of the project).

[5] Leistungsäbhanginge Schwerverkehrabgabe

Vote on Public Transport Funding				
Date	Subject	Turnout:	Yes:	No:
27.09.1998	Federal Act on heavy vehicle charge 1)	52 %	67.1 %	32.9 %

1) Bundesgesetz über eine leistungsabhängige Schwerverkehrsabgabe (Schwerverkehrs-abgabegesetz, SVAG).

A civil servant of the Canton Bern commented:

> *"Finöv is a financing program which secures that we can have sufficient funds for the project till 2020. But the world will hopefully not end after 2020 and then it is likely that a new program will be set up, so the NEAT can be fully completed"*

The people of Switzerland had to decide about a heavy vehicle tax (LSVA). Opponents of the LSVA were for example the ASTAG (Schweizer Nutzfahrzeugverband, the Swiss association for transport sector) that said that heavy transport had already been burdened enough. Two months later, a second referendum took place about the FinöV. On 29 November 1998, with 1,104,235 votes in favour (63.6 per cent) against 634,711 no-votes (37.7 per cent), Swiss voters clearly accepted the FinöV proposal. In addition the members of the Council of States voted in favour with 20.5 against 2.5. Thus, in the next 20 years, CHF 30,5 billion (approx. € 19 billion) are available for building the new alpine base tunnels at Gotthard and Lötschberg, for the completion of the Rail 2000 ('Bahn 2000'), for the connection of Switzerland to the European high-speed net and for noise protection measures.

Vote on Public Transport Funding				
Date	Subject	Turnout:	Yes:	No:
29.11.1998	Vote on public transport funding 1)	38 %		
	People:		63.5 %	36.5 %
	Cantons:		20½	1½

1) Bundesbeschluss über Bau und Finanzierung von Infrastrukturvorhaben des öffentlichen Verkehrs.

The financing was totally different from 1992 (with fuel taxes of 25%, and capital market loans of 75%). The new structure with the Finöv fund meant no direct financing by the State, but instead earmarked taxes for the project.

By these referenda, the NEAT projects were financially secured. The NEAT-Concept focused on the following points:

- Making Switzerland a hub in the European high-speed passenger rail network.
- Integrating intermodal goods traffic into the European rail corridors.

The Swiss had to deal with the European Union about the level of the LSVA tax for EU lorries. This discussion reopened the issue about the weight of the lorries: 28 or 40 tons? After negotiations, Switzerland accepted the 40 tons, and the European Union accepted the introduction of the LSVA, but only after a transition period allowing for a progressive increase for transit traffic from Basel to Chiasso. This transition period would end after the opening of the first NEAT base tunnel (Lötschberg). In effect this provided a significant stimulus for the LBT to be completed on time, because the tax level could be substantially increased after completion.

The former chairman of the NAD commented:

> *"The countries within the EU strive for a unobstructed flow of goods between the member states. This also means an unobstructed flow through Switzerland as transit country. On the other hand, Switzerland has in interest in the environmental friendly flow of traffic. Because of this a policy was developed to achieve a modal shift from road to rail. To bring the interests of the EC and Switzerland together, heavy debates took place for example on whether or not the LSVA could be accepted and if yes to what extent. Then the, in my opinion brilliant, concept was developed to put a tax on heavy vehicles such as lorries which would provide funds for the construction of new infrastructure. This concept became the basis of the international agreement between the EC and Switzerland"*

Round 3 Important discussions after the referenda of 1998

The 'go' decision for the Gotthard and Lötschberg base tunnels was not truly challenged after 1998, although there were fierce debates about the increase in costs that exceeded the project budget. In the light of the referenda of 1998 is an increase of budget possible? It is felt that this is possible, if parliament agrees to a budget increase. But it is always possible for organisations or people to initiate a referendum to oppose to this rise of costs or budgets.

Here we want to discuss three other important issues since 1998:

a The Zimmerberg and Ceneri tunnels.
b Canton Uri, 'NEAT im Berg' at Gotthard.
c Frutigen at Lötschberg.

Zimmerberg and Ceneri base tunnels

At this stage, we will consider the two base tunnels. The construction started at the Gotthard and it was decided that the Zimmerberg and Ceneri should be built in stages, which left the possibility that postponement could lead to a cancellation.

The project director of the ministry (BAV) on the Ceneri Base Tunnel:

> *"It is a totally different situation as in Canton Uri, since the Tunnel does not result in additional traffic hindrance for the region but instead means a better connection to other regions. In addition the Canton expects a positive influence of the construction of this project for the labour market. As a result the Canton and communities actively support the decision to build. This is the basic difference from the situation in Uri"*

The Ceneri Base Tunnel was the subject of debate around 2004. After the disasters in the tunnels in the Alps around the turn of the millennium, which we also mentioned in regard to Betuweroute and A73-South projects, discussions started about the safety of the Ceneri tunnel, because the Ceneri Base Tunnel had been designed with only one tube for the two tracks. The Gotthard Base Tunnel had been planned with two single track tubes, because this base tunnel was almost four times longer (57 km. to 15,4 km.). The construction of this extra tube would mean a large rise in costs for the Ceneri. The Canton Tessin and the cities were in favour of the Ceneri Base Tunnel, because of the better connection for the region and the positive impact on the labour market and so they supported the building.

The former chairman of the NAD commented:

> *"And essential discussion, which also resulted in a large increase in costs, was the decision to build the Ceneri Tunnel in two instead of one tube. After the major tunnel disasters, the original decision to construct both tracks in one tube was not supported anymore. The change to two tracks in separate tubes makes the project a few hundred million CHF more expensive. The discussions on this costs increase are still ongoing: on the hand we see a concern for safety on the other hand and interest in keeping costs down"*

Finally it was decided to build two tubes for the Ceneri. In 2007 work on the access tunnels had been started.

The Zimmerberg tunnel consists of two phases. The first phase of the Zimmerbeg tunnel is a connection at Nidelbad, part of Rail 2000 and which had already been completed by Swiss Federal Railways (2003). The second phase of the Zimmerberg tunnel (Nidelbad–Litti) is a short cut through the mountains and is part of NEAT. The plan was to start construction in 2006 with completion in 2013, but the Zimmerberg phase 2 was postponed – maybe for a long time. In 2007, the Swiss Federal

Council had announced that in 2007/2008 it would conduct a full review of public transportation projects financed from the FinöV fund on which construction had begun, including the Zimmerberg Base Tunnel.

The question may rise: had it been decided to undertake the Zimmerberg and Ceneri tunnels in the referenda of 1992 and 1998? No, this was not the case. The referendum of 1992 secured the NEAT, it made it possible, but the completion was not decided (forced) by the referendum. And in 1998 the financing was subject of the plebiscite.

Canton Uri 'NEAT im Berg' at Gotthard

The northern entrance to the Gotthard base tunnel is located in Canton Uri. Due to the Canton's mountainous nature and limited level ground, the main area of cantonal development is also exactly where the start of the tunnel was planned. Because this developed area is so limited, the impact of the connecting line to the Gotthard base tunnel is enormous for those living there. This has caused heated and intense discussions between the involved stakeholders, most notable the local public, the Canton, ATG and BAV.

During the early phases of the project, in the 1980s, heavy resistance was already felt from the citizens of Uri. However these concerns are quickly picked up by SBB, the Swiss railway company in charge of the project at that point, which meant that work was done to develop a jointly accepted solution to cross the valley within the Canton. This joint solution was developed by the engineers of the Canton and incorporated a covered track to limit nuisance. However later, in 1994 this joint solution was abandoned mainly because there was a need to achieve cost savings in the project. As a result the scope as submitted into the spatial planning procedure contains an open track alternative – not covered and above ground level on some parts. This alternative is most unwelcome to the citizens of Uri and to the Canton's administration.

Because of the new proposed track configuration the relationship between Uri and SBB is seriously damaged. As a result the committee 'NEAT im Berg' (NEAT in the mountain) is founded by citizens. The committee demands a study to relocate the tunnel approach from the valley into a tunnel within the mountain. About 10,000 Uri residents share this concern and place their signatures on a petition. The Uri legislature is prepared to present the Federal Council with targeted questions regarding the concept of a mountain alternative. The protests of the citizens stimulate the Canton to perform a study, using its own resources, to develop a mountain alternative which can be compared to the alternatives in which the valley itself is crossed.

In 1995 parliament decides to initiate new studies on how the valley should be crossed. The studies will be undertaken by the Canton Uri as an assignment from ATG. In this a mountain alternative should be developed and the valley alternatives optimised. In addition the opinion of the citizens should be investigated further. The studies showed that the citizens support a mountain alternative but in the discussions of the parliament over the following years no final decision is reached. ATG and BAV are in still in favour of a valley alternative while Uri only wants to approve a mountain alternative. ATG and BAV also stick with their initial solution because the overall NEAT project has become too expensive.

In order to speed up things, ATG then decided to propose a valley alternative again in spatial planning procedures of 2000. In addition, however, the possibilities for a mountain alternative will be investigated further. The Canton Uri responds furiously by stating that their demands are not taken seriously by ATG and BAV and threatening to use all legal means to obstruct the proposed alternative.

As a result of all protests within the Canton, new investigations are executed on the feasibility of a mountain alternative. In 2002 BAV decides that the mountain alternative is now preferred. As a result the track which is constructed should be built in such a way that to make a future mountain alternative possible. This means that a small part of the mountain alternative will already be built in the form of an underground junction. This new plan is proposed in 2003. Currently the valley alternative, with some alterations to previously proposed plans, is to be built. The mountain alternative is put into the spatial planning procedures but the final decision on what and when to build is not yet taken– nor is the financing for this part of the project secured.

Partly as a result of the discussions in Uri the execution of the project is already heavily delayed because of these discussions.

These discussions led to an important delay, see figure 3.22.

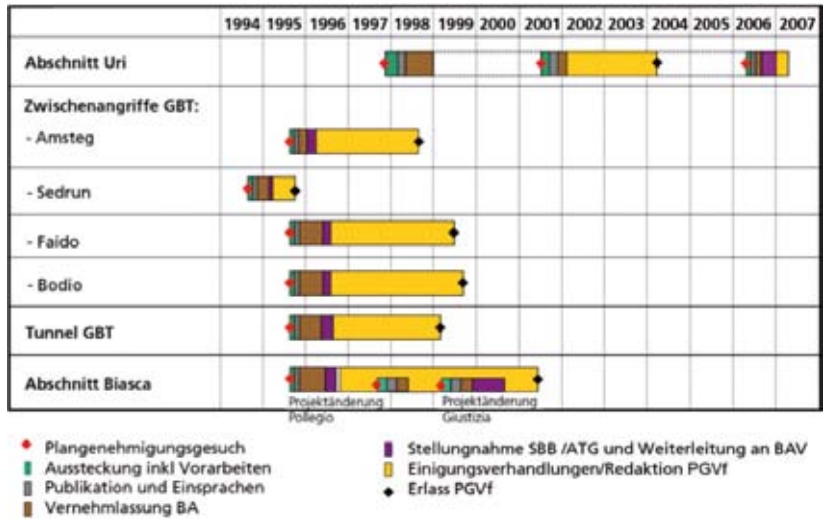


Figure 3.22: Planning procedures Gotthard

Frutigen and the Lötschberg

Frutigen is a small town on the northern entrance of the Lötschberg tunnel. Here the initial plan was to bypass the village with a tunnel ('Niesenflanktunnel'). However this tunnel was sacrificed for reasons of cost in the mid 1990s. Frutigen would be crossed using open track. This alignment would split the village in two parts.

The authorities discussed possible variations for connecting the base tunnel in the area of Frutigen. All agreed that the project ought to be optimised, but no universal agreement can be found. The canton of Bern favours a by-pass. All parties agree however that two tracks must link the base tunnel directly with the station of Frutigen.

Finally a solution is proposed including a covered track with two tunnels connecting to the station of Frutigen. This proposal is however modified by BAV which instead decides to build one tunnel first and a second tunnel later. This causes protests in the village because it would mean the village would be inconvenienced by construction activities for two long periods instead of one.

After new talks between BAV, BLS, Frutigen and the Canton of Bern, a new solution is reached. It is decided that both tunnel tubes will be constructed at the same time but that only one tube will be technically fitted out for operation. This means that the citizens will only experience inconvenience during a single construction period. In addition changes have been made to adapt the construction activities so they include new infrastructure facilities – such as a bridge crossing – to benefit the local community. All these measures have increased the support for the project.

3.4.3 Comparing Switzerland and The Netherlands

In the table below some major differences between the Swiss and Dutch situation in the execution of LIPs are elaborated.

Switzerland	The Netherlands
Referendum needed to execute a LIP. Both the cantons and the people need to support a LIP for a GO decision	The house of representatives decides on the GO decision for a LIP
Civil servants of the Federal Office of Transport (BAV) can talk to the members of the NEAT Aufsichts-Delegation directly. This is a permanent committee with members of the House of Representatives that monitors the NEAT project Gotthard and Lötschberg.	There is no possibility for civil servants of the Ministry of Transport to talk to the House of Representatives directly.
A large part of the budget for unforeseen costs is controlled by the Federal Council (Bundesrat).	Generally the budget for unforeseen costs is controlled by the project organisations
Strong focus on the administrative side of the project from the beginning: risk management, control and a quality system	The importance of the administrative side of the project has increased during the project. Dutch LIPs have learned project control during the projects.

It is important to note that all these differences have consequences for the management of complexity in LIPs. This makes studying, and possibly learning, from these practises an interesting challenge. In the next section we continue to investigate the management of complexity in the international arena of LIPs by switching our attention to the West Coast Mainline.

3.5 WEST COAST MAINLINE

In this section we will describe the story of another large infrastructure project: the West Coast Mainline (WCML). This brings us also to a different institutional setting since the project is located in the United Kingdom. The information presented in this chapter is partly drawn from the interviews held and report written for the EU funded NETLIPSE project. The information and analysis was also used as a basic for chapter 4. 'Appearances and Sources of Process Dynamics; the Case of Infrastructure Development in the UK and The Netherlands' in the book Managing Complex Governance Systems (Teisman, 2009).

In the Dutch cases we have more or less centred on the elements of complexity. In the Swiss project we have added some first insights into the management of complexity as well. We will continue to do so in the case of the WCML where we will

show how major changes in the institutional context along with major differences in management have lead to completely different results. But we will start of with presenting the facts and figures of this highly dynamic project.

3.5.1 Project Facts & Figures and stakeholder constellation

Project Purpose and Project Definition

This section represents the status of the project as at the start of 2007.

The West Coast Main Line (WCML) is Europe's busiest mixed-use railway (see figure 3.23). It links London with major urban areas in the northwest. More than 2,000 trains a day use the line, transporting both passengers and freight. The train services consist of long distance, regional and local (short distance) commuter trains, along with substantial freight traffic. The latter represents around 40% of the total rail freight traffic movements in the UK. The WCML relates to the 650 km main line between London Euston and Glasgow, which also serves the West Midlands (Birmingham), the North West (including Manchester & Liverpool) and North Wales (with connections to & from Ireland). Presently, there are some 22 million passenger-train km a year and 6 million freight-train km a year.

The objectives of the WCML project have shifted several times. The current objectives (2007) were formulated in the WCML Strategy report of June 2003:

1 The upgrade had not only to address the major backlog of maintenance and renewals on the route, but should also ensure value for money;
2 The upgrade should also establish sustainable and cost effective maintenance regimes;
3 The upgrade should provide additional capacity for anticipated growth in passenger and freight business over the next 20-30 years, with substantially faster and more competitive journey times between major cities served by the West Coast route;
4 The upgrade should also provide an improved level of performance, safety and reliability which will, in turn, help the railway regain lost market share and increase the role it can play in the national and regional economies;
5 Finally the upgrade should achieve above the objectives on a 'railway in use' allowing for the continuation of freight and passenger services during the rebuilding and enhancement work.

In meeting the above objectives, the project will deliver a modernised and sustainable West Coast railway. The success of the project will also depend on key outputs being achieved: for example, a 125 mile/h route between London and the West Midlands, Manchester, Liverpool, the North West, North Wales and Scotland, exploiting the capability of tilting trains to deliver much faster journey times. There will be capacity for 80% more long distance passenger trains than today and for up to 60-70% more freight paths than at present.

Fastest journey times to/ from London Euston:	Pre-Project	May 2006	Post-Project (Expected, Dec 2008)	Reduction in journey time (Pre-/ Post-Project)
Birmingham New St.	1h 39m	1h 21m	1h 18m	-21,2%
Manchester	n/a	2h 05m	1h 59m	-
Liverpool	n/a	2h 09m	2h 06m	-
Preston	2h 25m	2h 10m	2h 07m	-12,4%
Glasgow	5h 06m	4h 24m	4h 15m	-16,7%
Number of fast line train services to/from London per hour:				
Peak time	7	11	13	
Off peak	5	6,5	11	

Table 3.2: WCML Frequency

Figure 3.23: West Coast Mainline

Facts and Figures

Renewal elements:

- Track works: 780 miles of track (out of a total of 1,660)
- Bridges: 30 spans
- Number of stations: 20 intercity & 30 regional/ local

Finance

The first calculations of the costs of the upgrade made by Railtrack (RT) went no higher than £ 3 bn. More realistic estimations at the beginning of the 2000's indicated that a renewed and modernised line might well cost in the region of some £13 bn. plus. Government, as part of an agreement, approved the project budget based on the content of the June 2003 WCML Strategy report. The budget was set at £9,9 bn. (2002/03 price level). Cost control has been achieved and the project has been kept well within this limit. By joint assessment of cost reduction opportunities, value maximisation and scope control, the current baseline amounts to £8,3 bn. (2005/06 price level).

Although the UK rail industry has been privatised since 1994, it is still reliant on substantial public subsidy for both capital investment and ongoing revenue support.

The funding flows according to figure 3.24.

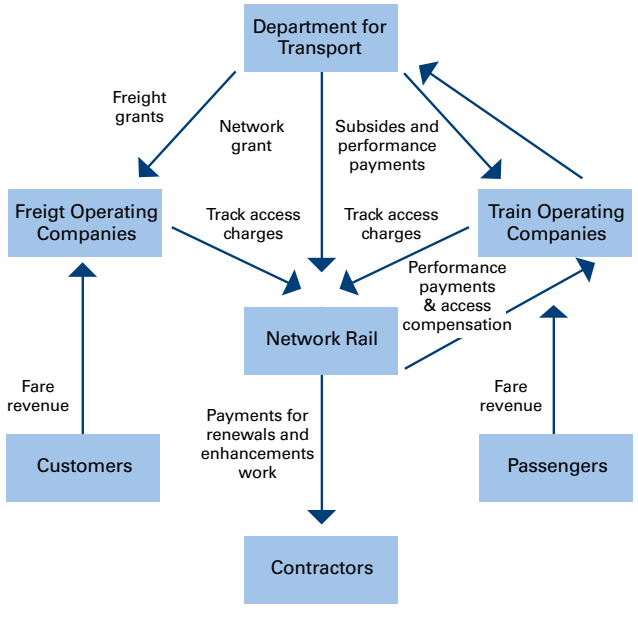


Figure 3.24: Funding flows for the West Coast Programme

Planning

Present stage of project (1 January 2007)	Approximately 2/3 completed (final 1/3 completed by the end of 2008)
Time of decision to build (go/no go decision)	Spring 2002 (present project)
Time of start of construction works	2002 (earlier work started in 1998)
Time of delivery	December 2008 (complete project)
Time of begin operations	Staged between 2004 – 2008: Sept 2004: London Euston – Crewe Dec 2005: London Euston – Glasgow Dec 2008: All

Contracting

Network Rail has a formal procurement and contracting strategy:

- EU and UK regulations are the basis.
- The preferred contracting option is to enter a series of contracts split by discipline with the contract deliverers, rather than to main contractors – who then sub contract the majority of work and in effect act as Construction Managers.
- The preferred forms of contract will be either fixed price, lump sum or 'bids of quality with re-measure'.
- Due to the nature and present time scales each contract will need to be reviewed independently to determine the form of contract.

Organisation

Given the high profile nature of the project, the importance of the route and the high level of expenditure, the government decided in October 2001 to take the strategic lead for the project through to completion, with Network Rail being responsible for the delivery of the infrastructural aspects.

The governance of the project is managed through a Project Board. See figure 3.25 for the project's governance arrangements in December 2002. This Board is made up of Network Rail, The Strategic Railway Authority (SRA), and Office of Rail Regulation (ORR) Board Members and Network Rail and SRA West Coast Directors, dealing with strategic decision-making. Reporting to this Board is a Project Development Group (Network Rail, SRA & ORR) dealing with detailed decision-making on delivery, costs, resources and operational issues and a WCML Joint Board (train and freight operators) considering operational performance and maintenance issues. Reporting to the Development Group are Network Rail's and SRA's West Coast Teams.

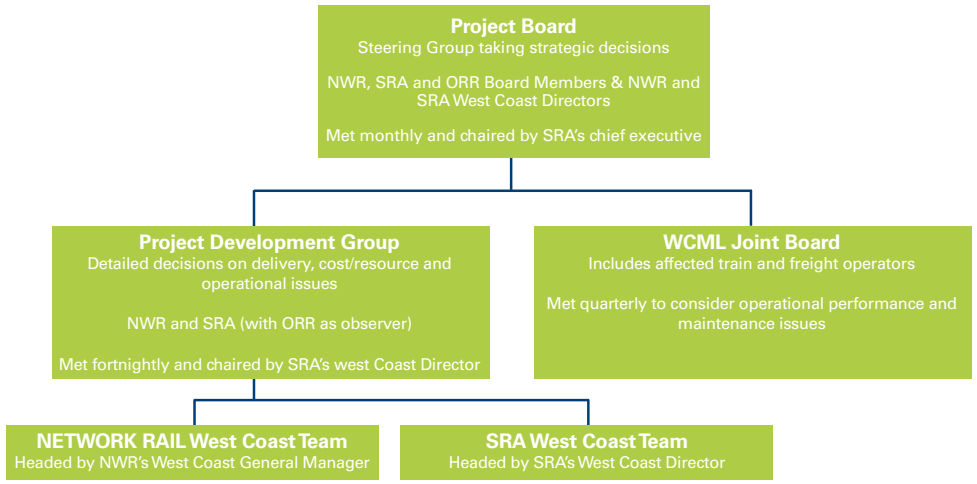


Figure 3.25: WCML project's governance arrangements (December 2002)

Stakeholders: internal and external

The first group of internal stakeholders are those parties within the rail industry, or those directly associated with it, that play a direct role in the delivery of the project and are directly affected by its outputs. These parties comprise the following, see next table.

Internal Stakeholder:	Responsibility:
• Government (represented by the SRA prior to Summer 2005, DfT after summer 2005)	Project strategy definition.
• Network Rail, a not-for-profit organisation	Infrastructure works delivery.
• Passenger & freight train operators	Train service delivery (timetables), revenue generation and customer service.
• Office of Rail Regulation (ORR) (prior to July 2004: Rail Regulator)	Protection of the interests of users and the promotion of competition, efficiency and economy in the provision of railway services.

Each of these parties has a major responsibility in the project. The project was presented as "Britain's railways working together".

External stakeholders are the bodies that are indirectly affected by the outputs of the project; that can influence funding or support for the project; and, in some cases, which have a statutory right to be consulted in the process of development of the project. In total there are over 700 organisations identified and the Department for Transport and Rail (DfT) contacted each of them individually.

External stakeholders are separated into 2 groups: a group which the West Coast Team has to consult from a statutory standpoint, which like the Passenger Transport Authorities and Executives have responsibility for the delivery of regional transport services in the major provincial cities. The West Coast Team does not have to consult the second group from a statutory responsibility (none of the bodies in the second group has a 'veto' over the content or delivery of the work being undertaken, except in for few local planning issues). However, consultation of this group of stakeholders is highly desirable, because it is vital to ensure that their local knowledge is aligned with the overall direction of the project. Many of the bodies represent areas that would benefit by the improved services or would generate business to support the investment.

In order both to inform and to seek agreement to the strategy underpinning the revised project scope and outputs, a consultation document was published in October 2002. This was provided to all parties in both the first and second groups. Details of this activity and the results of the consultation exercise are contained in the final WCML Strategy report published in June 2003.

There continues to be an ongoing dialogue with external stakeholders, to keep them abreast of developments at the side of the WCML, but also to consult with them over the more detailed aspects of the project as they emerge, and to receive early indications about developments in the stakeholder context that could be useful or prejudicial to the process of upgrading. To facilitate the link with such bodies, a number are grouped together. An organisation entitled 'West Coast Rail 250' represents many of the local authorities along the line of route and also has a Parliamentary branch enabling a direct dialogue with Members of Parliament. DfT, along with Network Rail and the train operators, continues to meet this body on a regular (bi-monthly) basis.

3.5.2 Storyline West Coast Mainline

Built in stages over three decades from the 1830s. The description of the reconstruction of the line starts in 1984.

In the case of the West Coast Mainline there is a variety of crucial events. We can distinguish three institutional periods starting and ending with main events. In this section we summarise the key elements in which we illustrate the complexity and how it was managed.

Round 1 Locked in a non-innovative British Rail *1984 - 1990*

British Railways was created in 1948 out of ailing private regional rail companies which were bankrupt following the stresses of the Second World War, British Rail was for a long period the manager of the West Coast Mainline. Although the route was extensively renewed and upgraded as part of major electrification investment schemes, work carried out since has been limited. Although British Rail recognised that further renewal work was necessary and contemplated options during the 1980s, the route had not seen any significant renewal since its electrification in the 1960s and 1970s. This period can be described as 'the public monopoly period'. British Rail was in charge, had a lot of 'tacit' knowledge of what should be done with the West Coast Main Line, but did not have the ability to put this into action. The main objective seemed to be 'preventing the system from breaking down'. Money was put where the biggest impact on reducing failures with severe effects were expected. The route needed renewal in the 1990s because, with its infrastructure ageing, train service reliability was deteriorating, leading to a fall in demand. Plans for upgrading the line were made, but were never implemented.

This, combined with the overall global wave of privatising and market orientation, led to the erosion of support for the nationalised British Rail and stimulated people to look for other (and therefore private) approaches. In the mid 1990s the breakup and privatisation of British Rail was completed. This ended a period of stagnation and technical degradation on the WCML.

Round 2 Chaos in the private domain: The story of broken dreams *1990 - 2001*

The Railway Act 1993, introduced by John Major's Conservative government, started the privatisation of British Rail. British Rail was broken up into over 100 separate companies and sold off. By doing so the Railway Act 1993 created a complex structure for the rail industry.

Railtrack (RT) took over ownership for all track, signalling and stations and was hastily privatised in 1997. In 1996, the Passenger Upgrade 1 (PUG1) contract was agreed between Railtrack (RT) and the Office of Passenger Rail Franchising (OPRAF) to modernise the rail infrastructure with existing technologies. RT then owned and was responsible for operating, maintaining, renewing and developing the rail infrastructure. Virgin Rail Group (VRG) a joint-venture of the Virgin Group and the Stagecoach Group won the franchise to operate long-distance passenger trains on the WCML in 1997 until 2012.

However, Virgin Rail Group (VRG) wanted to go further than PUG1. It agreed with RT a renewal and upgrade programme known as Passenger Upgrade 2 (PUG2) that allowed higher speed trains with a higher frequency. VRG took the view that significant increases in capacity would be needed for its franchise. After being approved by OPRAF and the Rail Regulator, PUG 2 was signed in 1998.

RT and VRG were confronted with the worn-out line and started enthusiastically with plans for high quality upgrading. Their plan was reliant on new technology, such as moving block signalling to increase capacity and train speeds at low cost. The plan drawn up by Railtrack estimated that the upgrade would cost £ 2 bn. and would by ready by 2005 (in two phases: 2002 and 2005). The ambitions were high: the upgrade would cut journey times from London to Birmingham from 1hr 40 minutes to 1hr. This would be achieved through increasing the line speed to 225 km/h. VRG ordered a fleet of new tilting trains that would be capable of running at 140 mile/hr, with delivery planned for May 2002.

Both the private newcomers, Railtrack and Virgin, were anxious to show how an innovative, quick and smart private sector could deal with the neglected system. They focused mainly on financial return, delivered through innovation and market expansion. These objectives were at the core of the contracts between RT and Virgin to upgrade the line – the core purpose was to make money, rather than deliver transport improvements. The two private parties however seriously underestimated the restrictions that came with the existing (lack of) quality on the line.

The programme ran into difficulties. RT's estimates of the expected final cost increased rapidly and in December 1999 Railtrack decided not to use moving block signalling, as the technology was not sufficiently mature. Other factors, including West Coast contract liabilities, created a financial crisis for RT which resulted in October 2001 in the government putting RT into Railway Administration. In effect Railtrack was bankrupt. VRG's procurement of its new tilting trains rolling stock also fell behind schedule. With hindsight the plan was doomed from the beginning, since Railtrack had not assessed the technical viability of 'moving block signalling' prior to promising the speed increase to Virgin and the Government. Moving block signalling had never been implemented on such a complex line as WCML before. It soon became apparent to experts that the technology was not mature enough to be used on the line. The bankruptcy of RT in 2001 brought a reappraisal of the plans whilst the original costs of the upgrade continued to soar. The revised estimates indicated that the line upgrade would cost a total of £ 13 bn. and would be ready by 2008 with a maximum speed of 200 km/h for tilting trains. The ever-present 'phantom' of cost overrun and delay in infrastructure was beginning to re-emerge.

We have referred to the PUG2 contract. In interviews, we heard a firmly negative judgement about the contracting by Railtrack to Virgin in PUG2. Two quotes taken from the interviews:

> *"Railtrack was a bank, not a railway company."*
> *"Contractors had basically Railtrack's cheque book."*
> Manager West Coast Mainline, interview 2006.

Due to ignorance and lack of local knowledge of the rail system the two parties managed to make highly ambitious, but unrealistic (in retrospect) plans and contracts,

hoping for the big money prize. In the process they created enormous cost overruns and delay, contributing significantly to the fall of RT and the need for a new project definition by public authorities. A further dramatic moment occurred with the railway accident at Hatfield in 2000, where the lack of competent asset management led to the derailment of an East Coast High Speed Train. In order to deal with the perceived risks, RT imposed over 1200 emergency speed restrictions on its network, creating enormous delays and severe losses for the service providers. This was a classic moment of crisis. The lack of asset knowledge in RT became fully apparent to the nation.

Secretary of State for Transport, John Prescott decided that SRA, a non-departmental public body responsible for providing strategic direction for the British rail industry would impose a solution for this crisis. This means that political intervention led to the return of Railtrack and its assets into the public sector, as hastily as it was previously handed over to the private sector.

Virgin renegotiated their contracts with the government from high risk, high return to low risk, low return.

Round 3 Reinventing public-private cooperation: A realistic approach 2001 - 2007

In Autumn 2001, Government took direct control of RT and its assets. As already noted, Secretary of State for Transport, John Prescott decided that Strategic Rail Authority SRA, should impose a solution. The renewed role for government did not lead to a return to the British Rail regime since many aspects of privatisation had proved to be successful. SRA concluded that abandoning the project was not viable. 80% of the works were needed to replace ageing infrastructure and cancelling works already contractually agreed would incur substantial financial penalties. The project could however be respecified with deliverable outputs and a clear positive business case. In 2004 the SRA in its turn was abolished. Its strategic tasks were transferred to the Department for Transport (DfT), as was the letting of contracts for passenger franchises. The operation of the infrastructure remained with Network Rail, the successor of Network Rail.

The WCML Strategy report, published in June 2003 addressed the need, not only to repair and renew the railway to ensure its continued operation, but also to provide the capacity and capability for high-speed long distance trains. Moreover, it allowed the continued provision of local and regional passenger services and the serving of the important freight market. It was decided that proven technology was to be used wherever possible: the project had a huge scale and could not continue to be burdened with the uncertainties in timescales and costs associated with the development of new technology. A business case was built, leading to clear insights about the revenues of upgrade activities and working as a communication instrument

with all parties involved. Finally the predictions of the cost of the project were brought back from £ 13 bn. to £ 9 bn., following further cost reductions the expected costs are less than £ 8 bn. (December 2006).

The West Coast strategy was built upon an extensive consultation with stakeholders, both within the railway industry and with other interested bodies, such as local authorities and user groups. Trust was built up and kept. Indeed, there has been overall consensus throughout over the specification and delivery of this stage of the West Coast Project. These close links have been maintained and have assisted the continued development of the route and its outputs.

The WCML Strategy report sets out three stages of project delivery. The first of these was introduced in September 2004, involving the upgrade of the line between London Euston and Crewe / Manchester. These also enabled accelerated improved services to be introduced on all key inter urban corridors, including increased frequencies and faster journey times. Trains were also permitted to operate at 125 mile/hr in tilt mode south of Crewe. The second stage was planned in 2005, when the line North of Crewe was upgraded to provide for 125 mile/hr in tilting mode. By April 2006, around three quarters of the physical work of the project was complete. Remaining key works include the enlargement of Milton Keynes and Rugby stations and the widening of the Trent Valley route (third stage).

The upgrading activities are performed mainly by Network Rail. They prepare schemes for upgrading parts of the line and announce when the line is to be closed for use. The line is out of use to a considerable extent, especially, at weekends.

Nevertheless it seems to be clear that the upgrading activities will be finished in 2008. The first Pendolino trains were operating on the WCML in 2004 and the amount of users is growing very strongly. The expectation is that, at constant price levels, revenue will triple between 2003/04 and 2012/13, from just over £ 300 mln. p.a. to £ 1 bn. p.a. and that freight traffic on the route will also grow strongly. Looking at these achievements one could say "all's well, that ends well", but there was some significant waste in the early, uncontrolled, days of the project, mostly borne by the loss in the share price of the private infrastructure controller, Railtrack.

The approach in this third round of upgrading was different from the previous rounds. The strategy was build up in consultation with shareholders within the industry and with stakeholders such as local authorities and user groups. The passenger and freight operators, who had been excluded from contributing to the project, became heavily involved and provided the SRA with an immense amount of practical advice and guidance. This plan was not made in splendid isolation as was done before, but in interaction with the whole rail industry and important stakeholders. This led to an arrangement beyond the boundaries of the public and

private domain that was based partly on control but for a large part on building and maintaining trust.

This led to a complex institutional arrangement once more. This time, however the managers in charge were able to deal with this complexity. They focused on desirable outcomes, managed support and dealt with the continuing institutional change, like the abolition of SRA and the division of its tasks between DfT, Network Rail and ORR.

This third period is still going on and has led to an intriguing combination of public guidance and private production. An effective network of parties has been built up capable of dealing with the network characteristics and interdependencies of the physical rail network and future delivery. On the one hand there were clear formal divisions in tasks and responsibilities, but on the other there were effective informal networks and methods of collaborative planning; building up sufficient knowledge and support.

3.6 SUMMARY AND CONCLUSIONS

In this chapter we have presented six projects and presented storylines of their history. We have used a 'rounds model' to develop these storylines. The storyline analysis has allowed us to draw some first preliminary conclusions on the occurrence of complexity and its management. We will now look back on the presentation of the six project cases and describe the further development of this thesis based on these first findings.

Complexity and its management is similar and comparable for LIPs

While there are many differences between the storylines it is clear that the characteristics of the projects and their implementation processes also show some large similarities. Similarities can, for example, be found in the non-linear implementation process in which various rounds of decision making can be distinguished. Or in the large number of players which are involved with different responsibilities. Based on these similarities in facts & figures, 'stakeholder constellation' and historical development we come to the conclusion that LIPs are comparable on a European scale. The similarities are not only present when comparing Dutch projects but also when comparing the projects in Switzerland and the WCML. This is an important observation for the further development of this thesis because it shows that a comparison of complexity and management strategies is potentially fruitful. Even while the institutional context, which is of high importance as we saw earlier, is different between countries, there are enough similarities to compare management strategies in the management of complexity. For the Swiss situation we presented an overview of some interesting differences

in approach in management of LIPs. While due to the different institutional context and other factors these approaches might not be immediately transferable to other countries, they provide us with new and interesting options to consider.

> *The projects studied in Switzerland, The Netherlands and United Kingdom are comparable in the management of complexity in LIPs on an European scale.*

An illustration is the case of the project director of the West Coast Mainline. After investigating the Betuweroute, Øresund fixed link and Ring road Bratislava for NETLIPSE, he used experiences of these projects in the tender documents in a new project: the purchase of rolling stock. He mentioned:

> *"Studying these projects was of more training value for me than I ever expected."*

When performing a first analysis of the cases which we have presented we can conclude that complexity in LIPs is both visible in:

a Characteristics of the project
- Tightly connected to their context
- Multi player game
- Implemented in a unique context

b Evolution of the implementation processes
- Non linear implementation process
- Unique starting position and subsequent events are of key importance
- Complexity is visible in all rounds of decision making

a Characteristics of the project

Tightly connected to their context

The storylines illustrate that context factors within LIPs play a very important role in how decisions are taken and what effects decisions will have over time. Examples of the influence of 'context factors' are emergent events such as the 'Bos alternative' for the HSL-South or 'Alpine Initiative' for the Gotthard. Other context factors of high importance that were observed are related to the privatisation of the railway industry (HSL-South, WCML), (un)favourable market conditions (BR, HSL-South) and the Ministry's preference to promote regional co-operation at the Highway 73. All these factors can be seen as being part of the 'context' since they are not under the direct control of the project delivery organisation. They more or less reflect the characteristics and circumstances of the wider system of stakeholders in which the project delivery organisation is trying to implement the project in the form of an infrastructure facility.

In terms of management this means that successful management approaches for complexity in LIPs need to take the context into account. Management strategies need

to assist project managers to properly embed the infrastructure facility so as to fit the broader stakeholder network. At the Betuweroute we saw that this aspect was largely overlooked which resulted not only in resistance from local stakeholders but also in a difficult relationship with the users of the new railway line. At the WCML we also saw the importance of the context in which the privatisation wave left a major mark on the project. It even became one of the main triggers for near project failure during the second round. Later, in round 3, we see a management approach which fit the interests of the railway industry in a far better way, producing superior results.

Management strategies which place great importance on the context, have been called 'strategies of interaction' by us , and are outlined in chapter 8.

Multi player game

Within the LIPs we described in this chapter there were often large differences of interest between the involved key stakeholders. The Ministry of Transport, House of Representatives, Project delivery organisation, local stakeholders, contractors and NGO's often have very different objectives they want to achieve within a LIP. And, in addition, the differences are not only present between stakeholders but also within stakeholders. This especially holds true for the public or government side of the project in which several departments (Ministries) are involved. It is a key challenge in the management of LIPs to deal with these differences of interest in the successful realisation of LIPs but this is, more often than not, extremely difficult. Dealing with conflicts of interests seems to be one of the main tasks of the project manager in dealing with complexity. We will further outline this when we describe the social complexity in LIPs in section 4.4.

Unique context

As previously noted, the context of LIPs is unique for, while there might be similarities with other projects, the project context is never absolutely identical. One example where we saw the importance of the context was when the contracting model for the HSL-South was decided. This decision was taken at a time when which both the Minister and Ministry were looking for new and innovative forms of contracting. This high interest in contract innovation led to the application of Design & Construct for the substructure and a DBFM for the contract for provision of infrastructure . Other examples of the context influencing decisions and project results are the booming construction market and the privatisation of the NS. These circumstances, outside the control of the project management within the project delivery organisation had a major impact on the development of the project.

The unique characteristics of the context in which LIPs are implemented, means that blueprint 'clear-cut' solutions are bound to fail since these fail to take this uniqueness properly into account. This is an important insight for the rest of this thesis since it means that the outcome will not be a 'one size fits all' type of management solution

but more an overview of an array of management strategies which can be 'mixed and matched' to develop a tailor made management solution which fits the project to which it is applied (see chapter 9). The project manager's task is to select the right mixture of strategies and to adjust this mixture over time.

b Evolution of the implementation process

Non-linear implementation process

The case histories all demonstrate 'non-linear' development of the implementation process. At first glance the events within one round can seem to follow linear patterns but particularly between 'rounds' we observe many and large differences. This was observed in its most extreme form in the WCML case where three very distinctive institutional environments were present over the course of the project. The implementation processes of LIPs can, to a large extent, only be reproduced afterwards and not be outlined during the process. It is highly difficult, some scholars will say impossible, to predict the course of the project over time which makes the job of the project manager comparable to that of a sailor making a journey with a vaguely known destination and with only minimal knowledge on the route which will be followed. The characteristic of non-linear implementation is further outlined in section 4.8.

Related to the non-linear implementation process is the observation is that the goal of the projects may also evolve. Gotthard and Lötschberg evolved from a transport project to become "the biggest environmental project in Switzerland". The A73-South evolved from a single highway development to a package of five projects (A73-Aouth, A74, N280-East, N293, N273 Haelen). At the Betuweroute the survival of the Cargo department of Dutch Railways (NS Cargo) was an important initial goal of the Betuweroute. But this goal faded away. Finally the Betuweroute Hermans Committee changed a financial profitability objective into a decision on a 'strategic investment'. So the project is not only a solution for a specific (mobility) problem, but can also become an infrastructure facility looking for a suitable application in the field of mobility!

The observation that the implementation shows significant signs of non-linearity – especially between rounds, means that management approaches need to address this. For this reason, the traditional, linear, management approaches based on control (presented in chapter 7) need to be accompanied by approaches that are more suited to dealing with non-linearity characteristics (presented in chapters 8 to 10).

Unique starting point and subsequent events

A further observation regarding the implementation process, is the influence of starting conditions and unique subsequent events that influence the implementation

of LIPs. It appears that perceptions and ideas formed during early phases are very difficult to change during the latter stages of decision making and implementation. This was found at both the BR and the HSL-South where initial ideas proved to be extremely persistent in the following stages of the project. Within the Betuweroute the 'power-play' attitude of the Ministry of Transport largely backfired and resulted in a 'contaminated' project for the latter stages. Within the HSL-South the initial option for building a new railway connection all the way to Amsterdam turned out to be very persistent when other options were presented, such as the Bos alternative. It shows that the implementation process of LIPs suffer from 'historical path dependency'. This is something which we further address in section 5.4.1.

In terms of the management of complexity the uniqueness of events and starting points mean that each project requires tailor made solutions. This does not make learning fruitless however since patterns of evolution and similarities can also be found which can be useful in the management of a project (see chapter 8.3.3 on the use of pattern analysis). Learning from other cases can in addition be very helpful for managers to enable them to understand the implementation process and characteristics of the project in which they are participating.

Complexity is visible in all rounds of decision making

Another conclusion which can be drawn based on the case material, is that complexity appears to present in all rounds of the project. While it holds true that complexity is traditionally high during the early phases of the project, complexity does not seem to disappear or fade over time. It seems that once one important issue is solved, others will come up for attention, later in the project. Good examples of this were observed at the Highway 73 where important discussions regarding tunnel safety, location on the east or west bank and environmental compensation were present long after the political agreement was signed. Other examples are the struggle with ETCS/ERTMS complexities and the order for rolling stock (transport contract) within the HSL-South. Similarly, at the Gotthard we noted the ongoing discussions within the Canton Uri which are unlikely to reach closure at any time soon soon since the 'mountain alternative' is not to be constructed in the near future.

Apart from the similarities in characteristics and in implementation process, our storylines show that:

> *Studying complexity in LIPs by applying the rounds model with the use of storylines is useful and more appropriate than using a straightforward phase model.*

Specific rounds of decision making and implementation can be distinguished. Each of the rounds can be analysed by looking at the complexity and how this complexity was dealt with by the stakeholders involved. The outcomes for each round can be studied by looking at the results. These results are measured in terms of stakeholder satisfaction as well as 'more objective' standards such as costs, time and scope. Now how to proceed? The cases show that complexity within LIPs can be found in all kinds of aspects: technical, social, financial, organisational, legal and time. This is the basis for an empirical model on complexity, or what we have labelled the 'practitioners' view' which we outline in our next chapter. In chapter 5 we will then add a theoretical point of view to the cases – where we distinguish two views on complexity: detail and dynamic complexity.

The analysis of the storylines has provided us with first indications on the occurrence of complexity and its management. It is important to note that these indications are mainly built on 'outside observations' based on the case histories. To put it differently: in this first analysis the complexity is basically defined by the researchers and not by the key participants involved in LIPs. In the next chapter we will add the 'insiders view' on complexity by demonstrating how complexity is perceived by project managers and other people active in LIPs.

4 MANAGERS PERCEPTION OF COMPLEXITY

4.1 INTRODUCTION

"The project has extremely diverse characteristics, technology (innovation), contractors, politicians and other stakeholders play a very important role. That makes the project very special."
Director Betuweroute, ProRail.

In the previous chapter we introduced our cases both by using an overview of facts and figures, as well as of their history by presenting storylines. This provides first impressions about why complexity might be of importance and what challenges it causes for the implementation of large infrastructure projects. The first impressions of complexity have been based on an 'outsiders view'. In this chapter we will add to this the perception of complexity by practitioners.

How should we define complexity in LIPs? This is the subject of in this chapter, or if we put it in a more elaborate way:

Why is complexity and the management of complexity a main issue in the successful implementation of large infrastructure projects? How is complexity defined by project managers and other participants?

The word complexity is often used by practitioners dealing with LIPs. At the same time they will not explicitly define what their definition of complexity is. Furthermore they are not acquainted with the recent theories on complexity in the social domain. The word 'complexity' is often used — mostly without explaining the meaning. The specific literature on complexity as applied in management science is for the most part fairly new, not tied to LIPs and has a dominant theoretical base. In addition, many complexity scientists describe complexity from an external viewpoint. They define certain situations as simple, others as complex or even chaotic. In our social world of LIPs, managers vary in competences and experiences. A situation 'complex' for one manager can be seen as 'simple' by another. Complexity is experienced in the work of project managers in LIPs which means that it has a clear subjective component. Because of this we have preferred not to answer the question 'what is complexity in LIPs?' by starting with the theory on complexity found in the literature on the subject. Instead we have opted to start on a grounded basis by asking project managers and other stakeholders in LIPs how they perceive complexity in their projects. This has resulted in what we will call the 'practitioners view' on complexity. This view is illustrated in this chapter.

The practitioners view was developed by asking respondents: 'What makes this project complex to you?' Since in our study we are interested in how to manage LIPs from the project manager's point of view, it is of great importance to know what makes the management and organisation of LIPs complex for the project managers involved. Based on our interviews, our experience and discussions with practitioners we developed a view in which we distinguish six types of complexity within LIPs. To practitioners complexity in their projects is mostly seen as requiring management attention.

The practitioners view is presented in this chapter and is illustrated by adding examples from authors that have studied complexity in large projects (De Bruijn et. al. 1996, 2004; and Hertogh, 1997). The six complexities have been discussed with project managers during which we have discovered that our framework appears to be recognisable and useful ('sensitised') to them and other practitioners in the field. The overview of the six types of 'complexity' as perceived by practitioners demonstrates that complexity is a concept that highlights the challenges that project managers face in the implementation of LIPs.

The six elements of the practitioners view are:

1 Technical complexity
2 Social complexity
3 Financial complexity
4 Legal complexity
5 Organisational complexity
6 Time complexity

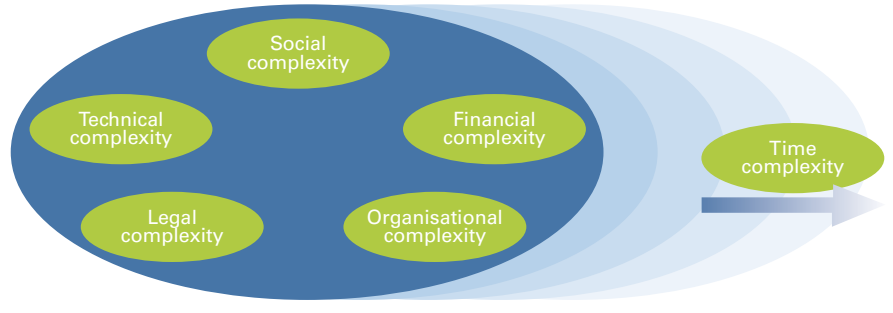


Figure 4.1: Six complexities within LIPs

In the next section we will explain these six complexities within LIPs by using examples of projects, especially from the Betuweroute project. By doing so we will use documents produced by the project delivery organisation within ProRail and the

Ministry of Transport (ranging from 1993-2005). But in order to present a real life image of complexity we start with a description of one of our sub-cases: Tunnel Technical Installations (TTI) at the A73-South. This sub-case exemplifies many of the elements of complexity in LIPs and will be used as a reference for the remainder of this chapter.

The quotes in this chapter are from interviews during the period 2004-2006.

4.2 TUNNEL SAFETY AT A73-SOUTH

Round 1 Development of a safety concept

The Highway A73-South passes the little town of Swalmen on the west and the city of Roermond on the east. To lessen the inconvenience for all inhabitants who live near the highway, in these two places tunnels have been planned. The tunnel at Swalmen is 1,0 kilometre long and that at Roermond 2,45 kilometres, (making it the longest land tunnel in The Netherlands). The tunnels have two lanes in each direction. The tunnels in Roermond and Swalmen will be the first tunnels in The Netherlands that allow the transit of hazardous substances category "0", the category that is most dangerous.

To study tunnel safety, a working group was formed with RWS Limburg (the regional department of Rijkswaterstaat[1]), Bouwdienst RWS (the engineering department of RWS), the regional fire brigade and a consultant. At approximately the same time, the tunnel disasters in the Alps took place (Mont Blanc tunnel March 1999, Kaprun in November 2000 and Gotthard in October 2001). Because of this, safety in tunnels was a much debated topic in the Netherlands, including the safety of the tunnels of the Betuweroute and HSL-South. At that time there was no generally accepted safety-philosophy and because of this there were heated debates regarding the A73-South tunnels. RWS Limburg wanted to apply a probabilistic and quantitative approach. On the other hand the fire brigade suggested a scenario approach, which can be typified as 'deterministic'. These opposing views led to significant debate between the participants.

Figure 4.2: Tunnel Roermond, North side entrance (www.vialimburg.nl).

[1] Rijkswaterstaat (RWS) is the implementing organisation of the Ministry of Transport, Public Works and Water management and works to protect against flooding and to provide sufficient clean water for all users. RWS also promotes the rapid and safe flow of traffic on national roads and waterways.

Round 2 From hard shoulders to Compressed Air Foam

In the initial design (1995), both tunnels of the Highway A73-South were planned to have hard shoulders and this was approved in the Environmental Impact Assessment (E.I.A). However, it was never discussed explicitly whether these hard shoulders were necessary. In 2003 the head office of the Ministry of Transport, Public Works and Water Management suddenly decided to remove the hard shoulders in the tunnels. The minister of transport, Mrs. Karla Peijs, commented that it is unusual in The Netherlands to use hard shoulders in a tunnel, and that safety could be guaranteed without this facility and that when a decision was taken to include hard shoulders it would create a precedent for other tunnel projects. At the same time the minister mentioned the need for budget savings. This statement gave the impression to the regional participants that the removal of the hard shoulders, was basically a cost saving. This was denied by the Minister.

The province of Limburg, the cities and RWS Limburg (the main regional participants) were not satisfied with the decision of the Minister. The region was worried about safety and about delays due to the design having to be changed. The region was also dissatisfied about the process because the decision to remove the hard shoulders was not communicated directly to all partners in the region, for example the alderman in Roermond first heard about it from a newspaper. Furthermore, it was not discussed with RWS Limburg, leaving them embarrassed. The province and cities stressed it was a deviation from an earlier Political Agreement of December 1999, and considered it to be "a breach of contract". But the minister was unrelenting and threatened the region with the use of legal instruments ('aanwijzingsbesluit' by Minister) to make them co-operate if necessary.

After the regions' initial response of disbelief and rejection, they said they would co-operate when it became possible to reach the required safety level without constructing hard shoulders. The discussion shifted from a specific technical solution (hard shoulders) to a discussion on the required safety. To reach the required safety level, several solutions were discussed such as detection of low speed vehicles and sprinklers. The 'sprinkler' solution was not acceptable to the minister, because the application of sprinklers along the Betuweroute had generated major discussion in the House of Representatives. As a result the word 'sprinklers' was to be be avoided at all costs.

Even before 'hard shoulders' announcement from the minister, there had already been discussion about how fires should be extinguished in the tunnels. The regional fire officer preferred a technical solution of so called 'Compressed Air Foam' (CAF). The discussions on the application of CAF and removal of the hard shoulders, became combined. CAF was known for use in mobile fire extinguishers, but it was a non proven technology on this scale for tunnels. After first tests with CAF, it seemed

that this was a good solution for the tunnel safety without hard shoulders. The CAF extinguished fires faster than traditional methods, which meant that the tunnel could be open to all traffic, including trucks with hazardous substances of the highest category. In fact, the safety level was considered better than in the initial solution with hard shoulders. The project organisation, the fire brigade and the cities worked together in some testing (in the open air) and eventually, they agreed upon applying CAF. The aldermen of Roermond and Swalmen supported the CAF solution. But the key question which remained was how to get the approval for this solution of the head office of the Ministry and more importantly: that of the minister?

In the hierarchy within the Ministry of Transport, it was difficult for the project director and the director of the regional RWS department to talk directly to the minister. In general it was not always fully clear how things were running in 'The Hague' (where the head offices of the Ministry are), which made the position difficult to manage. "It is a black box to me", a manager of RWS Limburg told us about his own head office. The Limburg delegate suggested an alternative approach. To accelerate the decision making process he telephoned the Minister directly and they arranged a meeting. Apart from the minister and the delegate, a high-ranking officer of the head office of RWS, the director of RWS Limburg (HID), the project director of RWS Limburg, the regional fire officer (wearing a fire brigade uniform) and the aldermen of Roermond and Swalmen were also present. The minister was impressed by the explanation of the regional fire officer. The CAF solution was approved by the Minister — contrary to the advice of her officers, who felt that the CAF-solution was too costly compared to the risks at hand, and who didn't want to establish a precedent for other projects.

The decision of the minister in the meeting was documented with everyone agreeing that the content of the memo was a correct reproduction of the decision. The aldermen promised their co-operation in changing the spatial plans and in granting the necessary permits.

Round 3 Pilot Project Compressed Air Foam

After the decision of the minister, the CAF solution needed to be designed.
A requirements specification and testing programme were developed by the project organisation within RWS Limburg and the fire brigade of Roermond. RWS Limburg made a plan for CAF and approved it internally. RWS Limburg started the pilot project in the beginning of 2004. The cost estimates at the time, indicated investment costs of € 16 million.

CAF was full size tested in a tunnel in Norway. At the testing, several problems occurred, such as how to transport the foam across large distances, how to extinguish fires in sections, when to switch on the system (immediately or after a while?) and how to deal with the long transport time of the CAF (up to 2 minutes for the whole system). To overcome these problems the design was adapted which caused the cost estimates to rise to € 30 million.

In the third quarterly report of 2005 the project delivery organisation reported that the CAF system turned out more expensive than initially expected. In the fourth quarterly report, they mentioned the estimated investment of € 30 million. The project delivery organisation recommended continuation with CAF, because there was room to deal with this cost increase in the project budget. The responsible director at the head office of RWS agreed with this in February 2006 and said that he would discuss this with DGP. DGP is the Directorate General for Passenger Transport of the Ministry for Transport — the client and budget holder for RWS. As long as projects that were funded and complied with constraints regarding time and budget there was no liaison necessary with DGP, but in case of cost overruns etc., DGP had to be informed. DGP didn't receive the project's quarterly reports but the director of RWS told the project delivery organisation that he didn't expect any problems. However DGP found the proposed CAF-solution far too expensive. The most recent cost calculations indicated an investment cost of € 40 million and they were, once more, afraid of establishing a precedent. The additional cost rising was caused by extra needed interfaces with other tunnel elements.

In June 2006 Minister Karla Peijs decided to drop CAF altogether. This again created turmoil amongst the regional partners, who still supported the CAF-solution. In a meeting the minister provided two options to the parties involved. The first was to look for cost savings and the second was to look for alternatives. A working group with representatives of RWS Limburg, RWS head office, fire brigade and two specialists were given two weeks to come up with options. The result was that no substantial savings were possible but that there was a possible alternative in the form of a water-mist system, with an estimated investment of € 25 million. Water-mist was regarded a promising alternative as it was already used in tunnels in Italy and Switzerland for extinguishing (smaller) fires. The minister decided on this new water-mist system, which could be implemented January 2008 with providing a budget limit of € 25 million.

This was the first time she was specific about the budget restrictions for the safety system. With water-mist the reliability of a clear target budget had been given by the Minister, as was not the case with the first decision about CAF, where no clear budget arrangements were made.

Round 4 Pilot Project water-mist

By October 2006 the water-mist design had been approved by the regional fire brigade and a market scan showed that around five possible suppliers were available (instead of only one for CAF).

Analysis

The sub-case shows several elements that were identified as being complex to the participants. All six elements of complexity in our practitioners view are visible in this sub-case. See text box 4.1.

Six types of complexity at the event of Tunnel Safety

At the described case of Tunnel Safety, we observe many technically complex issues. The unproven technology of CAF caused difficulties. The discussions about the safety-philosophy with respect to the content (e.g. deterministic versus probabilistic) can be labelled as technical complexity. This discussion had also a main social component, because there was a conflict of interest on the safety-philosophy between stakeholders.

Both socially and organisationally complex was the relationship between the region and the headquarters of the ministry based in The Hague: the Region had difficulties contacting the Ministry and getting to the highest level of decision making. We also saw that the communication between these two organisations was not flawless, evidenced by the non-communication about the decision to remove the hard shoulders and the quote "it is a black box to me" from the project director of the project delivery organisation. Care was needed in the communication of selected technologies for extinguishing fires, because the word 'sprinklers' should be avoided. This exemplifies the social complexity in the case.

Financial complexity was demonstrated by the cost calculations, that rose from € 16 million, to € 30 million, to € 40 million (CAF). It shows how difficult it is to estimate the investment costs of technological solutions that are relatively unproven. Legal complexity was at stake when looking at the required safety levels for tunnels in The Netherlands, which lacked a firm legal basis.

Finally time complexity was observed when looking at importance changes resulting from external events e.g the tunnel disasters in Kaprun and at the Mont Blanc.

Text box 4.1: Six types of complexity for tunnel safety at the A73-South.

The examples show that tunnel safety at first appears to be a case dominated by the technical complexity. But when looking into more detail, other types of complexity can also be observed. It also becomes evident that the types of complexity do not stand alone but are often related.

We now describe each of the six types of complexity and how they were observed in the cases considered in more detail — starting with technical complexity.

4.3 TECHNICAL COMPLEXITY

At Gotthard and Lötschberg technical aspects were often mentioned when we asked respondents directly, 'what do you perceive as complex?'. As examples of technical complexity, interviewees mentioned above all the geology and the construction logistics of the tunnelling process. This is not surprising since it is extremely difficult to construct 57 and 28 kilometre tunnels through hard rock.

> *"The Geology is the most unknown factor, even with all the control measures we take. And also the logistics of the construction works is a challenge for the contractors that they have never experienced before."*
> Project manager, AlpTransit Gotthard.

Technical complexity seems to be of high importance in all our studied cases. By analysing our cases we can single out two main issues on technical complexity:

a Unproven technology
b Technical uncertainty

a Unproven technology

What makes technology innovative? The level of innovation seems to be dependent on the specific characteristics of the technology. De Bruijn and Leijten (2004) distinguish seven important dimensions to determine technical complexity (table 4.1):

	Controllable, in cases	Less controllable, in cases
1	Robust, over design	Less robust, under design
2	Proven technology	Unproven technology
3	Divisible	Indivisible
4	Loose coupling	Tight coupling
5	Fall back option available	No fall back option available
6	Mono functional	Multi functional
7	Incremental implementation	Radical implementation

Table 4.1: Dimensions of technical complexity (De Bruijn and Leijten, 2004)

A more detailed explanation of the factors from table 4.1:

1 Robust means strong and unlikely to break or fail. The intention of 'over design' is that it leads to less unexpected incidents. 'Under design' may give you more freedom during the process for adaptations but will often result in a less robust final solution.
2 Applying a 'proven technology' will give you more certainties, but has likely less potential than 'unproven technology', which might be more risky.
3 Divisible projects have fewer dependencies and as a result are more controllable. However more indivisibility can sometimes give more opportunities for optimisation.
4 In cases of 'loose coupling' problems can easier be isolated. This can enhance solving these problems in timely manner.
5 A fall back option is as a reserve. If a back-up option is costly, one has to consider whether the extra costs compensate the acceptance of certain risks.
6 The more functions a project has, the more uncontrollable a project tends to be because all those functions need to be included. On the other hand more functions can give the project more chance for survival and enrichment.
7 A radical implementation means that the product will be put into use at once instead of a gradual implementation.

When we apply the elements of innovation to our case projects we see that all these elements could be observed. The various types of technological complexity can all be found in practice in the Betuweroute project — illustrated in text box 4.2.

Technological complexity in the Betuweroute project:

1 The Betuweroute contains several examples of over design and under design. One example of under design relates to the substructure addressed in the Alliance contract between Sliedrecht and Gorinchem. This contract relates to a section of track that needed to be built on weak soil. Because of the open form of contract (no specific solutions), several cost savings were achieved.
2 Examples of unproven technology include ERTMS/ETCS2 signalling systems.
3 The Betuweroute in itself is an example of a highly indivisible project: almost the complete scope needs to be finished for the line to be used effectively.
4 An example of tight coupling is the relationship between the tunnel technical installations and the tunnel infrastructure. Changes in the design installations led to changes in the basic infrastructure which made configuration management on these interfaces essential.
5 With the Betuweroute a Design Build Finance Maintain (DBFM) contract for the superstructure was envisaged. No fall back option was available when this contracting strategy failed, causing massive time pressure for the project organisation.
6 The Betuweroute can be classified as a monofunctional project: it is strictly meant to serve the transport of freight. However, if you are using a more broad definition of the project it can be stated – and it has over time – that the project serves multiple goals such as achieving a modal shift from road to rail, connecting the harbour of Rotterdam to Germany and preserving the environment.
7 For the Betuweroute two specific delivery dates are relevant: the 'Havenspoorlijn' (from the sea to Kijfhoek, at the south-east of Rotterdam) and the 'A15-route', from Kijfhoek to the German border. For these two sections no partial delivery was planned. Each section will be delivered to the ProRail parent organisation fully completed. On the other hand there is a test phase planned to check the functioning of the line.

Text box 4.2: Technological complexity at the Betuweroute

When looking at the answers from respondents and the analysis from our sub-cases, one factor clearly sticks out regarding technical complexity:

> *The application of new unproven technology, presents the main technical complexity for project delivery organisations and other stakeholders involved.*

Some new technologies we have observed in our cases include tunnel safety technology (TTI) and ETCS/ERTMS, the new European safety and communication system for trains. Analysing the introduction of these new technologies shows us how difficult this can be. The first challenge is often to find a suitable technology that fits the demands. Often these demands, as in our example on tunnel safety in 4.2 are not clear, even to those involved, to begin with. At the same time we see that introducing these technologies does not fit well with the traditional project constraints: there is a large possibility for schedule and budget overruns when applying new technology which can cause discussions among participants about who is responsible for paying for the extra costs. It shows that new technology can foster, stimulate or even trigger the other forms of complexity – such as social complexity which we come to next.

At the same time technical innovations are considered necessary in LIPs. Large projects often generate important R&D-developments. Because of the large scale, it is sometimes sooner financially attractive to innovate and because of the long duration of LIPs, there is more time available to achieve innovations than in other projects. And in addition: people often feel great pride in being innovators:

> *"…it was exciting, and that is something that I am really proud off, that we have applied many new technologies. For example new technology for bored tunnels in weak soil."*
> Project manager Betuweroute, ProRail.

But still, there are reasons not to innovate: the application of new technology brings new risks into the project that might threaten the compliance with project constraints:

> *"… we have chosen to focus on proven technology … we should have used a modular approach with the main question: 'What can you do based on you budgetary restrictions?"*
> Mayor Gorinchem, about Betuweroute.

An additional reason for innovations within LIPs, is the political and social sensitivity of the projects, with conflicting demands of players. In negotiations, new technical solutions can bring participants together which often requires advanced technical solutions. This can make working on LIPs very challenging for technicians. Because of this the latest, not necessary proven, technical insights and innovations are used to overcome conflicting demands. Afterwards technicians have to prove that these, often expensive, technologies will function. As a result, large projects have a variety of known and unknown technical uncertainties that need to be dealt with (Storm, 1996).

Text box 4.3 shows three main technological innovations at the Betuweroute.

Major technical innovations at the Betuweroute

1 ERTMS (European Rail Traffic Management System)
ERTMS/ETCS checks whether a train can enter a line section (a section of the railway line between 1 and 1.5 kilometres in length). If it may not enter, yet still does so ERTMS/ETCS takes over train control. This can happen if, for example, there is another train already in the line section or because repair work is being carried out or there are track workers on the line.

2 25 kV power supply
The 'ordinary' Netherlands railway has a 1500 volt overhead line system, which is enough to allow passenger trains to accelerate and run normally. This is not enough for heavy freight trains and high-speed trains, however. Most countries in Europe use 15,000 volt or 25,000 volt AC power. It has been agreed in a European context to use a single standard, namely 25,000 volts, in other words 25 kV. The countries using the lowest voltages will be the first to be converted. This applies in the Netherlands in any case to the lines for high-speed trains (High-Speed Line) and to the most important freight lines, such as the Betuweroute.

3 Bored tunnels in weak soil
There are three bored tunnels on the Betuweroute. The Botlek Railway Tunnel was the first. This is the first bored railway tunnel in The Netherlands and was dug using an earth pressure balance shield. The Sophia Railway Tunnel and the tunnel under the Pannerdensch Canal were both bored using a fluid shield, but continuous boring was tested in the construction of the Sophia Railway Tunnel.

Source: Information from website Betuweroute http://en.betuweroute.nl, 2007

Text box 4.3: Technical innovations at the Betuweroute

b Technical uncertainty

The second element which became highly visible in our analysis of technical complexity is what we label 'technical uncertainty'.

> *Technical uncertainty, the uncertain conditions faced which heavily influence which technology is used, is an important source of complexity in LIPs.*

Geological complexity is somewhat different from the examples of new technology previously quoted. Geology has to do with the specific difficult and unknown conditions that the project faces in its execution. The Gotthard for example crosses various geological barriers that require special building techniques and measures to be taken. It is extremely hard to predict the geology so it is often necessary to develop new solutions on the job that might result in extra costs. That same can be said of soil decontamination and archaeology which are also uncertain conditions which are hard to predict but which can have a major impact on the investment costs and time schedule even though sometimes traditional 'proven' technology can be used to tackle problems once they appear.

Unknown conditions often influence project costs and time schedules. Often when dealing with uncertain condition we may know the range of possible outcomes which enables some form of control. For example we do not know which type of rock will be found when starting the tunnel drilling process, but we do know which types of rock can be found. Also we generally know how to solve the problems once they appear. When a specific rock formation is found, special techniques are available to deal with this. With new technology we often miss this frame of reference: new solutions can become obsolete before construction and will need to be changed as we saw with A73-South. The application of a new unproven technology may be the most challenging form of technical complexity observed in LIPs — but we must not forget that uncertain conditions that make even the application of proven technology cause challenges.

4.4 SOCIAL COMPLEXITY

"My project is not a technical project, but a social project."
Project manager, A73-South, Rijkswaterstaat.

Conflicts of interests and how to deal with them, are at the centre of complexity in the field of LIPs, more so than technology, organisation, finance, legislation or time. These elements of complexity can also be important, but arguably most critical is the social arena of stakeholders where a difference needs to be made. Social complexity was found to be prominent in all studied sub-cases and in every single studied round within these sub-cases. This shows how dominant social complexity is in LIPs.

For our main case — the Betuweroute — this conclusion may not be surprising, because the Betuweroute was heavily discussed in public debate when the project started. On the other hand, this debate took place a decade ago, but we still recognise this social tension. We can explain this in two ways. The first is that social complexity at the Betuweroute remains very important during the execution phase.

"These types of projects have very many neighbours, often these people have to deal with years of inconvenience from the project. At the Betuweroute we see this at Barendrecht. But still you will need to try and cooperate to make the best of it."
Project manager Betuweroute, ProRail.

The second explanation is 'path dependency': there seems to be a commitment to an unchanged view from the past, despite changes in attitudes of the project delivery organisation and the appreciation of local stakeholders. At the Betuweroute the local stakeholders were largely satisfied with the cooperation with the project delivery organisation during the construction phase. However the negative view from the planning phase still seemed to dominate public debate each time the project was mentioned. Negative experiences with a LIP could haunt the project for an extended period of time. We look into this path dependency into more detail in section 5.4.1.

Social complexity at the Swiss tunnel projects was often mentioned, a project director answered the question: "What makes this project complex to you?":

"That it has so many stakeholders. There are so many partners to agree with, to manage this in such a way that everything will come together at some point, requires a special performance."
Project director, Lötschberg tunnel, BLS.

When looking at social complexity interviewees also stressed the difficulties with local stakeholders, at the Swiss projects for instance: Uri and Frutigen.

"In the valley there is only a small area where we can live and this area we want to preserve. Our cities have been affected, also cities that are very characteristic for the area. When we do not make the right choices on how the new line crosses the valley, it might mean that the canton will almost completely be depopulated."
Spokesman Canton Uri.

Also with the HSL-South social complexity was a prominent issue, see text box 4.4. In chapter 3 the relationship with local stakeholders – see the Bos alternative – and also with Belgium was stressed.

Importance of internal stakeholders at the HSL-South

In the Summer of 2004, the project director of the HSL-South felt that the project was coming to a critical phase and wanted to investigate the opportunities and threats in two workshops with the entire management team of the project organisation. 14 persons were present. In the first workshop, the project director illustrated the need for both workshops to deal with the current problems of birds being killed by flying into the transparent sound barriers (this is one of the sub-cases studied in this thesis). He thought the managers could learn from this case, and used it as a start to the discussion on how the project organisation should react on political–sensitive issues.

In the workshop the managers were asked with which three stakeholders they most wanted to improve relationships. The outcome was remarkable: all of the three organisations chosen were parent organisations of the project organisation, whereas the facilitators of the workshop expected NGO's or local governments (such as local fire brigades). The top 3 in October 2004 were:

1 'HK', the head office of RWS. RWS is the implementing organisation of the Ministry of Transport, Public Works and Water. HK is the internal client of the project organisation for the realisation of the line.
2 'DGP', part of the Ministry of Transport, Public Works and Water Management. DGP was the Directorate-General for Passenger Transport that was the client for the transport contract.
3 'ProRail', the organisation that is taking care of capacity, reliability and safety on Dutch railways. ProRail maintains, renovates and expands the 6,500 kilometres of railroad track.

Text box 4.4: Importance of internal stakeholders at the HSL-South

This brings us to an interesting observation regarding social complexity. When we started this research we expected that social complexity would be most dominantly visible in the interaction with local stakeholders and NGO's, most of who have a 'negative interest' in the project. Whilst this was the case:

> *Social complexity is prominently visible in the relationship between the project delivery organisation and local stakeholders.*

However, of equal importance was that we also noticed:

> *Social complexity is prominently visible in the relationship between the project delivery organisation and their principal and parent organisations.*

In many of the cases we observed stressful relationships between these organisations working on projects. In the various rounds of the HSL project, various stakeholders present opposing views. This is not only the case in the discussions between stakeholders but, much more intriguing, within stakeholders such as found in the discussions on the 'Bos alternative' (section 3.2.2, round V). Here the government side of the project contains examples of opposing views. These views are put forward by the main three Ministries involved: Finance, Transport and VROM. Basically the Ministry of Finance does not support any changes in project scope because they will only result in added costs. VROM however is clearly unhappy how the new line is planned to cross the Groene Hart area. Finally the Ministry of Transport mainly focuses on transport goals for the new line. The main goals of each Ministry are different and as a result cause various clashes. Finally the debate ends with a decision to change scope so as to construct the Groene Hart tunnel.

Another example where the different interests within a stakeholder can be observed is within the HSL-South project delivery organisation. After some problems with the control of the project it was decided to place the transport and infraprovider contracts under different responsibility from the substructure contracts. It is also interesting to add that this decision was later reversed (in the year 2007, which is outside the storyline timeframe).

The social complexity in LIPs can be explained by the fact that several arenas – or 'chess boards' – exist in which the project delivery organisation (and other stakeholders) play different roles. The reconstruction of the implementation of the Betuweroute gives us an indication of the complexity of its realisation. Agencies like ProRail and governmental organisations, like the Ministry of Transport, have to perform their tasks and responsibilities within a highly dynamic context which is demonstrated in each of the three rounds of the storyline in chapter 3. From the first, implementation was managed predominantly as an operational technical problem: "what is needed to realise low costs track which is suited for freight transport between place Z and Y?" This interpretation neglected the strategic dimension of the project in terms of sustainable transport and the need to fit the line into an existing landscape, already used for a variety of functions. From the very first moment on a divergence can be found between the local and regional level of policies and politics and the national and European level (the Betuweroute is on the list of TEN-T projects). This divergence turned out to have a major impact on the project.

The Betuweroute shows us a variety of stakeholder arenas in which conflicting interests need to be managed. The project management, represented by ProRail, had to play chess on a variety of boards. At the start of the project there was the arena of local stakeholders where the project management was facing scope extensions over and over again, normally not supported by additional funding from these stakeholders. Regional and local stakeholders combined direct interaction with lobbying of Parliament. Proposals previously rejected by the Ministry and ProRail often came for further consideration via Parliament. This 'game' was new to many of the participants. They did not orchestrate the debate about scope, so events and changes more or less 'unfolded'. The events constantly led to scope extension and rising costs.

A project participant stated on the initial process of scope and budget changes that:

> *"Every time politicians in Dutch Parliament went on a bus trip to visit the route of the Betuweroute this resulted in scope increases that meant that the costs went up with millions of euros."*

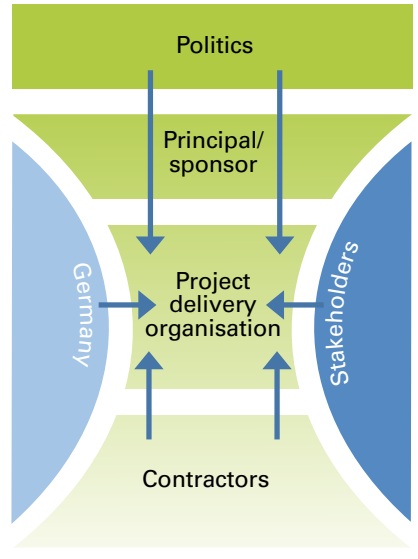


Figure 4.3: Four Areas Chess Boards of the Betuweroute

A second chess-board was that of the principal-agent relationship between the Ministry and ProRail. ProRail was responsible for building the project, while the Ministry was

sponsor. Both are dependent on each other in terms of success, but have different definitions of failure. The Ministry had to deal with the fact that the project stayed under political criticism and was reconsidered during every change of government, each time leading to the same conclusion that the benefits were doubted, but the point of no-return had been passed. ProRail had to deal with the cost effects of ongoing scope changes which partially originated from demands from local stakeholders but also from developments in technology and legislation.

A third chess-board was that of the contracting arena. In the first part of the implementation the building industry was in a phase of overheating. Prices went up over and over again. The project management was blamed for that, even though this context variations were mostly out of their hands. In the third round of the project this situation reversed which made large budget reductions possible — caused by lower tender prices.

A fourth chess-board is present: that of the development of a European rail system for freight. The relationship between planning in the Netherlands and Germany was crucial. Both governments signed agreements that Germany would undertake to create enough capacity for freight transport on German passenger tracks.

The four separate chess boards show us that the project delivery organisation of the Betuweroute had to deal with various arenas of stakeholder networks. The interests and management of the arenas interfere and sometimes conflict with each other.

In line with these various chess boards observed at the Betuweroute, our overall finding regarding social complexity is that:

> *Social complexity in LIPs originates from conflicts of interest between the involved stakeholders that lead to different perceptions (opinions) and attitudes, on issues that have a large impact on their business, life or environment. Managing these conflicts of interest emerges as a core theme in the management of complexity in LIPs.*

Social complexity evolves around conflicts of interest which means that it is most often found when goals and interests of stakeholders conflict and when this results in different interpretations, opinions and perceptions. For instance, at A73-South, on the one hand the fire brigade wants to achieve a maximum level of safety, hence the deterministic approach. On the other hand, the project delivery organisation wants to balance safety and budget, meaning that a probabilistic approach is more suitable. These conflicts of interest can in turn become problematic when the measures discussed have a large impact on the stakeholders. The relevance of safety is undisputable and in addition when for example, the Canton Uri feels threatened in its existence by the coming of the Gotthard line, the citizens are unlikely to back-off their demands. The conflicts of interest and high impact itself appear to be more important than the sheer number of stakeholders. So in summary:

Social complexity is high when we observe the following elements:

a Conflicts of interest.
b Different meanings and perceptions.
c Large impact.

a Conflicts of interest

> *"Make politicians deal with politicians."*
> Delegate province of Gelderland, about Betuweroute.

Where different players are involved, many interests are at stake. Some goals of LIPs are explicitly formulated, other goals are more implicit or hidden. For the Betuweroute in 1997 the following objectives could be distinguished (Hertogh, 1997):

1 Strengthening the competitiveness of Rotterdam harbour.
2 Achieve a modal shift from road to rail. Reduce the lorry traffic on the roads, in general as part of a sustainable society.
3 Strengthening the position of NS Cargo (at that time the cargo-department of Dutch Railways).
4 Integral expansion of the Dutch freight railway lines.
5 To give a stimulus to the Dutch national economy, by means of the planning and construction of the line, as well as the use of it.
6 Strengthening the regional economy of the Province of Gelderland, e.g. the area around Arnhem and Nijmegen.
7 To achieve a return on the construction investment.
8 To gain technological experience.

The eight stated objectives of the Betuweroute are project related, but can be linked to the involved interest groups. Basically it shows how LIPs are also used by people to promote themselves or their organisations. Think of a politician who wants to show his decisiveness by giving clear and powerful statements on the continuation of the project. Or the environmentalist who hopes to get national popularity by opposing a big project.

In 2008 some of the stated goals are still valid, others seem outdated, for example the goals related to NS Cargo (goal number 3). In 2000 NS Cargo was sold to the Deutsche Bahn which made this objective obsolete. In addition the development of the regional economy of Gelderland (6) had become less important.

A key factor concerning the interests of stakeholders is that they are not always aligned. This causes friction and debate, especially when these stakeholders have the power to

influence decision making in the project. In the working field of LIPs, various stakeholders try to exert their influence on the outcomes of the project. This behaviour is driven by self-interest:

The driving force of the behaviour of stakeholders in LIPs is self-interest.

From our cases, we do not get the impression that the 'general' or 'overall interest' is served in any way — even when the involved stakeholders are all part of the public service such as the various parts and layers of the government institutions dealing with the deployment of a LIP.

b Different Meanings and Perceptions

"It is a religion. Everyone who knows something about this project is either completely supporting it or totally against it. The others are crazy. Heaven and earth are often close to one another in this water and people filled Rijn-Maas Delta."
Quote from Bervais, 'Landschap als geheugen', 1993.

People give different interpretations to objects. Wittgenstein (1953) refers to the different interpretations of a painting, and the different meaning the painter and the viewer might have. A hammer has a different meaning to a carpenter than to someone who occasionally uses it.

Just like a hammer has a different meaning to different people, so do big projects like LIPs. Different players attach a different meaning to a LIP (see figure 4.4) (Hertogh, Baker, Staal, Westerveld, 2008).

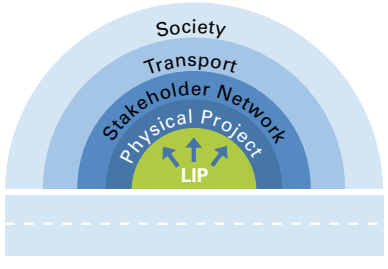
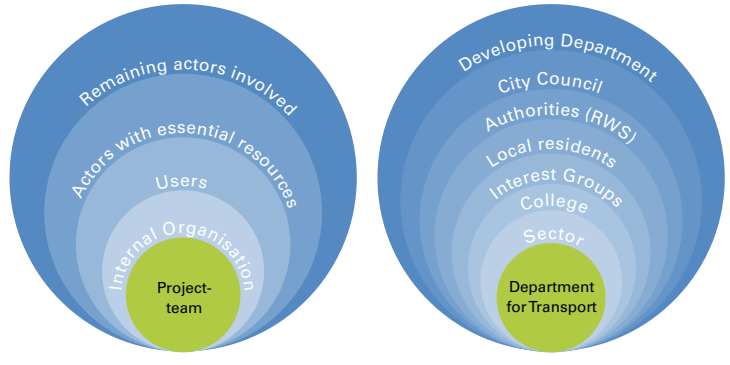


Figure 4.4: Different perceptions and goals of LIPs

Engineers generally like the technological challenges that LIPs face, others are especially worried about protection of the environment. An HR-manager will focus on the development and satisfaction of employees within the project organisation and is keen on the development and sharing of knowledge and experience within the organisation. A financial controller wants to see a convincing business case and wants to apply tight budget control and could investigate the possibilities for private funding. Users and carriers perceive the project as a new way to transport themselves and their goods. Overall we can see the project as an important factor in the functioning of society as a whole (see also the quotation of Mrs. Loyola de Palacio at the start of chapter 1). As a manager of LIPs it is important to realise that these and other points of view are relevant in the project implementation.
Within LIPs there is an ongoing process of interaction (Termeer, 1993) in which perceptions and meanings are formed. Perceptions and meanings are heavily guided by the self-interest of a stakeholder. For example: a fire brigade officer would strive for the maximum level of safety while a project manager would also have to look at budgetary constraints. One can say that during this process "reality is created". In this arena where many players meet, there is no longer one reality to which we can refer, but there are many realities and meanings of all involved that 'circulate' through social processes. Using the vocabulary of Weick (1979), in these processes "sense is made". This is not static. All individuals create their own senses and these senses – or meanings – are continuously reconstructed. Kastelein (2003) introduces the term 'dynamic meaning' to describe this process.

The left part of figure 4.5 shows a presentation of stakeholders that are part of the internal environment (the first two rings) and external environment (the three outside rings) (Hertogh, 1997). The figure gives an overview on the distance towards the project organisation. The right part of figure 4.5 shows the answer of employees of the department of Transport in a medium seized city in The Netherlands (about 150.000 inhabitants) at a workshop when asked for 'the perceived distance towards the project delivery organisation'. The figure shows that the Department for Transport – which hosted the project delivery organisation – felt strongly related to the sector they are part of and to the alderman as part of the city council. On the other hand surprisingly, they felt a large distance from the developing department (a different department within their own organisation!). These answers show that the perceived distance of project members can greatly differ from which you might expect from the formal organisational or stakeholder network structure.



Stakeholders: internal and external environment

Presentation from the viewpoint of the Department for Transport of a medium-seized city in The Netherlands

Figure 4.5: Stakeholder network at LIPs

c LIPs have a big impact on the environment

> *"The Betuweroute has two times 160 kilometres of neighbours."*
> Theo van Bekkum, Director Project Control Betuweroute, ProRail.

Large projects cross large areas of land or are constructed at important locations. Their influence is far more widespread than the specific land needed for the project itself, projects have an impact on future developments in the whole area surrounding the newly built infrastructure.

To reduce the inconveniences that construction projects create, they can be linked to existing infrastructure. For a great part of the track the HSL-South is build along the highways A4 and A16 in a so called transport corridor. The reconstruction of the highways A4 and A16 has been integrated into the construction of the HSL-South. This is the same for the Betuweroute where the highway A15 has been upgraded as part of the project.

4.5 FINANCIAL COMPLEXITY

Financial complexity in LIPs is related to value for money (cost-benefit ratio), cost calculations, financial control (management and accountability), and the financing itself.

In practice we observed financial complexity in:

a The costs and benefits, which are difficult to calculate and are not equally divided.
b The perception of cost developments, which can differ from calculations.
c Different perceptions about definitions and agreements.
d Strategic misinterpretation, optimism bias and pessimism bias.
e 'Cascade of distortion'.

a The costs and benefits which are difficult to calculate and are not always equally divided

The benefits and burdens at a LIP are seldom equally divided. The benefits will for example go to the user of a new highway, the burden in the form of noise nuisance will go to an inhabitant living next to the highway. The problems are often easy to assign and relate to 'single issues'. Benefits are more widespread as between players and are more difficult to assign.

Financial management of projects is tightly connected to the management of scope. Setting the scope for a LIP is often highly difficult as a result of which reasonable cost estimates are difficult to calculate. Dealing with changes in scope and the resulting cost estimates can prove to be especially troublesome. An interesting case in this respect is the risk contingency that was introduced to finance unforeseen costs for the Betuweroute and HSL-South projects in The Netherlands. This contingency provision caused major political debate and argument. It was a completely new idea to reserve budget from the funds for infrastructure to finance additional demands and to deal with unforeseen circumstances. In the way the government sets its budget, it is usual to link a budget to a specified work beforehand, however in this case the scope of work was to be determined after the risks occurred.

The difficulties in estimating and allocating costs and benefits is highly visible in the scope development of our selected cases. In each of the cases major scope changes occurred to accommodate the demands of involved stakeholders, which in turn resulted in major cost increases. This development of scope, costs & benefits and demands of stakeholders illustrates the tight relationship between financial complexity and social complexity.

Another important element of financial complexity which was observed is the difficulty of determining and managing the project benefits. Often project benefits are intangible and cannot be allocated to specific stakeholders. On the other hand the stakeholders that are negatively impacted by the project are mostly easy to identify which means that:

> *Financial complexity in LIPs is focused on difficulties in estimating cost and benefits and how to allocate these costs and benefits towards the involved stakeholders.*

This uneven distribution of benefits and costs is one of the major dilemmas that a principal and project delivery organisation need to deal with. Financial complexity can both be found in the financial control (scope and budget management) as well as the project objectives (project benefits and business case). Combined, these form key elements of financial complexity in LIPs.

b The perception of cost developments which can differ from calculations

Thomas Pfisterer, chairman of the NAD committee (NEAT-Aufsichts-Delegation, or Delegation for the Supervision of the NEAT), mentioned in an interview (April 2005) cost overruns at Gotthard base-tunnel:

> *"Often people take geology as an example when we talk about cost increase at the Gotthard, but geology only has had minimal impact. Only 5 to 13% of extra costs originate from geological difficulties. The major part, more than half, originates from change orders which are also politically approved."*
> Thomas Pfisterer, chairman of the NAD committee.

The same arguments holds true regarding the cost overruns at the Betuweroute. Westerveld and Flyvbjerg mention that in 1992, the estimated costs were calculated

at € 2,2 billion, which is much lower than the € 4,7 billion the project was estimated to cost later (source TCI). But the cost overrun in the realisation phase from 1996 to 2007 is only 2%, whereas the average cost overrun for project in its class of reference is 34% (Flyvbjerg, 2007). So in fact the overrun during the realisation phase has been small. However at the same time in 2007 the public opinion was still widely spread that the Betuweroute was a financial disaster. These examples show that interpretations of cost development can greatly differ.

c Different perceptions about definitions and agreements

Perceptions of financial information can be very different depending on definitions and agreements. Let us say that a project manager tells a politician: "This infrastructure project will cost you € 1,234 billion." What does the project manager really mean?

- What is the scope you have calculated?
- What is the uncertainty margin of the calculated costs?
- What is the risk profile of the project?
- What are the conditions (e.g. soil)?
- Are these costs the construction costs or the total investment costs?
- Are these costs including or excluding VAT?
- What is the price level?
- What possible benefits can be achieved (e.g. toll)?
- Etc.

In all probability, the politician will not ask the project manager these kind of questions but they are very relevant to put the estimated cost in perspective. But all of these issues seem of importance when deciding on whether or not to execute a project.

From a rational point of view it seems necessary to reach agreements about the terminology used in, answering the above questions. But are politicians interested in the answers to all of these technocratic questions? It could be that they prefer some level of confusion because it gives them some flexibility to operate. This is the topic of the next characteristic.

d Strategic misinterpretation, optimism bias and pessimism bias

> *"It's interesting to see that financial experts at the Department for Transport deal with two important types of 'human' miscalculation in project development. The overestimation of income (benefits) and/ or the underestimation of costs and risks associated with the delivery of the project."*
> Financial Manager, Department for Transport, UK.

The budget for a LIP is difficult to determine. Think of uncertainties in scope (such as extra demands of local governments and local residents and extra scope because of mitigation), interdependencies between contracts, market and price indexes, new technologies, costs of archaeology, cables, contaminated soil and land acquisition etc., etc. But according to Flyvbjerg, in addition to these uncertainties, two more personal factors are important: the psychological explanation of optimism bias and the political explanation of strategic misinterpretation, both of which result in inaccurate forecasts and inflated benefit-cost ratios:

- 'Optimism bias': "cognitive predisposition found with most people to judge events in the future in a more positive light than warranted by actual experience".
- 'Strategic misinterpretation': "forecasters and planners deliberately and strategically overestimate benefits and underestimate costs in order to increase the likelihood that it is their project, and not a competing one, that gains approval for funding".

Based on a study of Flyvbjerg with Cowi (2004), the Department for Transport in the UK institutionalised this inaccuracy in their business cases to appraise their projects.

The Department for Transport addresses three different sources of error in coast estimation, see table 4.2.

Source	Description	How to address this in appraisals?
Risk	Events associated with known probabilities, measurable	Quantitative Risk Analysis (QRA). Calculating probability weighted costs.
Uncertainty	Events for which probabilities cannot be easily quantified	Describing sources of uncertainty. Adding a contingency uplift to cost (e.g. £100,000 for not obtaining planning permission)
Optimism Bias	Historically observed tendency to underestimate costs	Adding Optimism Bias adjustment to correct Bias (see table 4.3)

Table 4.2: Sources of error in cost estimation at Department for Transport, UK

Table 4.3 shows the uplifts for Optimism Bias recommended in 2006. The Department was reviewing this issue at that time and would issue further guidance.

	Pre-feasility	Project Definition	Option Selection	Single Option Refinement	Design Development
Capital Expenditure	66 %	50 %	40 %	18 %	6 %
Operational Expenditure	41 %	1,6 % per annum	1 % per annum	Evidence based	Evidence based

Definition of Project Development (5 levels) is consistent with Network Rail's project development definition.

Table 4.3: Recommended optimism bias Adjustments at Department for Transport, UK

Apart from optimism bias, financial experts at the Department for Transport also deal with 'Pessimism bias'. This is the case if only the direct effects of projects are taken into consideration and the indirect benefits realised with the project are neglected. Taking only direct effects into account will possibly even lead to the conclusion that only very few infrastructure projects should be realised at all. Non-financial benefits could be for example: journey time benefits, crowding benefits, freight non-user benefits; passenger non-user benefits, road de-congestion, accident benefits and environmental benefits. These benefits are often hard to calculate but are important when considering the feasibility of a project.

e 'Cascade of distortion'

> *"Sometimes I don't recognise the project planning that I made in the half yearly reports send to the House of Representatives."*
> Manager Planning and Risk Management, Betuweroute.

The communication on financial information is not always consistent within projects. We call this the 'cascade of distortion'. Communicating information from person to person is liable to distortion with every link in the chain. This potential for distortion can be observed in the process of writing periodical project reports, where information often goes through various management layers. For example:

1 A controller reports to the Contract Manager about what he thinks is a major cost overrun caused by a flaw in the project delivery organisation. In line with to regulations, the controller tells the Contract Manager that this kind of substantial cost overruns needs to be reported to parliament.
2 The Contract Manager reports to the Project Manager. Will he refer to the cost overrun? Maybe he thinks this is a chance to show he can handle the project, or he might feel embarrassed because the flaw is his responsibility. But let's assume he reports.
3 The Project Manager reports to the Project Director. Maybe the Project Manager judges the item differently and as not urgent or he reports them on paper without stressing the topic in the text. But let's again assume he reports the cost overrun clearly.
4 The Project Director reports to his counterpart: the Manager of the Ministry who serves as the principal of the project. Maybe the relationship between the two organisations is under stress, because of earlier cost overruns and the Project Director wants to find a solution before reporting. But let's assume he reports the cost overrun.
5 The Manager reports to his Director General. Maybe this Manager has other problems to deal with and he thinks it will be not beneficial to his relationship with the Director General when he reports the cost overrun now or in the hour long talk with his boss, he has more important to discuss. But let's assume he reports.
6 The Director General reports to the Minister. Maybe he thinks that when the Minister informs parliament, the press will pick up the fact and write negatively about the project. But let's assume he reports.

7 The Minister reports to parliament. But maybe next month is election day and the cost overruns of LIPs will not be beneficial for the Ministers popularity and his political party. But let's assume he reports.

What will be the message be (if there is one) that parliament receives, and when? Maybe you remember the game children play, standing in a circle, where they pass on a message while whispering it in the ear of the neighbouring child. After seven children the original message is hardly to be recognised or completely distorted.

4.6 LEGAL COMPLEXITY

> *"Effective leadership is effective violation of rules."*
> Prof. Geert Teisman, Erasmus University Rotterdam.

Legislation makes LIPs complex because:

a Changing, non existent and conflicting laws
b Extensive legislation and rules, have an important influence on content and processes.
c People involved need space to operate.

a Changing, non existent and conflicting laws

> *"Every project will run into contradicting legislation."*
> Project manager, Ruimte voor de Rivier.

A factory that wants to build a new chimney can be told that in order to obtain an environmental permit, the chimney needs to be higher than is allowed according to rules applicable to building permits. Building permits and environmental permits can have different procedures. As is shown in our example, the requirements for obtaining a permit can be contradictory. Procedures can have differences between them, some have many opportunities for participation of stakeholders and others have not. Also the specific legislation reflects the culture and practice during the timeframe in which it was formulated. In the Netherlands, stakeholders opposing the project can often use the same arguments for obstruction in more than one procedure, at multiple authorities and multiple points in time.

Internal rules within a parent organisation might not always fit the characteristics of LIPs. Examples can be decision making and reporting structures within the parent, that are not suited to the project needs for reporting and decision making. Because of their need for specific arrangements, the project delivery organisations dealing with LIPs are often not placed within the functional hierarchy within a parent, but have a separate status, directly reporting to the board of the company. This can be justified looking at the large investment,

large number of stakeholders and political sensitivity. As a result, changes in internal rules need to be made in order to accommodate the project delivery organisation.

Legal complexity is mainly mentioned and observed as the result of changing, non-existent or conflicting laws.

Again, as we have seen before, it really starts to get difficult when legal matters influence the stakeholder universe. One example is tunnel safety at the Betuweroute (TTI). Here there was no legal framework for tunnel safety which meant it needed to be developed by the involved stakeholders. As the result of conflicting interests between the fire brigades, the Ministry of Internal Affairs, local stakeholders and the project delivery organisation this caused major challenges in the project. Questions needed to be answered such as: What safety level is sufficient? Which technology should be used? How to approve a building and user permit? Who would be responsible for dealing with accidents? How to balance the safety level and the investment to reach this required level?

It is interesting to observe once more that the sheer number of permits needed and rules to be followed does not seem to be the main cause of complexity. Although it is important to set up a tracking system for this, it can more or less be controlled by the project delivery organisation. This is not the case when the rules are absent or diffuse. In those situations legal complexity can influence the stakeholder network and lead to major turmoil.

b Extensive legislation and rules, have an important influence on content and processes

"We monitor new and changing legislation from the Ministry of Transport and ProRail, although you cannot get a 100% guarantee that every relevant change will be tracked down in good time."
Manager Planning and Risk Management, Betuweroute.

"The most difficult are time consuming decision making and procedures. The faster you can operate, the better you will be able to get results."
Deputy, province of Gelderland.

With every process from idea to completion of LIPs we have to deal with rules and legislation, such as:

- Interest protection: The right to give one's view at predefined moments in planning and other procedures and the right to object or appeal decisions.
- Content: requirements regarding safety, flora and fauna, soil cleaning, etc.
- Time and processes: the duration and sequence of procedures (say, terms, consultation).

- Contracting: e.g. European tendering legislation and additional tender rules set by parent organisations
- Costs: procedures will influence the budget (scope) and the procedure engineering. Running procedures requires capacity within the project delivery organisation.
- Information: when, which information, to whom, e.g. periodical reporting rules towards parliament.

Legislation has an important influence on the planning of LIPs. A whole range of rules and procedures needs to be followed, as shown in figure 4.6.

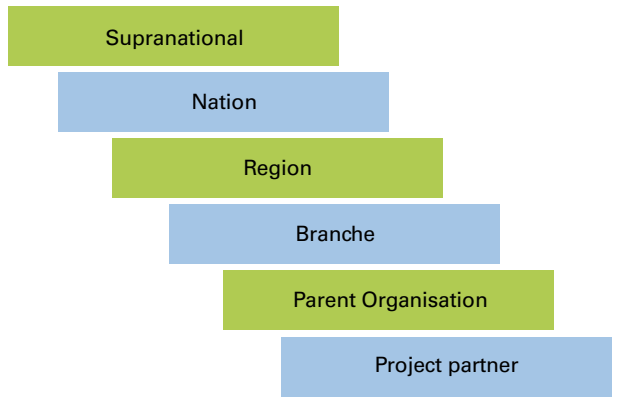


Figure 4.6: Main levels of rules and legislation

The Supranational level, most importantly EU, is the highest level. Every country has its own specific rules, as have regional governments (regions, provinces, counties, cities). Branch organisations create their own rules. Every parent organisation has its own rules, e.g. for contracting and purchase. And the project partners make arrangements about supplementary rules, such as covenants and contracts. The result is a whole range of laws, rules, contracts and procedures.

For LIPs specific legislation has often been set up, such as in The Netherlands with legislation to cover line infrastructure (Route decision law - "Tracéwet") and for Nimby (Not-in-my-backyard). Each country will have specific procedures for spatial planning and the purchasing of estates. In Denmark for example, a specific project law is issued for LIPs. In Germany we see that all necessary permits and plans are approved within one large over-arching procedure. These institutional differences between countries can be of great importance.

Project organisations need to organise to be informed on new and changing legislation in a timely manner. Within the Betuweroute project organisation this task is performed in close co-operation with a special department within its parent organisation, ProRail.

c *People involved need space to operate*

> *"Sometimes you have to be naughty."*
> Project manager of major infrastructure projects.

Those involved in the development of spatial projects admit that they often try to act flexibly in dealing with legislation (Hertogh et. al., 2004). A project manager who, to speed up the process, can take a decision that formally needs approval from the parent organisation might decide that he will seek this approval later. Hence, "Sometimes you have to be naughty."

Or just like Mr. Vonhoff, a well-known politician and governor in The Netherlands, says: "The more rules, the greater the tendency to ignore them. The result is that everyone gives his own interpretation to rules. In practice people will seek solutions for problems they experience. On the one hand this is necessary to keep things going, but on the other hand it can lead to complete randomness in behaviour. That is why we need less rules." (Hertogh et. al., 2004.) But that we need some rules, is clear.

4.7 ORGANISATIONAL COMPLEXITY

> *"The individual is always smarter than the system."*
> Prof. Arie de Ruijter, University of Tilburg and Utrecht.

The project organisation of a LIP has to cope with each of the complexities mentioned: technical, social, financial, legislation and time. To fulfil ambitions in this complex environment is an interesting challenge. We recognise that LIPs are organised in a complex way apparently to match the complexity resulting from the previously described factors. This is in line with the 'law of requisite variety' which originate in the field of cybernetics, control and systems theory (Ashby, 1956). An organisation's internal diversity must match the variety and complexity of that environment in order to deal with the challenges posed by the environment (see also Section 9.2.1, second strategy). Organisational members can cope with many contingencies if they possess the requisite variety of skills (Nonaka, 1995).

Indeed, in many interviews we heard of the difficulties people experienced in organising themselves for this process. This was also the case for external stakeholders. NGO's and local governments, as do the other stakeholders involved in LIPs, appear to have similar difficulties with organising themselves. The communities participating in LIPs sometimes appointed dedicated employees as co-ordinators for all matters associated with the project. In an interview at the city of Barendrecht (Betuweroute), this was mentioned as a key success factor. The co-ordinator worked closely together with the mayor and alderman. This approach was also chosen at

A73-South in the city of Roermond. Apart from NGO's, the co-ordinator of local pressure groups at the Betuweroute mentioned:

> *"It was complex for us as pressure groups since you have to do everything on your own. You don't have civil servants. And this all has to be done in your spare time."*
> Co-ordinator of local pressure groups Betuweroute.

So in general:

> *The complexity related to organisation is not only relevant for project delivery organisations but also to other stakeholders, such as NGO's and local governments.*

Another important conclusion, mentioned earlier, is that organisational complexity is often very closely related to the social complexity which we observed between project delivery organisations on the one hand and principals and parent organisations on the other. Many of the projects studied have or have had intense discussions about who should man the project delivery organisation, who should be the civil principal and who is responsible for the various parts of the project. So generally speaking:

> *Organisational complexity does not only have to do with structuring the internal organisation of the project delivery organisation but most importantly with the division of responsibilities and positioning of this project delivery organisation towards principal and parent.*

When we take a closer look at the organisational complexity of LIPs, issues that are important in cases examined are:

a To find and to keep motivated people appropriate to the challenge.
b Many decisions with no clear 'best solution'.
c The project organisation has numerous processes that interfere with each other.
d Consultants, contractors and suppliers require numerous contracts to be arranged.

a *To find and to keep motivated people appropriate to the challenge*

> *"You are proud to work on something such as the Betuweroute."*
> Member committee of architecture ('welstandcommissie') Betuweroute.

It is easy to argue that people are a key factor in project success, this is supported by various studies trying to identify critical success factors for projects (Westerveld, 2001). For a project delivery organisation competent people need to be recruited for specific, temporary functions. It is also important to keep key people in place during the project lifetime (Boddeke et. al., 2002). This is especially hard at the end of a project when people tend to look for new opportunities.

When Patrick Buck stepped down after the opening of the Betuweroute after serving ten years as a project director, he had three important recommendations for his successor Peter Dijk, to complete the job in the last one and a half year:

1 Try to get authority from your people, you don't get this from the title 'boss'.
2 Invest in the relationship with key people who have to complete the job. These people in particular have to be motivated.
3 Ensure that people know you well, you should not be a mystery to them. People have to know what you are thinking and why, so they can foresee your reaction.

It is noteworthy that these three all concern the motivation of and relationship with people in the project team, underlining the importance of motivated and competent project team members within LIPs.

A former project director of the North-South metro line, Amsterdam stresses the differences in competences between people in the design and the realisation phase. This means that it can be appropriate to replace a successful manager for the design phase with a new project manager at the realisation phase (Hertogh, 1997).

b Many decisions with no clear 'best solution'

"A wrong decision is better than no decision."
Project manager Betuweroute, ProRail.

Some examples of decisions a project manager has to take where no single best solution is available:

1 Will we choose an unproven technology? What are the consequences? What are the chances of success? Can we estimate these chances of success? What can we arrange upfront with other organisations in case of cost overruns? Do we need a fall back option when applying this technology?

2 An environmental pressure group suddenly opposes the project organisation. What are the reasons for this unexpected opposition? What will be the consequences of this? Will other parties follow their example? Shall we try to persuade them to change their attitude towards the project or is it best to have an open conversation? Or is the best strategy to do nothing?

3 The economy is functioning at its peak and the construction industry is working near capacity. What will be the consequences for the price level for my tender? And who will pay in case bids turn out to be higher than our estimates?

4 During the design process the national government decides to impose stricter legislation. Are these new rules applicable to our project? How do we need to interpret these rules for the project? What are the consequences, for instance the implications for our agreement with local governments. What will be the effect on our time schedule? Can we estimate the costs accurately and who will pay for the extra costs?

5 What will be the demands for mobility over the next twenty years? Shall we anticipate this by building an extra highway exit to the city?

6 What are the criteria for choosing a Public Private Partnership or a more traditional contract? Will we have sufficient competition? What are the price implications? What gives us the most flexibility, will we need this?

Project managers have to live with the uncertainties of all decisions presented above. Uncertainty and ambiguity will be discussed into more detail in the next chapter.

c The project organisation has numerous work processes that interfere with each other

"You can't afford to miss anything; every lot has to be acquired, every permit obtained, all the more because with your project you are in the spot light, one flaw might be punished pitilessly."
Project manager Betuweroute, ProRail.

To give an example — the Betuweroute quality manual in 2000 consisted of 62 (!) different processes, divided into primary and supporting processes (table 4.4). In addition there were the elaborate control standards of ProRail and the contracts with and quality manuals of the engineering consultants, the contractors and the suppliers. These systems are often incompatible. For example a contract contains demands on reporting and this imposes important requirements on the partners' processes. Contracts and quality systems need to be tuned to ensure compatibility.

a Primary processes	b Supporting processes
1.1 Project management	2.1 Quality assurance
1.2 Planning	2.2 HRM
1.3 Finance and Control	2.3 Facility management
1.4 Risk management	2.4 Document control
1.5 Conditioning	
1.6 Design and realisation	
1.7 External communication	

Table 4.4: Paragraphs of the Quality Manual of the Betuweroute project delivery organisation (2000)

Each paragraph of the Quality Manual (table 4.4) consist of several processes. For example 2.1 Quality assurance has 5 processes: maintenance of quality system; internal deviations; internal audits; proposals for improvement; and management review. Some processes were split into sub-processes. For each process one employee was responsible. The difficulty was to manage all the separate processes at the same time as managing the interrelationships between the processes. An extra strain was that all these Betuweroute processes had to be managed in an environment with a low tolerance of failure. When something went wrong, the media was eager to publicise the problems.

Each process is a subject for improvement. An example of an innovation is the system of configuration management and change control applied at the Dutch High Speed Link, which was needed to get a better overview of the huge number of objects (as described in object trees) and interfaces.

The project organisation has the resources to staff its organisation. But local interest groups often experience difficulties in organising themselves. When we asked "What makes this project complex to you?" Carla Fenijn, spokesman of several Betuweroute local interest groups in the first half of the 1990's, responded (in 2004):

> *"As a pressure Group you will need to take care of everything by yourself. And this all needs to be done during your time off from work. We are like the cartoon hero 'Calimero'. There was no administrative support for us at all."*
> Co-ordinator of local pressure groups, Betuweroute.

d Consultants, contractors and suppliers requiring numerous contracts to be arranged

At the execution phase tens of organisations involving thousands of people are working at the project. The project organisation is responsible for the contracting of organisations like constructors, suppliers, consultants. All agreements and actions have to be coordinated.

What will be the best type of contract? Traditionally the project delivery organisation has the preliminary and detail design prepared by the engineering department or consultants and afterwards a detailed contract is set up where the contractors have to compete on logistics and price agreements with subcontractors. New ways of contracting place greater responsibilities on the contractor earlier in the process, examples are Design & Build contracts with the possible addition of Maintenance. Ultimately contracts could include finance (F) in DBFM, or even the operation (O) in DBFMO. These are often highly complex contracts because of their sheer size, requirements, duration and the number of interfaces to be managed.

At the HSL-South management chose to apply innovative and large contracts. For the substructure large Design and Construct Contracts; for the superstructure, the infrastructure provider a DBFM contract and for the carrier a concession. The management of all of these separate contracts turned out to be a huge challenge by itself, and even more challenging was the management of all the interfaces between these contracts.

4.8 TIME COMPLEXITY

> *"Their long duration alone, makes LIPS complex."*
> Prof. Hans Rudolph Schalcher, ETH Zürich.

> *"Politicians have a short memory."*
> Director Project Control, Betuweroute, ProRail.

Time complexity is more abstract to project participants than the other types of complexity. It is also very much related to changes which can occur tied to each of the 5 other types discussed earlier. Especially with the Betuweroute and the Gotthard/ Lötschberg many people refer to the development of the project and seemed to be very aware of the history and therefore this aspect was often explicitly mentioned. For example:

> *"It took five years for the local people to know that the Betuweroute would be constructed. This is an awfully long time."*
> Head of the communication department, Betuweroute, ProRail.

At the A73-South, we heard interesting remarks about the period after delivery. A good example:

> *"Beware of the spin-off this road will have! It will attract companies wanting to invest and will cause an increase in traffic and recreation. It is necessary to think about environmental compensation for this intensified use, but this did not happen. It would mean that NGO's should change their perspective to one which also contains the operational phase. Nowadays this perspective is often still lacking."*
> Toine Wuts, co-ordinator A73-South, Stichting Milieufederatie Limburg.

The long term impact of LIPs is a force to be reckoned with — a factor hard to recognise for local stakeholders and NGO's:

> *Time complexity – the long duration of planning and construction – means that citizens have difficulties realising which impact a project will have on their living circumstances.*

This could for example be observed in the case of Canton Uri where the connection to the Gotthard Base Tunnel threatened the fabric of living of the entire Canton. Here our interviewees mentioned that in particular the long duration of the project influences the project image. Because of the extended timescale, people tend to think that the project will never come to fruition and are surprised when the project is executed and impacts heavily on their environment. The LIP is like a steamroller that does not move quickly but cannot be stopped and has a huge impact once it reaches its destination. This characteristic of LIPs cannot be downplayed: the huge effects LIPs have on personal lives should be taken very seriously by project delivery organisations and all concerned.

We will illustrate two main issues which show the influence of time complexity on LIPs:

a Long time frame with continuous developments
b No sequential process of implementation

a Long time frame with continuous developments

> *"Large Infrastructure Projects are a static facility in a dynamic environment."*
> Mr. Diederick van den Wall Bake, Berenschot.

The implementation of LIPs takes a long time. The Betuweroute is an example of a project that was implemented relatively quickly. In 1989 the Betuweroute was first mentioned in planning schemes of the government and in 2007 the project was expected to be put into operation — a total duration of 18 years. The HSL-South took a few years more. During these timeframes society changes. Many relevant aspects will change: new technological innovations appear; organisations change because of mergers; elections will take place that result in changes of councils and administrations; change in awareness e.g. about environmental issues; changes of needs, interests and views; development of legislation; new financial insights, etc. Not only the context will change, but so will the project delivery organisation itself. People come and go and with them new beliefs and approaches.

This means that all the complexities previously mentioned in our LIP scheme change.

To give an example: in 1989 risk management was not widespread, the management of archaeological heritage was unknown, contracting was conducted on traditional lines, the information revolution still had to take place and safety regulations for tunnels were not as strict as nowadays. During the planning and realisation of the Betuweroute, all of this change took place — and more will change during the operational phase.

All complexities mentioned will change. This is difficult in itself but the impact is amplified by the fact that infrastructure projects have a relatively static character

with fixed track, concrete or steel bridges, tunnels that cannot easily meet changing requirements, etc. This may create tensions with the more dynamic environment in which the project is set, with quickly changing demands, views and insights. The technological life of infrastructure is usually over one hundred years. After the £ 8,3 billion investment programme (2006) spent over the previous fifteen years, the current track alignment of the West Coast Mainline still follows the old alignment, built in the middle of the 19th century.

The question arises as to how much flexibility has to be built into an infrastructural facility, not only during the development, but even more importantly, during operation. Relative inflexibility after the realisation depends heavily on the nature of preparation and initial decision making.

b No sequential process of implementation

> *"Railtrack wanted to deliver new innovative systems, but things have changed: Network Rail now sticks to proven technology."*
> Head of Programme Investment WCML, Network Rail.

At LIPs we deal with a great number of parallel processes, the implementation of which is seldom a sequential, step by step process. Many projects tend to be engineered in detail, while discussions on benefits and necessity still have not been settled or solved. An example is the Westerschelde Tunnel (a bored tunnel with a length of 6.6 kilometres), where there was no 'go/no-go' decision because of financial reasons, while the contractor had already done a lot of design work and there was an agreement on the contract prices. We often see a continuously iterative process, with frequent feedback and feed-forward loops in all phases of LIPs (Hertogh, 1997). This means that you can seldom pinpoint one 'point of no return' or 'go/no-go decision'. After each decision the collective process of sense making continues, new rounds lead to new opportunities (Teisman, 1992, 2005).

LIPs generally experience what we call 'a non-linear implementation process'. According to traditional project management insights, project managers can expect that a project is a matter of linear/ straightforward planning. This suggests that there is a stable content that should be realised against a fixed budget. But as observed in at the WCML, nothing is less true. In practice project managers will constantly experience events and developments which emerge that create important influences in their plans — experienced as 'disturbances'.

Non-linearity applies to the contexts of LIPs such as observed with the WCML. The dramatic changes of the institutional context of the WCML provide ideal examples of non-linearity (see table 4.5). First the context is purely public and monopolistic. The client and return on investment are barely relevant. In the second round this context

is mainly private. Profit gets a central position. The rail system is seen as a market and competition is a leading element determining behaviour — affecting the behaviour of Railtrack and Virgin. The rail engineers, dominating the first round, disappeared from the main stage. Development becomes heavily focused on competition and creative – and often risky – financial arrangements, meaning that organisations can go bankrupt. This market principle is also at work in the WCML case. Subsequently it becomes clear that rail industry is not fully a private domain product. In the third round a rather curious hybrid and complex system emerges on the edge of the public and private domain.

The dynamics of the focus of the project are volatile. In the first round of the WCML the focus of British Rail is on repair, that changes in the second round with Railtrack and Virgin with a primary focus on short term profit. In the third round the focus is on creating a joint interest for a much larger variety of shareholders and stakeholders over the long term. Realising a joint business case becomes the main aim of the project. The course of estimated costs verges on the whimsical. The WCML starts with 2 billion pounds, going up to more than 13 billion and then down again to less than 9 billion.

Non-linearity in the approach of the process occurs, the management changes its approach to technology several times. First non-innovation, then large scale innovations and radical upgrading, not restricted by any 'path dependency' from the past it seems, and finally abandoning innovation experiments, only using a few innovations, previously tested in other places.

Dynamics in:	Round 1	Round 2	Round 3
1 Context	Public	Private	Public-private cooperation
2 Focus	Repair	Profit	Joint business case for a larger variety of organisations
3 Costs	£ 2 bn.	Max. £ 13 bn.	Less than £ 9 bn.
4 Technological innovations	Non-innovation	Innovation as a main driver	Preference for proven technology

Table 4.5: Non linear implementation of the WCML

An important disadvantage of the long period of feasibility and planning at LIPs is that players will be uncertain about the ultimate impact of the project on their situation. Farmers, on whose land a new highway has been projected, will ask themselves whether they should invest in their enterprise or not, without knowing if and when the project will be completed or in what form.
This brings us to a new dilemma: because of publicly demanded openness the project delivery organisation will communicate possible routes, without knowing the exact impact on all specific players.

With the Betuweroute three main project phases had been distinguished within the project organisation:

1 Initiative: the phase of definition, feasibility and definition of the scope
2 Conditioning: design and planning
3 Execution

There is not an exact moment that the Betuweroute changed from initiative to design or from design to execution. There are many, many transfers at different times for different parts of the project. Also the delivery is split. There are two main elements delivered: the first for the part within Rotterdam (completed in 2002), the second for the part from Rotterdam to the German border (delivered in 2007).

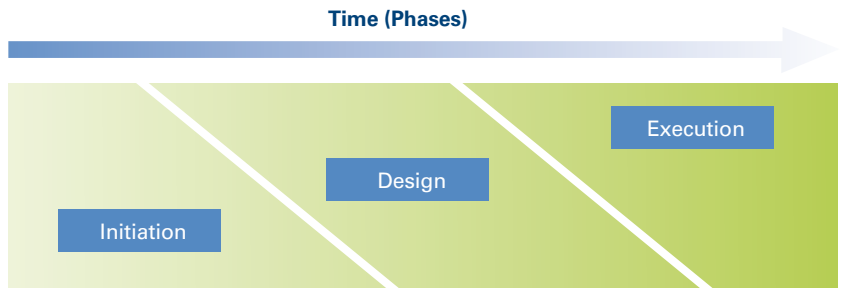


Figure 4.7: Phases of the Betuweroute over time

The LIP planner has to deal with numerous processes, for which the durations are estimates and with relationships with other processes that are not always clear. Relationships are uncertain and ambiguous. And throughout, the planner has 'to create' information for reporting and steering based on the planning.

> *"When you can finally start the building phase of your project, many processes will already have changed. That means you continuously need to adapt."*
> Deputy of the Province of Gelderland.

In interviews we hear from planners: "be realistic in your planning", but managers and decision makers sometimes decide differently, as can be witnessed by the research of Flyvbjerg (see chapter 1). Planners may find themselves in a difficult situation, when they hear prognoses that are not believable, a problem is also faced by controllers.

These ideas regarding time complexity are very much related to theory on dynamic complexity which we will come to later (chapter 5). We observed the element of non linear implementation process of LIPs in many of our cases, as could be observed in chapter 3 — for example the West Coast Mainline (section 3.5).

4.9 COMPLEXITY SCAN: THE RELATIVE IMPORTANCE OF THE SIX TYPES OF COMPLEXITY

In the previous section we have outlined the practitioners' view of complexity. Now a legitimate question is whether complexity – and its management – is really a main issue in the implementation of LIPs. We posed this question in our introduction. The question can be addressed by looking at the relevance of the term 'complexity' as it was described in this chapter. First of all we can conclude from our interviews that the term complexity is recognisable in practice by those responsible for or involved in the implementation of LIPs. So the concept of complexity is truly sensitised in the way that it has distinct value to practitioners in describing their work and challenges. Secondly we have shown that there are many perceptions of what complexity in LIPs means to practitioners. In our description of this broad array of definitions we think the key issues faced by managers in LIPs have been highlighted. So, in general, we can conclude that complexity and its management are indeed main issues in the implementation of LIPs.

We outlined each of the six types of complexity based on a practitioner's detailed viewpoint. But what is their relative importance? Do project managers perceive each of these complexities as equally important? And what relationships do we see between the six types of complexity? In order to answer these questions we have analysed the answers of respondents to our the question:

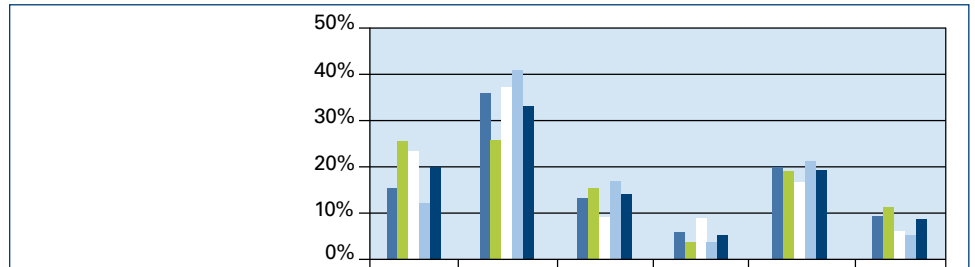
"What makes your project complex?"

and clustered these into the six categories to make 'a complexity scan'. For each interview we have divided 10 points over the 6 complexities and after summation over all the interviews, the total 'scores' were calculated. The results are shown in figure 4.8. The figure shows the relative importance of each complexity: the total of the 6 complexities for each project is 100% [2]. The numbers correspond to the type of complexity.

When we look at the answers from our respondents we see that all six types of complexity are recognised by the practitioners. But there are large differences in how often and significantly each of the complexities is mentioned and regarded. Social complexity scores higher than the other types of complexity. Legal and time complexity clearly received a lower score. Interesting to observe is also that while at the Swiss projects technical and social complexity receive a similar score, at the Dutch projects, social complexity appeared to be more dominant.

[2] To calculate the average: the data of Gotthard and Lötschberg has been taken twice.

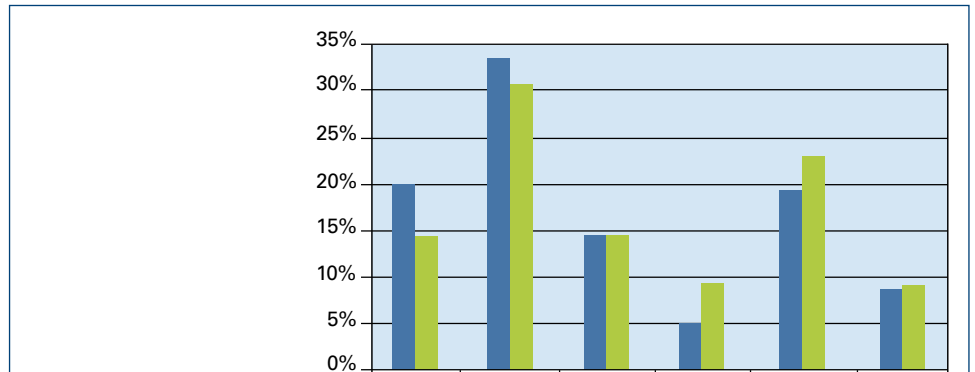
An indirect approach to complexity, focussing on important themes and events, was also used to study the case projects. We analysed 14 key events (see chapter 6.3 for a list) in depth in separate essays. For each event and within each 'decision round' we then analysed whether we observed any of the six types of complexity. Then we calculated their relative importance (total 100%).



	Techn.	Social	Financ.	Legisl.	Organis.	Time
Betuweroute	15%	36%	13%	6%	20%	9%
Gotthard and Lötschberg	26%	26%	15%	3%	19%	11%
A73-South	23%	37%	9%	9%	17%	6%
HSL-South	12%	41%	17%	3%	22%	5%
Average	20%	33%	14%	5%	19%	8%

Figure 4.8: Views of complexity from Betuweroute, Gotthard, Lötschberg, A73-South and HSL-South

The result of the analysis using the indirect approach is shown in figure 4.9.



	Techn.	Social	Financ.	Legisl.	Organis.	Time
Average Interviews	20%	33%	14%	5%	19%	8%
Average Events	14%	31%	14%	9%	23%	9%

Figure 4.9: 'Complexity' in 14 events as between types

Again, within the indirect 'event' approach social complexity was observed most frequently. When the challenge is enormous, social aspects seem to be the most important to deal with. The difference with the other complexities is similar to that observed in the results of the direct approach presented in figure 4.9. In general the critical events reflect the tendencies reported from interviews. The overall figure (4.9) shows a similar pattern to the answers on the question "What makes this project complex to you?" Social complexity is still the most dominant, and legal and time complexity are less prominent. Technical, financial and organisational complexity seem to be important, but not as dominant as social complexity.

So based on this analysis we can state that:

Social complexity is the dominant and central complexity within LIPs.
Legal complexity appears less prominently.

Strikingly legal complexity was the complexity least mentioned in the interviews. People apparently do not experience this as a key issue in organising a large infrastructure project. This may surprise jurists, but it seems that, in the end, legislation is not what makes the real difference. This does not mean that legal complexity is unimportant: it can still have a great impact on LIPs. But other factors appear to be of more importance. This finding conflicts somewhat with the impression that politicians often have that legal complexity causes important delays [WRR [3] 1994, Elverding Committee 2008]. They ask themselves: is it possible to speed up the delivery of LIPs by optimising the legal system? Although, definitely optimisations in the legal system can be beneficial, our research results indicate that the most benefits are expected from dealing with social complexity.

The practitioners' view has enabled us to show that the core of complexity within LIPs is social. This social complexity originates from the different interests and preferences of stakeholders. When the impact of the project on stakeholder interests is large, differences in interest lead to differences in perception and opinion that heavily influence project progress. The social complexity also appears to be triggered by four other complexities from the practitioners' view: technical, organisational, financial and legal complexity. Time complexity turned out to be a different view in itself: it shows the importance and influence of 'change' as a complexity factor, something that we will address into more detail in the next chapter. Based on this we conclude that:

Changes which can be on technical, organisational, financial or legal matters cause social complexity.

Our cases provide some interesting examples of these dynamics. For example the tunnel safety sub-case at the A73-South. Here the technical complexity, a new

[3] WRR: the Dutch Wetenschappelijke Raad voor Regeringsbeleid' (Scientific council for government policy)

unproven technology, resulted in rising cost estimates. This in turn caused friction in the stakeholder network because it started a debate about who would pay for this increase. At the same time we see that the technical complexity made it unclear how the new CAF (or water-mist) technology would meet safety requirements. Again we see a relationship between technical complexity and social complexity. This seems easy to explain: problems do not arise when there is no reason for any of the players to change behaviour in the project. So the types of complexity really only cause trouble when they influence the interests of stakeholders.

The conclusion that the main complexity in LIPs is social also means that:

Complexity is connected to arenas of stakeholders.

To show how complexity is related we use the A73-South sub-case of tunnel safety, where the triggers for social complexity between the principal and project delivery organisation are mainly financial and technical. The project delivery organisation has to deal with technically advanced solutions which bring rising cost estimates. These estimates do not fit the project budget as agreed with the civil principal and causes social complexity. At this event a second arena can be distinguished consisting of the local authorities, fire brigade and project delivery organisation. Here the complexity is mainly legal – what is the required safety level? – and technical – does the new technology achieve the desired safety level? Again this triggers a conflict of interest when the authorities develop a different view on safety from that of the project delivery organisation which has to deal with budget constraints. So here we see complexity at work in a stakeholder arena: the project delivery organisation cannot accommodate the fire brigade and local authorities since it will cause a conflict with its civil principal on a potential budget overrun. So accommodating one stakeholder, would mean conflicting another one. This brings us to one of the fundamental dilemma's within LIPs:

The tension between supporting stakeholders – the civil principal and parent organisation – and stakeholders that are hampered by the project is the key to social complexity. This tension becomes visible at the level of the project delivery organisation. This needs to deal with both the interests of all stakeholders that have a vested interest - but do not invest in the project, and with the constraints put forward by the civil principal and parent organisation that support the new infrastructural facility.

Project delivery organisations constantly need to manage this tension between demands and resources in a dynamic manner. This is because the balance between demands and resources is ever changing and cannot be frozen before or during project execution. We saw examples of this dynamic at work in both the tunnel safety/TTI sub-cases (Betuweroute and A73-South) but also in cases concerning the involvement of local stakeholders. See table 4.6.

No.	Sub-Case	Tension
1	Betuweroute, Organising	Between the demands of the civil principal (contract manager) and local stakeholders (stakeholder manager).
2	Betuweroute, Preparation of operation	Between the realisation of infrastructure demanded by the principal and the future users of the track: carriers, operation company and harbour of Rotterdam.
3	Betuweroute, Scope and cost development	Between the budget constraints from the Ministry and the additional demands, especially from the Province of Gelderland.
4	Betuweroute, TTI	Between safety demands of local stakeholders plus the fire brigades and budget constraints.
5	Betuweroute, Pannerdensch Kanaal	Between the budget constraints of the Ministry and the Province of Gelderland demanding a tunnel instead of a bridge.
6	HSL-South, Birds	Between environmental pressure groups and the planning and budget constraints of the Ministry.
7	A73-South, Tunnel safety	Between safety demands of local stakeholders and the fire brigades and the budget constraints.
8	A73-South, Political agreement	Between regional demands put forward by Province and cities and the Ministry of Transport in the Hague.
9	A73-South, Environmental compensation	Between demands from environmental pressure groups and the Ministry of Transport.
10	West Coast Mainline, History	Between the Ministry and private companies such as Railtrack and Virgin.
11	Gotthard and Lötschberg, Referenda	Between demands from Cantons and citizens and the budget constraints of the Ministry (BAV).
12	Gotthard and Lötschberg, Uri	Between local demands and budget constraints put forward by BAV and ATG.
13	Gotthard and Lötschberg, Frutigen	Between local demands and budget constraints put forward by BAV and BLS.

Table 4.6: Social complexity arising from the tension between external demands and constraints

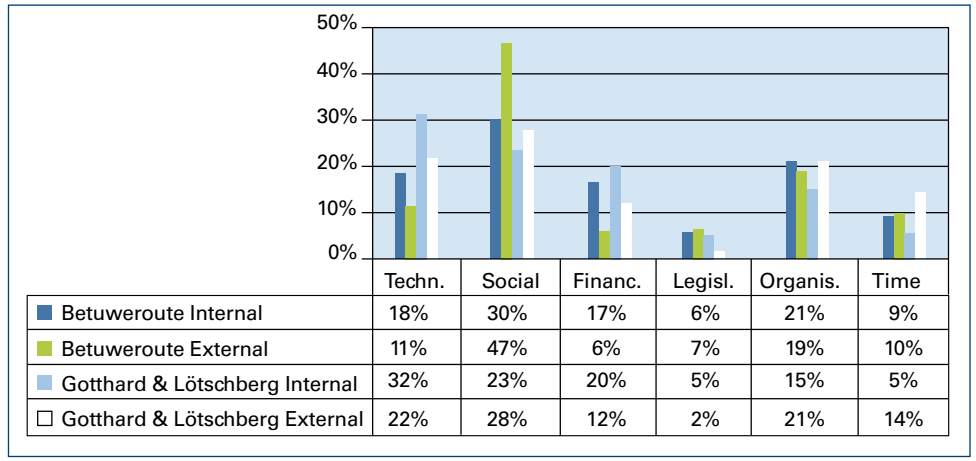
The table shows that in all our sub-cases this tension, was visible. All our sub-cases support our conclusion on this important nature of social complexity in LIPs.

Internal stakeholders and external stakeholders

Now we have looked into detail into the six types of complexity from the practitioners viewpoint. We have shown that social complexity is dominant. This makes it especially interesting to see whether there are differences in how complexity is perceived by the various stakeholders. When we take a closer look at the data, we also can relate the complexities to the organisation people represented. We have done this for the Betuweroute and the two Swiss projects. For our analysis we distinguished the following groups:

1 Internal stakeholders: the project delivery organisation, the civil principal and the parent organisation.
2 External stakeholders: NGO's and local governments.

The number of interviews at A73-South and the HSL-South was not sufficient to plot a figure with internal and external stakeholders (however the results show a similar picture). The results are shown in figure 4.10.



	Techn.	Social	Financ.	Legisl.	Organis.	Time
Betuweroute Internal	18%	30%	17%	6%	21%	9%
Betuweroute External	11%	47%	6%	7%	19%	10%
Gotthard & Lötschberg Internal	32%	23%	20%	5%	15%	5%
Gotthard & Lötschberg External	22%	28%	12%	2%	21%	14%

Figure 4.10: References to complexity at Betuweroute, Gotthard and Lötschberg divided as between internal and external stakeholders

For all projects, 'external' NGO's and local governments mentioned social complexity most often. They try to influence the decision making and this is not always easy. External stakeholders experience social complexity at all projects more acutely than internal stakeholders — not surprising since the outsiders mainly are working to protect their interests in the project.

> *"In order to have influence, it is essential to be taken seriously by the cities and the project organisation."*
> Co-ordinator, Betuweroute, Welstand Committee (Committee of Architecture).

So based on our the interviews, we can conclude that:

> *Complexity is not only a 'privilege' of internal stakeholders. External stakeholders also experience LIPs as complex. For them social complexity is the dominant complexity, even more so than for internal stakeholders.*

4.10 SUMMARY AND CONCLUSIONS

In this chapter we started our search for what complexity might be in LIPs by taking an insider's view based on practice. We have shown that complexity, as a sensitising concept, is recognised by practitioners as a key element in the successful realisation of their projects. Grouping of the perceptions of practitioners has brought us a framework consisting of six types of complexity: technical, social, financial, legal, organisational and time. All these elements of complexity matter to practitioners in the implementation of LIPs. These are the elements they worry about in the implementation of their projects, requiring a great deal of management attention.

By looking at the answers from respondents and analysing our cases we conclude that the most dominant form of complexity experienced by practitioners is social. On the other hand legal complexity proved to be of less importance. This is interesting because many recent initiatives trying to stimulate the successful implementation of LIPs, have focused on legal aspects.

Organisational complexity was mainly visible in our cases in the relationship between the project delivery organisation and its parent and principal organisation. Project delivery organisations seem to experience just as many challenges in dealing with these parties as they do in dealing with, for example, NGO's and local stakeholders. So in this sense a key element of organisational complexity is very much related to social complexity, but focussing more on the shareholders and contractors that are collectively active in the implementation process. Other issues that fall under the umbrella of organisational complexity are: to find and motivate skilled people; many decisions with no clear 'best solution'; the numerous processes within the project delivery organisation that interfere with each other; and the numerous contracts that need to be arranged (including interface challenges).

Technical and financial complexity were demonstrated to be closely related to social complexity. Technical and financial complexity really begin to cause challenges when they influence the arena of stakeholders involved in LIPs. Technical and financial complexity trigger social complexity. Two main examples of technical complexity are: dealing with new innovative technology; and technological uncertainty. Financial complexity is for example related to the distribution of costs and benefits, the perception of cost developments; different perceptions about definitions and agreements; strategic misinterpretation, optimism bias and pessimism bias; and the 'cascade of distortion'.

In the previous chapter we have already concluded, based on the storylines, that one of the elements of complexity is that LIPs are a multi-player game. This conclusion also appeared prominently when we analysed the perceptions of practitioners in this chapter where social complexity emerged as a dominant theme. The core of social complexity lies in the different interests of the involved stakeholders. These different interests are mainly visible between the NGO's and local stakeholders on the one hand, and the principal, users and parent organisations on the other. The principal, users and parent are the ones that invest in the project and have a need for its final product. In order to control their investment, resources they apply are often rigidly defined in terms of scope, schedule and budget constraints. External stakeholders such as NGO's and local interest groups do not have these constraints but are mainly interested in protecting or serving their own interest in the project; time and budget constraints are in essence not their concern. The project delivery organisation serves as an intermediary between these two groups of interests, which makes it likely that it is here that conflicts of interest will become visible. It is at this level where the different interests that lead to differences in perceptions and opinions emerge. It is here where social complexity in LIPs is usually born. It is clear that dealing with this social complexity is one of the key challenges for managers working on complex projects.

In our analysis time complexity turned out to be the exceptional dimension since it is heavily related to the nature of change which affects the other five elements of our framework. In the previous chapter we already concluded that each project has a unique history and is strongly influenced by unique events. This means that LIPs are characterised by a non-linear implementation process — further outlined in this chapter. For managers this type of complexity means that a unique, tailor made approach needs to be developed to meet the challenges faced by a specific LIP. In the next chapter we will label this type of complexity 'dynamic complexity' and illustrate how this is visible in practice. In chapters 8 to 10 we will then provide management strategies to deal with this type of complexity.

When comparing the importance of the six elements of complexity in this chapter, it seems that practitioners have the most trouble in dealing with social and organisational complexity. This does not mean that dealing with technical challenges is unimportant however. Social and organisational seem to be more challenging which might be explained by the fact that they are more intangible and subject to change over time. New stakeholders enter the arena and interests may change over the course of the project as we have shown in this chapter and will work out into detail in the next chapter.

Finally we have shown that complexity is not only experienced by representatives of project delivery organisations and principals but also by the other stakeholders involved in LIPs. These other stakeholders (NGO's and local stakeholders) experience social complexity but also issues related to organisational complexity: how to organise yourself with no dedicated resources for example?

With this we complete our practitioners' view, we now continue our search for complexity in LIPs by introducing a more theoretical point of view. Digging deeper in the concept of complexity, to increase our understanding and provide more and new insights that can assist those active in LIPs in dealing with the challenges which they face.

5 SCIENTIFIC PERCEPTION OF COMPLEXITY

In the previous chapter we outlined a practitioner's view of complexity. Amongst many other things, this view has demonstrated to us that social complexity is dominant in the implementation of LIPs. We also showed that complexity is a recognisable term for practitioners which is useful to describe and discuss challenges in the successful implementation of LIPs. In this chapter we will try to build on this by adding the theory on complexity. We answer the research questions – "How is complexity defined in theory?" and "How does this compare to practice?" As a result we present a conceptual framework, based on the merger of theory and practice, which can be used to describe complexity in LIPs. In addition, this framework will provide us with the basic elements to link complexity to several distinct management strategies as we will show at the end of this chapter.

Reasons for developing both a practitioner's and theoretical approach are mainly because we regarded it useful to develop more than one view to increase research quality (the so called 'triangulation', see chapter 2), which is especially fruitful in the dominantly qualitative research approach that we have adopted. On other hand we found out that defining complexity in a uniform way was difficult because the word complexity seems to be explained in various ways in both practice and literature. There is simply no universally accepted definition of the phenomenon of complexity available. This is why we present two approaches, one based on practice (chapter 4) and one based on theory which is specifically tailored to provide insights in the available management approaches to deal with complexity (this chapter (5).

In this chapter we dig deeper into the theory on complexity. In our framework we distinguish two views on complexity: detail and dynamic. Detail complexity focuses on the many components and high degree of interrelatedness. Dynamic complexity focuses on the uncertain decision making and the non linear development of LIPs. Both approaches originate from different perspectives and define complexity in a different way. But both are useful! In the first two sections we will describe two separate perspectives on reality (5.1) and then introduce the two forms of complexity – detail and dynamic – that originate from those two perspectives (5.2). After this we move on by focussing on detail complexity (5.3) and dynamic complexity (5.4) which we will then combine in an overall synthesis on complexity in LIPs (5.5). After this synthesis we move further to identify the key implications for the management of complexity in LIPs (5.6). Finally in 5.7 we then introduce a framework of management strategies to tackle the various types of complexity in LIPs which serves as the basic framework for our chapters 6 to 10 on the management of complexity.

5.1 TWO PERSPECTIVES ON REALITY

"You are managing by using rational principles, but what you observe is that events unfold in line with complexity theory."
Gerhard Jacobs, Project Manager, in reaction on table 5.1.

In our search of the literature on perspectives on reality which can be linked to the management of LIPs we discovered an interesting distinction in perspectives. One which we will label 'deterministic' and one we label 'complexity'. This distinction is made by many authors in the field, although some use different phrases to describe the two views, and was found to provide useful insights in how to look at complexity in LIPs. A traditional approach stands for reductionism, causal thinking and order, relationships can be unravelled and underlying patterns can be known. We will call this the 'deterministic approach'. Complexity scientists have been developing a new approach, contrary to the traditional one. This contrary approach includes holism, interrelations and admitting coincidences. We will call this the 'complexity approach'.

Newtonian science has underpinned civilisation from the 1700s to the present. Newton's thoughts, especially his three laws of movement and his law for gravity, proved to be very successful. They symbolised a victory of the human mind over matter (S. Bais, 2005) and set an example to other sciences. In this view, the world is a well-behaved machine with clear and determined processes (J. Polkinghorne, 2002).

At the end of the 19th Century many physicists thought that the world was well described. Nobel Prize winner Albert Michelson said in 1894: "The only thing that remains for the natural sciences, is defining the sixth figure behind the decimal point" (J.P. McEvoy, O. Zarate, 1997). However, within a few decades (1900-1930) the theory of relativity and quantum mechanics launched a revolution proving that these thoughts were not valid.

In the traditional view, the effects between cause and effect are simple, clear and linear (Tetenbaum in Brukx and Wackers, 2001). Problems can be identified, solutions located and implemented and everything thus kept under control (Flood, 1999). The world is knowable, with a manageable order. However not only physicists, but also other scientists had their doubts about the deterministic perspective, especially those scientists who studied complexity. Teisman (2005) argues that it is nearly impossible to know all the initial conditions: persons, motives, personal interrelationships, the history of these conditions, variables of legislation, manners, international relationships etc. Social systems, such as can be found in LIPs, are more complex than the weather system and it is still impossible to make a good weather forecast

for Western Europe over a period of a week. It is impossible to have sufficient knowledge about initial conditions and their effects. In other words: it is impossible to completely unravel all the chains of causes and effects. Complexity scientists argued that the traditional, Newtonian approach of order and control was not appropriate to describe complexity and how to deal with it in its full breadth. They presented, in the last decades of the 20th century, a new way of thinking on complexity. A new way of thinking that also has been applied to the study of LIPs.

Teisman describes his findings from the 'Willemsspoortunnel', a railway tunnel project under the river Maas in the centre of Rotterdam. He tried to identify the 'go decision' to build the tunnel, which was needed in terms of the deterministic approach. He could not find this decision (Teisman, 1992). It seems that the decision was never made formally. What he found registered were many little decisions, but not all of the relevant (sub)decisions could be retrieved. For example, how do you take into account an important (informal) bilateral discussion between the Minister of Transport and a contractor during a boat trip? And what would have happened if this boat trip had been cancelled because of bad weather?

In table 5.1 we summarise the main differences between the two mentioned perspectives (based on: Stacey, 2001; Flood, 1999; Axelrod and Cohen, 1999; Flood and Carson, 1988; Teisman, 2005; Tetenbaum, 1998).

In table 5.1 it is clear that the perspectives on reality are linked to different management principles. And, although we will describe the management of complexity later in this thesis, it is useful to present some first thoughts on this.

Stacey (1993 in Rosenhead) mentions the need for two types of management. These types of management largely correspond with the two views presented:

- Ordinary management for day-to-day problem solving to achieve the organisation's established objectives, with control at its centre. This type of management is needed to deliver cost-effective performance.
- Extraordinary management, by contrast, is required in situations of open-ended change. It is necessary to encourage informal structures with members from different business units, functions and levels etc.

Perspective	Deterministic perspective	Complexity perspective
Basic Assumptions		
Knowable	The world is knowable, controllable, predictable and manageable.	The complex nature of the world is partly unknowable, uncontrollable, unpredictable and unmanageable.
Rationality	Objective rationality and judgement.	Bounded rationality and boundary judgements.
Coincidence	Coincidences are of minor importance.	Coincidences are more important than any single decision.
Nature	Stability.	Instability.
Viewpoint	Researchers as independent external observers of the world.	Researchers are part of the system.
Openness	Closed system, which can be described separately from the environment outside the system.	Open systems, change in reaction to their environment and vice versa; complex situations evolve over time. Emergence: The system is the source of the characteristics. The rate of change is context dependent.
Causality	A causes B rationality. Solutions are defined in terms of causal factors. The effects between cause and effect are simple, clear and linear.	Behaviour is the results of loops, where variables are interrelated.
Management strategy		
Break down	Reductionism. The whole can be divided into parts, without losing information.	Holism. Appreciation of the world as a whole, comprising many interrelationships. The whole is greater than the sum of parts.
Key to successful organisation	Command and control. The dynamic is directed by a central authority and results from formal rules and practises.	To make connections, which lead to vital networks. Management by 'sense-making'.
Problem Solving	Problems can be identified, solutions located and implemented and everything thus kept under control.	Problem solving must grapple with many interrelationships and emergent behaviour that is inherently unknowable to the human mind.
Goal setting	Focus on long range planning and fixed implementation.	The most we can do is to manage the local. Continuously revisiting what might be going on.
Self-organisation	None. The focus is on organising from an independent position.	Dynamic behaviour is capable of producing unexpected variety and novelty through spontaneous self-organisation.
Main body of theory	Systems management (project management)	Proces management (dutch) Complexity management

Table 5.1: The deterministic approach versus complexity perspective

Teisman (2005) states that both approaches (table 5.1) are necessary in present-day complex environment and he connects these approaches to the core competences of managers, figure 5.1.

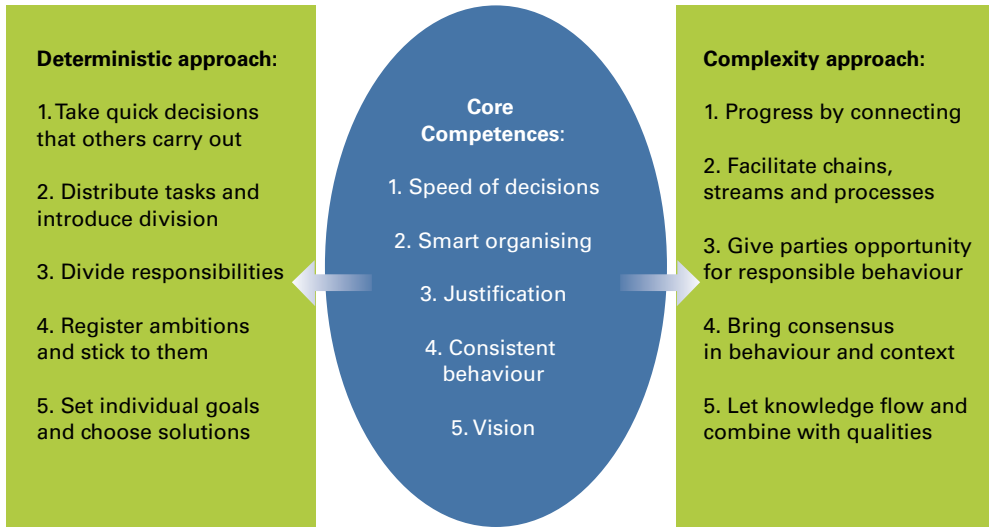


Figure 5.1: Two core competences of project managers (Teisman, 2005)

The distinction in this section gives us a first impression that there are different approaches possible to complexity and its management in general which can be applied to LIPs. We will clarify the management approaches in more detail starting in section 5.6. These differences can originate from basic differences in how to observe and study reality. We then continue by showing how these two opposing perspectives on reality have been translated into the definition of the term 'complexity'. It has brought us to make a distinction between detail complexity and dynamic complexity.

5.2 TWO PERSPECTIVES ON COMPLEXITY

"The World originates from an endless stream of coincidences which unroll over time."
Harry Mulisch, writer, NRC Handelsblad, 18-19 November 2006.

Let us now look at the concept of complexity itself. What does complexity mean according to authors from the field of complexity management? And how does this compare to the two perspectives on reality presented in the previous section?

Literature on complexity is fairly recent and largely theoretical in nature. Many authors speak about complexity and how to deal with it, even without defining the concept of complexity itself. Even in many books that have the word 'complexity' in their title, the search for a definition of complexity will be in vain! Fortunately some leading authors do define complexity and some have made an overview (e.g. J.M. Sussman, 2002).

We will not discuss all the authors in detail but look at common elements found in their work. When we analysed the various definitions of complexity combined with our findings on the complexity defined by practitioners, we recognise two perspectives on complexity. Complexity can be:

1 Detail complexity
   - Many components with a high degree of interrelatedness.

2 Dynamic complexity
   - The potential to evolve over time: self organisation and co-evolution.
   - Limited understanding and predictability.

We have chosen this distinction between the two types as our main basis for the description and explanation of complexity in LIPs. This has been done for the following reasons:

1 Detail and dynamic complexity are distinctive in theory.
2 Detail and dynamic complexity are sufficiently distinctive in practice.
3 The distinction between detail and dynamic complexity provides a fruitful basis to make a link between complexity and management strategies.

1 Detail and dynamic complexity are distinctive in theory

To define complexity, we have looked at thirteen authors[1]. Every author mentions what we refer to in detail complexity as a characteristic in their definition of complexity; about half of them mention dynamic complexity. Detail complexity is linked to the traditional perspective as presented in the previous section. It takes the number of elements and the relationships as its basis. Dynamic complexity on the other hand

[1] Authors that define complexity: Robert Axelrod, Michael D. Cohen; Peter Coveney, Roger Highfield; Robert L. Flood, Ewart R. Carson; Murray Gell-Mann; Joel Moses; Charles Perrow; Eberhardt Rechtin, Mark Maier; Peter Senge; Ralph Stacey; John Sterman; Joseph Sussman; Geert Teisman; Edward O. Wilson

can be linked to the complexity perspective where the relationship between cause and effect is diffuse and coincidences play an important role. The fist characteristic of complexity ('many components with a high degree of interrelatedness') is rather obvious. The second has broken with the traditional view that systems are knowable and predictable. Peter Senge (1994) identifies these two sorts of complexity. Detail complexity refers to systems in which there are many variables. Dynamic complexity refers to situations where cause and effect are subtle, and where the effects over time of interventions are not obvious.

Dynamic complexity occurs according to Senge (1994):

- when the same action has dramatically different effects in the short and the long run.
- when an action has one set of consequences locally and a different set of consequences in another part of the system.
- when obvious interventions produce non-obvious consequences.

An example that sometimes 'obvious interventions might produce non-obvious consequences', can be found at the investigation of the parliamentary enquiry of the major infrastructure projects in The Netherlands (TCI report). Based on an analysis, several recommendations were made in order to improve the future execution of Large Infrastructure Projects. These recommendations however were strictly aimed at only a part of the stakeholder system involved in LIPs, namely the relationship between the political side (House of Representatives) and the civil principal (Ministry of Transport) responsible for project execution. While these recommendations make sense for this particular part of the system, they might produce completely different – and possibly unwanted – results for the whole system of stakeholders involved in delivering the results of LIPs.

Other authors use similar distinctions to the one introduced by Senge. An overview is presented in table 5.2

Author	Description of types of complexity	
Senge (1994)	Detail complexity	Dynamic complexity
Teisman (2005)	Complicated	Composed
Whitty & Maylor (2007)	Structural	Dynamic
Williams (2002)	Structural	Uncertainty
Many Authors (i.e: Kurtz, Snowden)	Complicated	Complex

Table 5.2: Distinctions in complexity made in theory

As table 5.2 shows, the distinction uses various names for each type of complexity but the definitions are fairly similar even though some differences might exist. Throughout this thesis we have opted to use the distinction 'detail' and 'dynamic' complexity as introduced by Senge. In our opinion these two terms best describe the core of each of the two types of complexity.

2 Detail and dynamic complexity are sufficiently distinctive in practice

In the previous chapter we presented our practitioners' view on complexity in LIPs. In the description we found many connections with the concepts of detail and dynamic complexity. Two examples from interviews at the Swiss tunnels, illustrate that both detail and dynamic complexity are observed by practitioners within LIPs.

A manager of BAV, Section Alp Transit, when he focused on geology, gave us an example of detail complexity:

> *"The geological demands are complex. And also the technical risks. The logistics of building material for example. But in general we can handle this. This is all manageable."*

Dynamic complexity was at stake in the answer of a civil servant of Canton Uri in Switzerland about the Gotthard tunnel project, when he responded:

> *"You have no general overview of what will become reality and what will not, something for which we are also partly responsible."*

If we take a look at our practitioners' view we can clearly see that some characteristics are forms of detail complexity and others are more linked to dynamic complexity. In table 5.3 we present an overview to give some general examples.

As table 5.3 (next page) shows, detail and dynamic complexity are visible in each element of our practitioners' view. Compared to our earlier practitioners' view, the distinction between detail and dynamic complexity provides a different angle to look at complexity, but is still visible in practice.

The distinction in detail and dynamic complexity was also visible in the case overviews we presented in chapter 3. Here we described the facts and figures (tightly related to detail complexity) and the historical development (tightly related to dynamic complexity) of each of our selected cases. Combining the two overviews allowed us to present a meaningful description of these projects. This makes them sufficiently complementary and grounded to use as a basis to describe complexity in LIPs.

Complexity	Detail complexity	Dynamic complexity
Technical	• Mega sized products (scope) • Many relationships between parts of the product	• Unproven technology • Technical uncertainty
Social	• Large number of stakeholders • Many relationships	• Different meanings and perceptions • Changes of interest over time • Changes in co-operation
Financial	• Difficulty in calculating cost for all sub elements of the product	• Changing market conditions • Different perceptions about definitions and agreements • Strategic misinterpretation
Legal	• Large number of consents and permits needed which are often related	• Changing, none existent and conflicting laws • Many decisions with no clear best solution • Future developments influencing the project delivery organisation
Organisational	• Large number of involved organisations • Numerous working processes that interfere • Large number of contracts with numerous interfaces	• Researchers are part of the system.
Time	• Planning of separate activities and their relationships	• Long time frame with continuous developments • No sequential process of implementation • Planning has to deal with numerous uncertain and ambiguous processes

Table 5.3: Examples of detail and dynamic complexity in the practitioners' view

3 The distinction between detail and dynamic complexity provides a fruitful basis to make a link with the various available management strategies

The six elements of complexity proved to be a fruitful framework to determine complexity. So why have we not simply taken these six elements as our main angle to study this phenomenon? The answer to this is twofold. Firstly, the six elements of our practitioners' view are not directly visible in the literature on complexity. But secondly, and far more importantly, the distinction between detail and dynamic complexity has allowed us to make a link to available management strategies. And since finding the key to the successful management of complexity in LIPs is our main research question, this is essential. This link is provided in sections 5.5 and 5.6.

5.3 DETAIL COMPLEXITY

The most dominant element mentioned in literature on complexity is that a system is complex when it has many components and that these components have a high degree of interrelatedness. We refer to this as being 'detail complexity' or a 'complicated system'. A system is complicated when it is composed of many parts, interconnected in intricate ways (Sussman, 2002). According to Perrow (1984) complexity is determined by the number of components in the system and their interactions.

'Many components with a high degree of interrelatedness' leads to the following notions on complexity:

- The relationships should be intricate.
- The length of the description that will describe the system determines complexity.
- More relations will not necessarily lead to more complexity.

More interactions between the components will not always lead to more complex systems. We will explain this with an example from Noble Prize winner Murray Gell-Mann. According to Murray Gell-Mann (Axelrod, Cohen 1999) a system is complex when it is difficult to predict, not because it is random, but the regularities it does have, can not be described in short. In other words: complexity is determined by the length of the description that will explain a system (Gell-Man 1994).

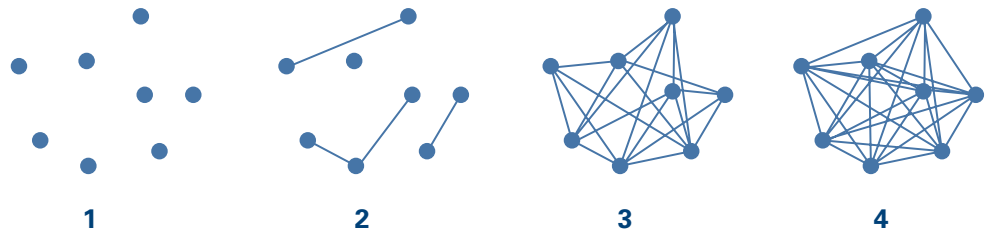


Figure 5.2: Some patterns of connection of eight dots (Gell-Man, 1994)

In order to explain this, Gell-Man (1994) draws eight dots, see figure 1 in figure 5.2. In figure 2 some of the dots are connected, in 3 there are more connections than in 2, and 4 shows all possible connections. Figure 1 is simple. Figure 2, including some connections, is more complex (or less simple) than 1. Most interesting is figure 4. An initial conclusion might be that 4 is the most complex of them all, since it includes the most connections. "But does that make sense? Isn't the property of having all dots connected just as simple as having no dots connected? Maybe figure 4 belongs to the bottom of complexity scale, along with drawing 1," Gell-Man argues. The length of the description necessary to describe figure 4 is shorter than 2 or 3.

Gell-Man concludes in The Quark and the Jaguar (1994) that any definition of complexity is necessarily context-dependent, even subjective: "… the level of detail at which the system is being described is already somewhat subjective – it also depends on the observer or the observing equipment. … The length of the description is dependent on the knowledge and understanding that the respondents share."

In practice we observed many examples of detail complexity in LIPs. This detail complexity was visible in the following three sub-systems that can be found in these projects:

1 Stakeholders
2 Product (infrastructure facility)
3 Activities

This distinction is the result from our search on elements on detail complexity. When we clustered the occurrence, these three sub-systems in LIPs emerged. The high detail complexity of these three systems is linked to the facts and figures provided in chapter 3.

In LIPs we recognise a network of many actors (players or agents) that have many different relationships. Think of the impressive number of external stakeholders at all of the investigated projects. At the West Coast Mainline for example, more than 700 organisations were involved.

The diagram of figure 3.5 shows the stakeholder network of the HSL-South with its numerous stakeholder organisations. Between these stakeholders there are numerous formal and informal relationships.

The same can be said of the response of the Betuweroute's local stakeholders. This is illustrated in text box 5.1. It is not hard to show that the number of players and their relationships at LIPs is extremely high.

Figure 5.3: Photograph Gerd Leers [photo Werry Crone.]

An example showing the impressive number of stakeholders can be found during the consultation period of the Betuweroute from 16 April to 27 July 1992 [TCI, Reconstructie Betuweroute, 2004]. In May 1992, 25 information evenings had been organised. The total number of responses from citizens and organisations was 1879. From August to October 1992, 450 people had been invited to clarify their reaction in 18 hearings. The organisation that coordinated this round of consultation (the Dutch 'Overlegorgaan Verkeersinfrastructuur'), needed more time to process all these reactions because the number far exceeded the initial expectations.

In figure 5.3 Member of Parliament Gerd Leers was photographed in 1993 with a pile of reports of the Betuweroute. It shows the enormous amount of paperwork produced in this project.

Text box 5.1: Local stakeholder involvement at the Betuweroute

So when studying LIPs it is easy to see that these are complicated in the sense of 'many components with a high degree of interrelatedness'. This statement is true for the players involved in the system and their many relationships between each other, as was illustrated. But this is also true for the infrastructure facility (the second system: product) to be built: the large number of different elements and relationships are clear by taking a glance at the facts and figures of projects studied. LIPs mean numerous kilometres of railway and road facilities with intricate relationships which can be found in the substructure, superstructure, communication systems, bridges, tunnels and so on. So not only the stakeholder system shows detail complexity, also the product – in LIPs the infrastructure facility – shows similar signs of detail complexity.

Thirdly and finally, the detail complexity can also be found in the activities to be performed. An example of many components and a high degree of interrelatedness was observed in the contracting model of the HSL-South (see section 3.2.1). Within LIPs a large part of the work is done by contractors with the project delivery organisation as their client. Within the HSL-South there were many interfaces between the various contracts. Separate contracts were handed out for parts of the substructure, the superstructure and transport. The management of the interfaces between these contracts was one of the key activities of the project delivery organisation. The examples shows that detail complexity can also be observed in

the activities which need to be carried out by the project delivery organisation and possibly other stakeholders.

So when we are looking at 'many components with a high degree of interrelatedness' we can conclude that in general this type of complexity can easily be observed within LIPs. In our analysis of the sub-cases however, we found that this type of complexity in itself does not play a main role when looking at the important themes and events in LIPs!

> *LIPs show the characteristics of detail complexity in the stakeholder system, the infrastructure product which is built and the activities needed to realise this product. However this in itself does not have the most dominant impact on their implementation process because it mostly does not affect the stakeholder arena.*

So while dominantly visible the sheer fact that detail complexity is present usually does not have to have a key impact. In fact, in our analysis of the sub-cases which were selected, we only noted one example in which detail complexity played a decisive role. This is in the costs and scope discussions for LIPs. The product scope of the Betuweroute and the attached cost estimates comprise many elements. These elements are highly related, since a change in one scope element can cause changes in other parts of the scope. For example a change in the tunnel technical installations can trigger a change in the concrete structure of a tunnel to arrange the necessary transport of fluids. The relationship between scope elements is hard to define which makes the budget – for separate elements and the total project – hard to calculate. So here we see that the complicated relationship between scope and budget is identified. This relationship is a form of detail complexity that impacts the implementation process because it makes discussions – especially between the civil principal and the project delivery organisation – to reach decisions on scope changes, very difficult.

The TTI example also shows how the complicated relationship between costs and scope can have a big impact on the stakeholder arena involved in LIPs. Here we have a first glimpse on why detail complexity did not come out as a main issue in LIPs – because it usually does not play an important role in the stakeholder network. So the sheer number of players and their various relationships might be impressive, but the number itself does not pose the main challenge to the management of LIPs. When players and relationships are well known and stable, the management tasks seem to be difficult but not extreme. Other issues proved to be more important and are related to dynamic complexity, as we will see in the next section. It is important however to stress that although detail complexity did not emerge as a main factor, it is something which definitely needs to be managed!

5.4 DYNAMIC COMPLEXITY

> *"Perhaps for the first time in history, humankind has the capacity to create far more information than anyone can absorb, to foster far greater interdependency than anyone can manage, and to accelerate change faster than anyone's ability to keep pace."*
> Peter Senge in The Fifth Discipline, 1994.

The second approach to complexity originates from the fields of biology and mathematics. Recently views developed on the complexity theory originating from these fields of study have been translated to the theories in the field of management.

As we introduced earlier, dynamic complexity has the following characteristics:

- The potential to evolve over time: self organisation and co-evolution
- Limited understanding and predictability

The first characteristic uses a systems point of view. Dynamically complex systems have the capability to evolve over time, they are self organising and characterised by co-evolution. This first characteristic is very much linked to the stakeholder system which is active in LIPs. Because of this, there is a link with the concept of 'ambiguity' which is often opposed to the concept of uncertainty. Ambiguity can be defined as a lack of common interpretations experienced by stakeholders. These views are discussed in section 5.4.1.

The second characteristic uses a decision maker's point of view. With dynamically complex systems, decision makers have to work with limited understanding and predictability. This is tightly related to the concept of 'uncertainty' which is outlined in this section. Decision making in a context of complexity also allows us to present some first insights on how to deal with complexity. In this section (5.4.2) we try to establish a first connection between complexity and its management.

5.4.1 The potential to evolve over time: self organisation and co-evolution

> *"Facts are facts, but perception is reality."*
> A. Einstein, scientist.

How do the systems within LIPs evolve over time? The main driver to this evolution lies, as we saw in chapter 4, in the stakeholder system active within LIPs. In this section we take a deeper look in how change occurs in this stakeholder system and what insights this gives us into the complexity of LIPs.

The potential to evolve over time leads to the following notions of complexity in LIPs:

a Emergent events may be of great importance - importance of coincidences
b Sensitivity of minimal changes in initial conditions - historical path dependency
c Complex adaptive systems, as found in LIPs, evolve and have the ability to improve
d Complexity in terms of ambiguity is connected to the conflicting preferences of stakeholders
e Shifting preferences of stakeholders which trigger changes in the stakeholder system often originate from dissatisfaction
f Shifts in preference of stakeholders are related to external factors and internal developments
g Changes in system state can be visible in all three main sub-systems found within LIPs: the stakeholder network, final product (infrastructure facility) and activities

a Emergent events may be of great importance - importance of coincidences

"It is striking that those people that you regarded unimportant to the process, often turn out to have the most power to block this process."
Frans Evers, Former Chief Executive Officer Society for the Preservation of Nature

Many scientists mention that what appears to be a minor factor may be of great impact. Small changes in initial conditions are magnified instead of being reduced. Can the flap of a butterfly's wings in Brazil set off a tornado in Texas? If, however, the butterfly had flapped its wings at a different time or in a different way, would this still have led to a Texas tornado (Flood, 1999). What we consider 'details' can in fact have great impact. March (1994) stresses the importance of coincidences and states that coincidences and specific moments are more important than any individual decision. An example of a minor event with great impact was found at the tunnel technical installations (TTI) of the Betuweroute. In a specially developed guideline for tunnel safety (the 'green booklet), there was a mention at page 67 that sprinkler installations should be applied. This exact formulation caused much discussion within the project because later there appeared major doubts whether or not sprinklers were the most appropriate solution for the TTI. One sentence in a guideline can cause years of discussions.

This was not the only sub-case where we observed that details can turn out to be of great importance. Another example was found in Switzerland. Here the procedures of the democratic process mean that important decisions are subject to voting by the cantons. Since there would not be sufficient cantonal support to build either the Gotthard or the Lötschberg tunnels, the government had to propose the implementation

of both projects at the same time to get the necessary cantonal support. In short one could argue that the apparently detail, the Swiss voting system, is responsible for the fact that two tunnels are built while only one might be sufficient to meet demand.

A final example was found at the HSL-South where we observed that because of the wish to construct a new line with a design speed of 300 km/h, the government, formed in 1994, sent out a very important signal in their government declaration. While this signal seems to be only one (!) small sentence in the declaration it turns out to be of high importance in the political debate. This sentence is that: 'The government confirms the plan to complete the HSL-project including the preferred route alternative'. So even before the important round of public debate and the decision in the House, the decision seems already fixed! The importance of this small sentence is highlighted by the fact that the Technical Committee Infrastructure (TCI) paid special attention to the wording and its background. One of the quotes on the use of the sentence is of Prime Minister at the time, Wim Kok.

"We saw the preferred alternative as the starting point. Whilst it is always possible to move from the government declaration, but only in a case where major events or changes require a change in opinion." (TCI report HSL-Zuid)

It seems that this small event, one sentence in the government declaration, turns out to have a major impact on the decision making of the project. This brings us to the following notion on complexity in LIPs:

Events that seem to be relatively small and unimportant might have large consequences within a LIP.

Apart from the general importance of minor factors and details, so called 'emergent events', play an important role in LIPs. A special development in the HSL project we want to highlight in this case is the 'Bos alternative'. This alternative was independently developed by a civilian (W. Bos). He supports and defends his alternative plan with passion: putting in an extreme effort in order to gain attention. Finally this attention is given, mainly because it meets the complaints of some stakeholders such as the Ministry of VROM and the EIA committee. This causes the alternative to play an important role in the discussion of alternatives within the Government. It is clear that it has strongly influenced the major scope change of building the Groene Hart tunnel. For the project organisation there is no way to predict the development of this alternative and the role it would play in the discussion upfront. It can be best labelled as 'an emergent event'.

Another emergent event which was observed in our cases is the decision to delay the A73/74 project by the Minister of Transport because of a lack of financial resources. This unexpected or emergent event is typical of the complexity found at LIPs. Here we

saw that this decision encouraged the regional parties to develop a new alternative in which the scope was expanded, eventually leading to a major overhaul of the project.

Many other influential emergent events were found in our cases. A good illustration is the discussion within the Gotthard and Lötschberg project with the European Union on the use of heavy vehicle tax. The implementation of a heavy vehicle tax in a stepwise increase provided a large stimulus to complete the Lötschberg project on time because this would bring in a large part of funds that would enable other projects to be completed. The Swiss project also provided more interesting examples of 'emergent events'. One of the most influential was the Alpine Initiative, which led to a referendum in 1994. Because this referendum was approved, the scope presented by the project organisation BLS and ATG was under constant pressure to meet the formulated demands regarding protection of the Alps. Another example can be found in the Ceneri Tunnel discussions. Because of tunnel disasters in other regions, there was pressure to change the original one tube design to a two tube tunnel.

> *Emergent events, outside the control of the management of the project delivery organisation, can turn out to have a major impact on the project's decisions and outcomes.*

It is important to note that many of these observed emergent events fall outside the control of the management of the project delivery organisation. This finding has major implications when looking at possible successful management strategies: how to manage something over which you have no apparent control? This is addressed in section 5.6.

b Sensitivity of minimal changes in initial conditions - historical path dependency

The insight that starting conditions are extremely important is not new. Already at the end of the 19th Century, the French mathematician Henri Poincaré proved that minimal changes in initial conditions, lead to totally different movements and outcomes (S. Bais, 2005). This extreme sensitivity to the initial conditions has major implications; it leads to apparently 'chaotic behaviour'. Vice versa, we can only reproduce the initial conditions up to a certain extent. This implies that for most of our problems, which are not simple, the exact solutions will be unknown. This view is contrary to Newtonian theory.

The importance of the starting conditions was also observed in the case projects described in chapter 3. The main example is the Betuweroute where the initial opposition to the project carried on for many years even though the project situation the was significantly changed. A similar example was observed at the HSL-South. The starting conditions of the HSL-South were European ambitions regarding the realisation of a High Speed Railway network. These ambitions were heavily supported by both the Ministry of Transport and personally by the Minister of Transport at that time. During this

very early phase it seems that some of the main project decisions are already finalised. The first major decision is on the design speed of 300 km/h, the second – of course tied to the design speed – being the construction of a completely new line instead of using the existing track. While these decisions are later challenged in the planning procedures by stakeholders such as civilians, local communities and the House of Representatives, they remain unchanged over the course of the project. The respective governments and the Ministry of Transport even show some signs that they are willing to defend their preferences at very high cost. This is most visible in the discussion on the 'Bos alternative' in which the government uses high political pressure to persuade the House to support the government preferred A1 alternative which contains a different crossing of the Groene Hart. So despite all possibilities in consultation, it seems extremely difficult for stakeholders to change some of the basic ideas and assumptions. This brings us to the following sub conclusion on complexity in LIPs:

> *LIPs are characterised by a historical path dependency, the starting conditions of the project play a very important role over the whole project's time span. This is especially visible in the behaviour of the project delivery organisation that has the tendency to stick to previously developed solutions.*

c Complex adaptive systems evolve and have the ability to improve

To describe complex systems, the concept of complex adaptive systems has been developed (e.g. Axelrod and Cohen 1999 and Stacey 2001). The stakeholder network in LIPs has the characteristics of a complex adaptive system. The framework starts with agents, who can be a person, an organisation, a family, a country etc. Players have strategies, the way agents respond to their environment, and strive to reach their goals. Agents with mutual consistent characteristics form populations. These large numbers of agents or populations interact with each other at a local level. The only rules are the rules at the level of the player. The basic element in these 'complex adaptive systems', is the local interaction between elements of the system. These local interactions will determine the behaviour and order of the system as a whole, but at the same time are not focused on the behaviour of the whole system. Agents endlessly repeat their interaction, adapting to each other, to changing circumstances and in order to reach their goals. This leads to a variety in actions, rules and adaptations. This leads to an important notion namely, that the systems itself evolves. An illustration is found in the evolutionary theory of Darwin (1859), where evolution takes place through selective reproduction and variety (mutations).

In short: complex systems are adaptive when they can learn and evolve; they have the ability to improve. The system will be adaptive when the complexity of a system exceeds a critical limit, and will produce unexpected variety and novelty through spontaneous, unpredictable self-organisation (Brukx and Wackers, 2001; Flood, 1999). The driving forces are the interrelations of players with continuous feedback.

So these driving forces are very much tied to the preferences of the involved stakeholders.

In traditional theory preferences of stakeholders are often consistent, stable or external to the choice process, but observations of organisations suggest that preferences are often far from consistent, stable or external to the choice process. As we will show in this section, preferences of players change, partly as a result of external pressures but also partly as a result of the evaluation of the actions they perform.

The system itself is the source of the characteristics of the system, which means that the systems are 'emergent' (Goodwin in Brukx and Wackers, 2001). To explain emergence, Flood and Carson refer to biology. Human cells form organs like the liver, heart and lung. These organs form a whole that is greater than the sum of the simple parts, the cells. It results in organs that have their own functions and roles to play. They also point out that a business (a project in our case) is not an aggregate of (management) functions, nor is society an aggregate of social groups. Things come together to form wholes whose properties are different from the parts. Emergence leads to the conclusion that "the whole is greater than the sum of parts" (Flood and Carson, 1988). In these emergent systems, new events or developments cannot be predicted from previous events, because they result from interactions which, we saw, cannot be fully known and understood (Teisman, 2005; Flood, 1999).

d Complexity in terms of ambiguity is connected to the conflicting preferences of stakeholders

So the stakeholder system within LIPs is a complex adaptive system that evolves over time. How is this visible in our studied projects? In order to study the evolving LIP stakeholder system we have used the concept of 'ambiguity' to analyse our (sub-) cases. Ambiguity refers to the absence of or contradictory interpretations about what needs to, can and should be done, when and where (Noordegraaf, 1999, 2000; Pauly, 2001). High ambiguity can be seen as an element of complexity in LIPs. Ambiguity is a lack of clarity and consistency in reality, causality and intentionality (March, 1994), it is fuzzy, a collection of elements whose membership is equivocal, as opposed to 'crisp' (Lerner and Wanat, 1983). In other words, you don't know what you want, or you don't know what is going on, and these ambiguities can not be resolved by just collecting more information.

Crucial when looking at ambiguity is that values, goals and preferences are nearly absent and not (fully) knowable. A dominant interpretation is lacking or the interpretations are contrary (Noordegraaf, 1999). Ambiguity becomes a problem, according to Pauly (2001) when an actor wants to cooperate with other actors, while the definitions of the problem, the directions for solutions, and political attentions diverge and conflict. In order to analyse how ambiguity is present in our cases we have used a distinction used by March (1988).

March distinguishes four ambiguities in respect to decision-making:

1 The ambiguities about preferences
In traditional theory preferences are often consistent, stable or exogenous to the choice process, but observations of organisations suggest that preferences are often far from consistent, stable or exogenous to the choice process. Organisational preferences change, partly as a result of exogenous pressures but also partly as a result of the actions they perform.
2 The ambiguities about relevance (causality)
Causality is less tightly coupled than in classical theory of decision making with causality between policies and activities, means and ends, solutions to problems, and actions in one part of the organisation to actions in another part.
3 The ambiguities about history
This deals with whether history as a basis for expectations about the future. According to March history is clearly and notoriously ambiguous.
4 The ambiguities about interpretation (meaning)
The presumption that decision making processes are organised around the making of decisions and understandable in terms of decision and outcomes, is doubted.

In all rounds of our sub-case descriptions we have analysed if and which type of ambiguity could be observed. When taking a look at the results we found that one occurrence of ambiguity was prominently visible in all our sub-cases:

Ambiguity in LIPs is mainly found in the form of preferences and interpretations. In practice this means that interpretations are linked to the preference – or 'interest' – of the different stakeholders.

Basically, perhaps not surprisingly, stakeholders tend to interpret situations in line with their preferences. So a fire brigade is only interested in the solution providing the best possible safety level, not hampered by the budget constraints a project delivery organisation might have. When the interpretations of stakeholders vary so much that they cannot get to a common view, this can obstruct the progress of the project. This was observed when the deterministic and probabilistic views on safety collided on the sub-case for tunnel safety at the A73-South (section 4.2). Apart from the dominant ambiguity being in shifting preferences, we also observed that, as stated earlier, interpretation of the available information is always in line with the preference of a stakeholder. Even though a project delivery organisation can show in an independent analysis that both a tunnel and a bridge have the same impact on the living environment, this does not mean that local stakeholders will support this view. Another related factor is that differences in culture and background of the involved stakeholders can lead to misunderstandings. For example within the HSL-South it

was decided during the construction phase to involve specific expertise to help solve cultural and language differences within the bi-national committee responsible for coordinating construction across the Dutch-Belgian border. So even when interests seem to be aligned, ambiguity can be present.

The analysis of ambiguity highlights the connection with social complexity which was described in section 4.4. Here we concluded that 'the core of social complexity lies in the different interests of the involved stakeholders'. The same can be said of ambiguity. This requires a slight deviation from the earlier described theory on ambiguity in which the focus appears to be more on 'a lack of shared interpretations'. Our research shows:

> *Ambiguity as the lack of shared interpretations is in itself not problematic. Ambiguity causes friction because the shared interpretations are dominantly related to the diverging interest of involved stakeholders.*

If a lack of shared interpretations – or ambiguity – is present in all interaction between stakeholders this would also mean that stakeholders clash on every subject. We did not find supporting evidence for this statement. There are numerous occasions where stakeholders quickly develop common views. Ambiguity seems to occur most when the stakes are high, the uncertainty is high and interests differ greatly: just as we observed in section 4.4 with social complexity. As a result, in these situations ambiguity will be high. In addition we observed that the differences between stakeholders are important. Some stakeholders have a completely different culture and employ very different people with different competences. When differences in culture are large, ambiguity is likely. This can be illustrated with an example of noise screens of the HSL-South. Here the representatives of the environmental protection agency, protesting against the noise screens, have a total different culture and background from the representatives of the project delivery organisation. As a result developing a shared understanding of the problem and solution can be more difficult than it already is because of the diverging interests.

> *Ambiguity tends to be high when the stakes are high, the uncertainty is high and interests differ greatly, organisations have different culture and people different competences.*

Another issue fostering ambiguity is that the collection of data itself to develop shared interpretations can be very difficult. At some airports a very complicated and expensive system is used for the measurement of the noise nuisance from aeroplanes. The nuisance is measured at many points in the surrounding area. Each measurement may not exceed a certain noise level. The strategy used by the airport is mainly focused on not exceeding the noise level at the points of measurement. So while these levels might not be exceeded, this does not necessarily mean that the total noise nuisance is acceptable because measurements are not taken at every possible location. The measurement results can easily be challenged by stakeholder according to their own view and location. Behaviour shows us that the measurement system itself becomes the goal, instead of the goal the measurement system was trying to serve.

In our cases we also found examples of ambiguity related to 'relevance' and 'history' but these turned out far less prominent. What was interesting however is that an interesting type of ambiguity was observed, which was not part of our theoretical framework:

> *Ambiguity in LIPs can also be observed in the roles of the stakeholders involved in project delivery. Meaning that roles of the parent, civil principal and project delivery organisation can be diffuse, unclear and changing over time.*

LIPs require an enormous amount of attention of the involved organisations. During the process of implementation, roles of stakeholders can be unclear and changing. This is not so much the case for those stakeholders serving their specific interest such as local stakeholders and NGO's but more for those stakeholders involved in the project delivery such as the principal and parent organisations. Often these principal and parent organisations have many other interests and an organisational structure which is not used to accommodating the organisation of a LIP in which many different 'policy driven' departments need to co-operate. Often we observed discussions and ambiguity on what role a specific stakeholder should fulfil. At the Betuweroute we saw that during the early phase, the Dutch Railways (NS) almost combined the roles of the project delivery organisation and the civil principal. Later this changed when the principal role moved towards the Ministry of Transport. Discussions on who is responsible for a certain task were also observed in the case of Canton Uri. Here it was unclear whether BAV – as civil principal – or ATG – as project delivery organisation – was responsible for putting forward a project scope that would be acceptable in local planning procedures. Basically ATG took the view that BAV should fund any plan alterations needed to get the approval of local stakeholders while BAV held ATG responsible to put forward an approved plan within the allocated budget. These views conflicted – one of the sources of delay at the Gotthard project.

The responsibilities of the civil principal can be unclear but it is also unclear which organisation should serve as the civil principal. In the case of the HSL-South during phases of the project, the substructure project had a different principal from the superstructure and transport elements of the project. However many changes were made in this relationship over the course of the project.

e Shifting preferences of stakeholders which trigger changes in the stakeholder system often originate from dissatisfaction

So how did the stakeholder system, a complex adaptive system, evolve in our selected

cases? In each of our (sub) cases we distinguished several rounds of decision making. In order to find out what separated one round of decision making from the next, we took a look at the main triggers of change. By taking a look at all selected rounds we came to the conclusion that there is one main cause for change: the dissatisfaction of stakeholders. This is in line with the theory of complex adaptive systems which presented earlier in this section (c). An example of the shift between rounds for the Betuweroute is presented in table 5.4 (see section 3.2 for a more detailed overview of the rounds).

Shift	Triggers for change	Effects
I-II 1996	• The House of Representatives seriously doubted the feasibility of the project. Rising cost estimates causing dissatisfaction. • The initial approach resulted in extreme resistance. The House, Ministry and ProRail were dissatisfied with this resistance. • The Ministry of Transport found the relationship with ProRail not transparent and uncontrollable. • The project delivery organisation within ProRail was quickly growing which demanded a new organisational structure.	• Installing the Hermans Committee to recommend whether the project should proceed. Goal of the project becomes a 'strategic investment' instead of an investment focussing on economic return. The scope was adapted to fit external demands in a better way. • New management approach focussing more on interaction with the stakeholders and not only shareholders. • Ministry serving as the formal civil principal and ProRail as the project delivery organisation. • A more formal 'hierarchical' organisation structure compared to the previous informal one. • Shift in arena from discussions between project delivery organisation and local stakeholders to discussions project delivery organisation and Ministry of Transport as civil principal.
II-III 2000	• Scope development ('creep') coming from external pressures and immature project control. This resulted in additional budget requests causing dissatisfaction in the House of Representatives. • High distrust and lack of collaboration between Ministry and PDO caused an overload in the hierarchy which slowed project progress and led to dissatisfaction at the Ministry and PDO. • The project progressed from conditioning to execution. The PDO was growing and felt it needed to adapt to the new phase.	• A protocol was set-up to arrange the principal-PDO relationship. A higher ranked officer was made project director. • Project control within the PDO was professionalised. • The 'colleague model' was introduced to facilitate co-operation between PDO and Ministry. • The PDO expanded and introduced a more decentralised organisation structure.

Table 5.4: Triggers for change between the rounds of the Betuweroute

As table 5.4 shows, the shifts between rounds are initiated by one of the involved key stakeholders. The same trend could be observed in each of our sub-cases. Again we use a sub-case from the Betuweroute. The changes in the relationship between the civil principal (Ministry of Transport) and the project delivery organisation within ProRail are visualised in figure 5.5 (please note that these changes do not exactly fit with the 3 distinguished rounds in table 5.4).

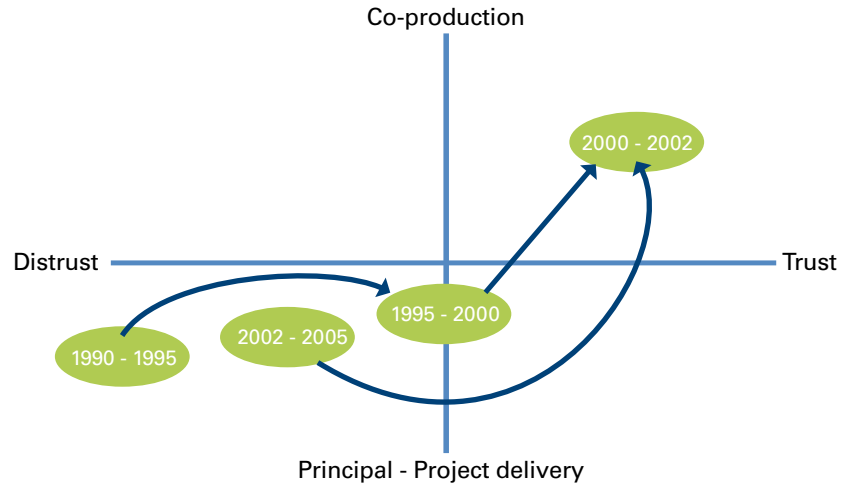


Figure 5.4: Relationship between principal and project delivery organisation at the Betuweroute

Figure 5.4 illustrates how the relationship can change from a more formal one, with a strict distinction between the role of the principal and project delivery organisation, to a more informal role where principal and project delivery organisation share responsibilities. In table 5.5 we list the triggers for a shift in the rounds for this sub-case and list the effects of the change.

Sub-case	Shift	Triggers for change	Effects
Organising the Betuweroute	I-II	• The Ministry of Transport found the relationship with ProRail not transparent and uncontrollable. • The initial approach resulted in extreme resistance. The Ministry and ProRail were dissatisfied with this resistance • The PDO was quickly growing which demanded a new organisational structure.	• Ministry serving as the formal civil principal and ProRail as the project delivery organisation. • New management approach focussing more on interaction with the stakeholders. • A more formal 'hierarchical' organisation structure compared to the previous informal one.
	II-III	• Budget pressure from the House resulted in a need for more control. • High formal relationship and distrust between Ministry and PDO caused an overload of the hierarchy which slowed project progress.	• New project directors installed at the PDO and Ministry. • The 'colleague model' was introduced. • New organisation structure: 'tension arcs'. • Operational phase was split from project execution.
	III-IV	• The Cargo department within the Ministry had insufficient knowledge to serve as civil principal. • The Ministry felt responsibilities between PDO and principal were unclear. Discussions were focussing too much on details. This was regarded a risk for the financial control of the project.	• Civil principal responsibilities shifted from the cargo department within the Ministry towards RWS • A protocol was set-up to arrange the principal-PDO relationship. A higher ranked officer was made project director.

Table 5.5: Triggers and effects of change for a sub-case of the Betuweroute

When we take a look at the common characteristics of what drives these changes we can draw the following conclusion:

> *Change events cause dissatisfaction amongst stakeholders which causes them to decide or act differently.*

The use of the word 'dissatisfaction' in this conclusion might cause some debate. One could state that this could perhaps also be driven by new opportunities. But this was certainly not observed in our cases. However one could state that generally changes occur within LIPs when a main stakeholder feels that the current status quo should be changed because his interest could be better served different way.

Again we see a close parallel with our conclusions regarding ambiguity where we also saw how the preferences of stakeholders change over the course of the project. Here we add to this notion that 'dissatisfaction' of stakeholders is the main driver of change in LIPs. In short: stakeholders do not like unpleasant surprises! In table 5.6 we list a selection (one from each case) of dissatisfaction drivers leading to change in our sub-cases:

Case	Driver	Effect
Betuweroute	Dissatisfaction at the Ministry of Transport with the rising cost estimates on the sprinkler installations for the Tunnel Technical Installations (TTI)	A new design for TTI was made which used a modular approach instead of going for the maximum safety level.
HSL-South	Dissatisfaction with the outcome of the planning process by the Ministry of Transport and local stakeholders during the start-up	The planning process (key planning decision) was followed again to accommodate demands of local stakeholders
A73-South	Dissatisfaction from the regional partners of the A73-South about the decision of the Minister of Transport.	Regional proposal of a new scope to the Ministry of Transport based on shared funding.
Gotthard & Lötschberg	Dissatisfaction on the rising costs of the projects in parliament and within BAV	A special new fund 'Finöv' was installed to fund the project.
WestCoast mainline	Dissatisfaction by Parliament and Ministry on the collapse of Railtrack and the stoppage of the WCML project	A new start was made with the Strategic Rail Authority negotiating new contracts with Network Rail and Virgin.

Table 5.6: Examples of dissatisfaction as a driver for change in LIPs

A final quote illustrates how dissatisfaction drives changes:

> *"In order to get a main investment boost for the maintenance of infrastructure in the United States I think we unfortunately need a major disaster to happen first."*
> Dana Levenson, managing director of the Royal Bank of Scotland's North American Infrastructure and Advisory business, at the Transfin conference in Barcelona, 2008.

f Shifts in preference of stakeholders are related to external factors and internal developments

So now we have outlined that dissatisfaction of stakeholders is the main driver for change in LIPs, the next question becomes: how does this dissatisfaction occur? An example of the Betuweroute can help to further understand how changes in

preferences occur in LIPs. In this project there has been a heated debate whether the Pannerdensch Canal ('Pannerdensch Kanaal') should be crossed by a bridge or a tunnel. The original idea was to build a bridge but after much discussion a tunnel was built. In table 5.7 we illustrate the preference of the involved stakeholders at the beginning of the process and after project completion. We also mark the reasons for a change, if there was any, in preference.

Stakeholder	Preference at start	Preference after completion	Reason development of preference
Ministry of Transport	Bridge	Bridge	A bridge was similar in terms of environmental impact for both citizens and environment. The extra costs are seen as a waste.
Project delivery organisation (ProRail)	Bridge	Tunnel	A bridge was preferred because this was agreed with the Ministry in the original project scope. After the budget was available for a tunnel this changed. Now the tunnel is regarded a more sustainable solution. Also the discussion has been finalised which allowed a smooth project execution.
Province of Gelderland	Tunnel	Bridge	Initially a tunnel was seen as the preferred alternative by the citizens. The Province also used this discussion to show the Ministry it was a force to be reckoned with by obstructing the decision making by preferring a tunnel. After completion (10 years later) this changed because the tunnel meant that a precedent would be set so that for the new highway A15 next to the Betuweroute, a tunnel should be build (instead of an additional bridge). This will result in higher project costs for the Province.
Architecture Committee	Not involved	Bridge	This committee was installed after the tunnel was decided. But the committee would have preferred a bridge because this would provide an excellent opportunity to build a 'architectural landmark' in the project.
Citizens	Tunnel	Tunnel	A tunnel was regarded a superior solutions for the living climate. Even though the environmental analysis showed that there is hardly any difference in impact on the living climate between a tunnel and a bridge.

Table 5.7: Changes in preference for the Pannerdensch Canal crossing

The table shows us some interesting examples of the dynamics of preferences in LIPs. Some stakeholders that initially supported the tunnel solution later became more supportive of a bridge and vice versa! And this is certainly not exceptional because our analysis showed that:

> *Various external factors and internal developments can trigger a change in preference of an involved player. External factors can be events or independent changes in context. Internal factors originate from the evaluation of the effects of past decisions.*

So changes can be triggered by both:

1 External factors: events or independent changes in context
2 Internal developments: resulting from the evaluation of the effects of past decisions in the process

Both external factors and internal factors are present in the changing preference of players in LIPs. An external factor is for example the shift in preference of the Province because the tunnel decision of the Betuweroute directly influences the cost of a key highway project next to the Betuweroute, still to be completed (A15).

Changing preferences at the A73-South

Another good example of a shift in preference was observed at the A73-South. Here the regional stakeholders tried to get their project approved and funded by the Ministry of Transport in Den Haag. However their project was postponed twice due to a lack of funds. Finally the project was accepted because the region could offer a package deal to the Ministry. This package deal meant that the implementation of the various project parts became cheaper and that the regional partners would act as co-financers. But also, more importantly, it was presented as a regional initiative. The Ministry of Transport used this project to show their new policy to support 'regional initiatives' and quickly approved the project! This shows how an external development – the new support for regional initiatives – can change the preference of a stakeholder, resulting in the approval and funding of the A73-South.

Text box 5.2: Changing preferences at the A73-South

Many more interesting external developments that influenced preferences of stakeholders were observed in our sub-cases (text box 5.3).

Examples of external factors influencing stakeholder preferences:

- Tunnel disasters influencing the preferences of the fire brigade and local stakeholders on the demanded safety level at Gotthard and Lötschberg Base Tunnels, A73-South, HSL-South and Betuweroute.
- The focus on privatisation in the railway industry has changed the preference towards new technology at the West Coast Mainline. While new technology was not an issue during the first phase, after privatisation it became a key element in the upgrading of the line.
- The focus on privatisation in the railway industry has changed the preference towards tendering the operation of the Betuweroute. This public tendering became an important objective of the project.
- When the Betuweroute project starts its execution in 1995 there is a gap between the cost estimates and the budget. This is however not seen as a main issue. This changes quickly later on when more pressure is applied from the House and when the media begun to report the 'scandalous cost overruns' on the project.
- The cost estimates of the Betuweroute started rising because of an overheated construction market at the end of the 1990s. This is one of the causes for conflict between the Ministry of Transport and the project delivery organisation within ProRail.
- The original preference of stakeholders to install transparent noise screens at the HSL-South was later revised because this caused numerous bird casualties.

Text box 5.3: Examples of external developments influencing stakeholder preferences

External factors are categorised as 'external' because they are outside the control of project managers of the principal and project delivery organisation. The massive impact of these external factors shows that within LIPs the context itself is subject of study and isn't fixed. Again we find a parallel with the field of physics. Einstein said the same about time-space theory. He released the context from the role of passive spectator to an active participant. The same in complexity theory: the context isn't fixed and is part of the system and its developments.

When analysing all external change factors we have tried to group them:

- Political changes
- Policy changes
- Economic changes
- Incidents and accidents

The first category is the impact of political changes. Every new government re-investigated the decision to build the Betuweroute. Most notable was the new government installed in 1994 where previous opponents of the project became members of the newly installed government. As a result a special committee, the so called 'Hermans Committee', was formed to investigate the necessity of undertaking the project. In this case, after an intense process, the committee advised the government to continue the project. But there are plenty of examples, such as the Zuiderzeelijn in The Netherlands, were political changes have been a main cause for abandoning a project.

A second category involves policy changes, by which we mean changes in policy within stakeholder organisations involved in LIPs. These changes can partly originate from political decisions but do not necessarily need to be. Examples of policy changes we noticed in our sub-cases include the preference for new contracting forms ('PPP'), the privatisation of the railway companies – which had a massive impact on the WCML – and the recent focus on sustainability.

A third factor are changes in economic climate. Shortage or abundance of personnel can heavily influence the course of a project. The same can be said of the development of prices on the tender market, that for example had a negative influence on the price level of the tendering of the substructure contracts of the HSL-South.

Finally there is the list of incidents and accidents. Earlier we described these as 'emergent events'. Examples include the influence of accidents such the Hatfield crash on implementation of the West Coast Mainline and tunnel disasters that influence the stakeholder system. The same can be said of incidents such as the discovery of dead birds as a result of the HSL-South transparent noise barriers.

The factors that are inside the control of the project managers of principals and project delivery organisations are predominantly related to experiences with previous decisions. Internal developments can be the result of preliminary results of past decisions. Initial decisions might not give the results initially pursued which after evaluation might cause a shift in preference. Some examples found, are shown in text box 5.4.

We distinguish the following clusters:

- Failure to meet objectives and expectations
- Changes in key personnel

Because of the uncertain condition in which decisions are taken (see section 5.4.2), many times the actual results fail to meet the original expectations – which triggers changes. Solutions can turn out to be too expensive – causing budgetary friction – or do not meet stakeholder demands – causing opposition. Again the main driver in this respect is 'dissatisfaction'. When a key stakeholder, i.e. a stakeholder with both high influence

and a large interest, is not satisfied with how a decision has turned out, this can cause a system shift. One of the most frequently observed examples in this respect is when there are expected to be overruns in the budget. An example was in the case of the Gotthard and Lötschberg where the project became too expensive and a phased building plan was needed, combined with a financing scheme ('Finöv').

Examples of internal developments influencing stakeholder preferences

- The original decision to build the Betuweroute involves goals of economic return on investment and achieving a model shift to stimulate sustainability. Because an economic return turns out impossible and achieving a modal shift is doubtful, these arguments are not used in later discussions. Instead the focus of objectives shifts to a 'strategic investment' to connect Rotterdam harbour to its hinterland.
- In several cases – such as the case of Tunnel Technical Installations at A73-South and Betuweroute – we observed that the cost estimates of original solutions started rising after a decision was taken. This often causes a change in opinion at the principal side demanding an alternative solution with lower costs. Cost developments are one of the main drivers of changes in stakeholder preference.
- Because innovation proved to be a main driver of failure during the second phase of the West Cost Mainline project, it was regarded unfavourably in the third phase of the project. Instead the responsible authorities opted for a more technological conservative approach (proven technology).
- Because the operation of the Betuweroute turns out unprofitable this makes the preferred organisational and tendering model obsolete. Instead the preferred model of operation seems to follow a trend from tendering upfront to tendering after completion of construction. The second observed trend is from full outsourcing to a private company towards a public company operating the track. These trends are at least partly caused by disappointments with earlier preferred organisation models.
- At the Gotthard Base Tunnel we see that the support to build two full axes (Lötschberg and Gotthard) diminished because of rising cost estimates. As a result a phased execution was proposed in which several initially planned sections have been postponed.
- At the Betuweroute a new project director within the project delivery organisation and the installation of a new civil principal within the Ministry meant that a new way of working emerged between principal and project delivery organisation. This change in personnel marked a shift from a more distant control approach to an approach of intense collaboration (generally referred to by the phrase 'colleague model' within the project). Both individuals had the feeling that the relationship between Ministry and ProRail was too distant and formal without much understanding and that for important decisions (such as financial) in this sensitive project a more collaborative approach was needed.

Text box 5.4: Examples of internal developments influencing stakeholder preferences

Another potential factor which can be typified as internal to the project is the changing of key personnel. New personnel such as a project director of a project delivery organisation might have a different view on how to approach subjects – which can cause shifts. We previously gave the example of the Betuweroute where changes in personnel marked key changes in the collaboration between civil principal and project delivery organisation. But also at the West Coast Mainline in 2003 key personnel changed with officers installed who focused on collaboration between Department for Transport, Network Rail, the rail industry and local stakeholders, together with clear arrangements between these organisations.

The list of change events and categories shows a range of possibilities in the division of causes. In reality the list can be much longer and overlaps may exist between the categories. And in addition, events can be related such as a policy change resulting from political change. But this division allows us to put into perspective the nature and consequences of the observed events.

g Changes in system state can be visible in the stakeholder network, product (infrastructure facility) and activities

So now we know the nature of changes in LIPs, the final question is: what exactly changes? If we take the TTI at the A73-South again as our example we can observe various change events. Some events such as the tunnel disasters happen totally outside the control of the project manager. Others involve decisions such as the decision of the principal, the Ministry of Transport, to remove the hard shoulders. The events trigger a whole series of changes that makes the system, i.e. the network of stakeholders, move towards a new equilibrium. These different states of the system are often the end of 'one round of the process' and mark the start of a new one.

Here we will also make the connection with 'a new system state'. So what can be the effect of these change events which result in stakeholder dissatisfaction? When we look at changes in system state there can be various interesting notions:

> *Changes in the system state are most dominantly reflected in the constellation of stakeholders. But a change in the system state can in addition be visible in the product (infrastructure facility) and in the activities.*

In section 5.3 we presented three sub-systems found in LIPs: stakeholder system, product system and (work) activity system. Combined, these three - in our view - reflect the total system state. A new system state in LIPs is often a new 'universe' of these three sub-systems.

The first change in a system state can be the entrance and exit of stakeholders. At the preparation of the operational phase for the Betuweroute we saw various stakeholders enter the arena, such as the bank Salomon Brothers and later the private party Towrail. The entrance of these parties was the result of a shift in preference of stakeholders. In the case of Salomon they were invited by the Ministry of Finance to investigate the preparation of the operational phase in order to provide a new vision on the project from an investment point of view. Before that, the previous phase was dominated by a 'construction view' in which a return of investment was of minor importance. In the case of Towrail the House of Representatives urged the Ministry to include a private party in the bidding process for the operation of the new route. This became Towrail. After various incidents however, Towrail was later excluded from the bidding process which shows that stakeholders can also exit the decision making process.

Some stakeholders, already part of the system, suddenly become the centre of attention. A good example of this is the development of the 'Bos-alternative' in the HSL-South. The alternative developed by a private citizen quickly gained momentum because it fitted the interest of the Ministry of Spatial Planning (VROM). As a result, the citizen becomes a central stakeholder in the system, instead of an outsider. So the position that stakeholders have in the network can completely change. These network changes can occur quickly. That is why Teisman gets the feeling when he sees a stakeholder analysis 'that he is looking at the weather forecast of a week ago' (Teisman, 2005).

The different relationships between stakeholders also mean that the power distribution amongst them will evolve. We noticed this in the preparation of the operational phase of the Betuweroute in which first the SPRI committee, which was mainly focussing on construction the line, was the dominant player. In later rounds, this changed when the Ministry of Finance pushed a more financial view of the project (supported by Salomon Brothers). Finally the Ministry of Transport took control of this issue once more, again introducing a focus on project construction. So the relative position and power of stakeholders switched over time.

> *As a result of (a series of) change events the system of stakeholders (network) changes with stakeholders entering and leaving and with evolving relationships. Friends can become enemies and vice versa. This also means that stakeholders that seemed of minor importance suddenly can become a major force.*

A second element of change can be the abandonment of previous solutions and the entrance of new ones. These can be technical solutions – scope changes – such as observed at the TTI case of A73-South, Each of the projects investigated has experienced various major scope changes as can be witnessed in chapter 3.

A third and final difference is reflected in the activities performed by stakeholders,

manifested in their 'management approach'. Very often changes of the system are also visible in the behaviour of stakeholders both within their own organisation and in their interaction with other stakeholders. An example of a newly found management approach was the introduction of a risk reservation for both the HSL-South and the Betuweroute to deal with the financial consequences of risks arising in these projects. After dissatisfaction with previous discussions on overruns and gradual budget increases, the Ministry of Transport saw this as a more appropriate solution. The new system state may mark a change of scope in the physical object and/ or the management solution.

New management approaches and solutions were not only found for project delivery organisation, the main focus of our research, but also for stakeholders. Local stakeholders for example can change from being collaborative to becoming hostile as we saw at the Betuweroute. Or vice versa, as we saw in the case of Frutigen at the Lötschberg tunnel. Here the first attitude was one of hostility. Later, when a new major was installed, this changed. With newly gained support from the Canton of Bern, the city was able to change the original decision to build two tunnel tubes through the city in two separate phases, to a building process including only one building phase. This change from hostility to collaboration meant that the city was able to reduce the negative impact of the construction project for its citizens.

5.4.2 Limited understanding and predictability

> *"A missing paving stone can cause a lot more trouble than a serious budget overrun."*
> Gerard Scheffrahn, project manager of major projects.

In the previous section we outlined the dynamic complexity in LIPs. Now how does this reflect on decision making? It has become clear that decision makers in LIPs have to act with a limited understanding and predictability. Here is where a theory on uncertainty can be useful.

In our day-to-day world, the number of components and interrelations are not so simple to determine and describe. Scientists are quick to argue that it is impossible for humans to know all details and their implications. Perrow mentions that complex systems are interwoven with many complicated, circular and unexpected interactions (Geldof, 2001). In line with this, Axelrod and Cohen present a broad definition (2001): "A system is complex: when there is a strong relationship between the elements, so that the current events heavily influence the probability of all sorts of future events." Simply taking into account the single fact of many components, is not enough (as we also concluded in the previous section on detail complexity). These authors refer dynamic complexity, and more specifically to limited understanding and limited predictability.

The concept of 'Limited understanding and predictability' leads to the following notions on complexity:

a A causes B rationality is diffuse, there is scepticism about long range planning.
b Uncertainty on decisions and bounded rationality.

a A causes B rationality is diffuse, there is scepticism about long range planning

One of the most striking notions of complexity scientists is their redefinition of the concept of causality. The traditional 'A caused B rationality' assumes that the effects between cause and effect are simple, clear and linear. Solutions will be presented in terms of causal factors. On the other hand, Senge begins his best selling book The Fifth Discipline (1990) with:

> *"From the very early age, we are taught to break apart problems, to fragment the world. This apparently makes complex tasks and subjects more manageable, but we pay a hidden, enormous price. We can no longer see the consequences of our actions; we lose our intrinsic sense of connection to a larger whole."*

When we can hardly understand the current situation and causality is under pressure, it is no surprise that complexity scientists are sceptical about long range planning. In the words of Flood: "The more that we try to think globally rather than locally, the more we experience the resistance of complexity" (Flood, 1999).

b Uncertainty on decisions and bounded rationality

Hellriegel and Slocum (1989) relate states of nature (certainty or uncertainty) with the type of decisions that need to be taken (figure 5.5).

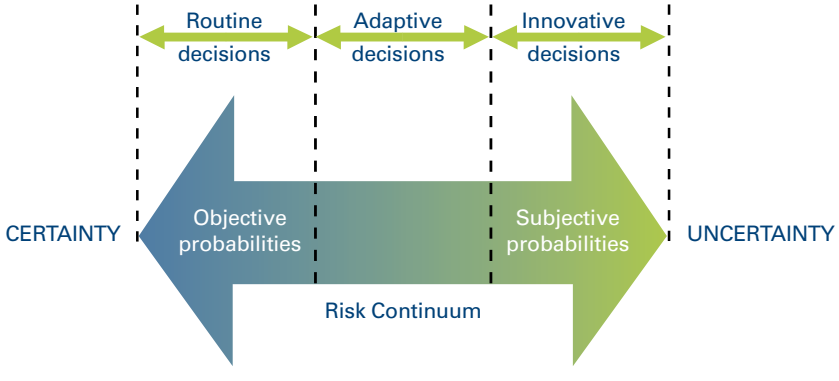


Figure 5.5: States of nature and types of decisions (Hellriegel and Slocum, 1989)

In a state of certainty managers are fully informed about a problem, alternative solutions and the possible results of these alternative solutions. Objective probability is the likelihood that a state of nature will occur, and if it does occur, when. Objective probabilities are based on data from the past, from the belief that past experience will be reliable in predicting the future. Subjective probabilities are based on manager's own judgements and beliefs. Uncertainty refers to the condition under which a manager cannot assign even subjective probabilities to possible states of nature.

For uncertainty, there is no broadly accepted and applicable elaboration of the concept (Weening, 2003). In this section we will discuss uncertainty from management and social studies (e.g. publications of Noordegraaf) that compare uncertainty with ambiguity. This concept of uncertainty within LIPs is heavily related to risks, opportunities and probabilities. Within LIPs there is a broad array of decisions to be taken as is illustrated in our sub-cases. These decisions reflect the 'certainty – uncertainty' continuum presented in figure 5.5. However since our sub-cases were selected as 'key' or 'critical' moments and events, we especially observed decisions related to the state of uncertainty in these cases.

The concept of uncertainty is related to the constraints of the human mind when deciding. These constraints are described by Simon (the famous concept of 'bounded rationality'), whilst Hellriegel and Slocum (1989) present 'the bounded rationality decision-making model', which reflects the tendency of managers to:

1 'satisficing': select less than the best objective or alternative, which can be easier identified and obtained, less controversial or otherwise safe.
2 limited search: the search for alternative solutions stops when they find one that seems adequate.
3 have inadequate information about problems and that nature cannot be controlled by them.

In our two tunnel technical installation sub-cases at the Betuweroute and A73-South we saw that technological solutions present themselves at a rapid pace. But the performance of these new technologies is largely unknown and unproven. This causes trouble in decision making for the project delivery organisation since the impact of the solution is unknown as well as the possible future occurrence of new technology which might make their already chosen technology obsolete. On the other hand, for a project delivery organisation it is impossible to be aware of all available technical solutions since the high time pressure under which LIPs operate does not allow for lengthy search processes and studies. This shows the influence of bounded rationality in decision making. The human mind cannot comprehend everything, and at the same time it is necessary to take decisions to keep processes running. This is illustrated with another example in text box 5.5.

Limited understanding and predictability for the 'Operations of the Betuweroute'
The sub-case on the preparation of the operational phase for the Betuweroute shows many examples of limited understanding and predictability. When the idea to build Betuweroute appears there is almost no experience of the private operation of railway track in The Netherlands. This means that information on alternative models is lacking as well as what will happen after a decision is taken on a preferred operational model. This makes it extremely difficult to predict what will be the long term effect of decisions taken. The available information on both organisational structures and the size of a possible contribution in investment from private companies is not comprehendible. This can also be said of the moment at which a concession to private parties should be tendered. All these factors underline the limited understanding and predictability of this sub-case.

Text box 5.5: Limited understanding and predictability for the operations of the Betuweroute

The examples provided show how limited understanding interferes with the decision making process in the implementation of LIPs. And this was observed in all our cases and sub-cases. In short we can conclude that:

Uncertainty in LIPs means that important decisions have to be taken with a limited understanding (bounded rationality) and predictability (uncertainty) surrounding their impact. This provides managers with one of the key challenges in the management of LIPs.

In terms used by Axelrod and Cohen (Axelrod, 2001): "We feel that a choice can have great impact, but we don't know what the impact will be." In the words of Flood: "The nub of the argument is that the complex nature of the world is unknowable to the human mind" (Flood, 1999).

The uncertain conditions of available solutions and their possible impact mean that decision makers need to operate under the regime of limited understanding and predictability. Long range planning appears to be an impossible utopia in our studied sub-cases. This does not mean however that all decisions in LIPs are uncertain; there are still many situations that are characterised by certainty, which allows us some form of planning.

Uncertainty was observed in the studied cases at various occasions. In our research we noted that uncertainty is not only a major issue for the project delivery organisation, it can also be extremely important for the stakeholders involved. At the Betuweroute, local interest groups found difficulties in collecting information. Basic uncertainties that were mentioned include: who is our contact person, what can we ask and to who?

"We even organised protests to get documents published. We set fire to a train because we wanted to get a document on safety published with the local government and fire brigade attending. That incident meant that the document was published immediately."
Carla Fenijn, co-ordinator of local interest groups at the Betuweroute.

Uncertainty at the Canton Uri
One of the most extreme examples of uncertainty is in the case of Canton Uri. The north portal of the Gotthard tunnel is in the Canton of Uri. Due to the mountainous nature of the Canton, only a very small part of the land is usable for building settlements. Most of this suitable land is in the valley the Gotthard line will cross. Ever since the start of the project there have been discussions between the project organisation (Alp Transit Gotthard), the Canton, the involved communities and the Federal Office of Transport. The Canton had strongly opposed early proposals on the Gotthard track. There was intense debate as to which solution should be chosen in Uri: an open track, lowered track or even bypassing the valley altogether by lengthening the base tunnel The final solution is still not completely clear: it was decided to first construct an adapted track and then, in a later stage, to bypass the valley with a tunnel. There remains a large degree of uncertainty regarding which elements would be built in the short and long term. This uncertainty impacts on local residents who have to live with the uncertain future of the Canton and their own existance in it.

Text box 5.6: Uncertainty at the Canton Uri

Uncertainty is related to a 'lack of information'. Some authors even define uncertainty as being 'the lack of information' (Noordegraaf, 1999). This is illustrated in our TTI examples where the impact of technologies on tunnel safety levels is largely unknown and it is impossible to collect all relevant information upfront. But in addition to a lack of information we also noted that the impact of decisions is uncertain – because future events and developments influence their outcomes. This adds a new element to the definition provided by Noordegraaf because it introduces the influence of external factors.

5.5 SYNTHESIS ON COMPLEXITY IN LIPS

In the previous sections we described how complexity was observed in our cases by using two perspectives on reality: the traditional deterministic view and the complexity view. These two views have been translated into two complementary views on complexity: complexity in terms of detail complexity and dynamic complexity. For both of these views we outlined conclusions on complexity. Earlier in chapter 4 we presented our practitioners' view. But how are these views and conclusions related? Many of the conclusions from each of the views seem to be connected at least. Now we will try to relate some of the conclusions to endeavour to get to the 'core' of what complexity is in LIPs – trying to achieve a synthesis between the separate views on complexity by merging theory with the findings in our cases. This without striving for one overall concept or framework which would mean that the separate views would be mixed. Mixing the views would get rid of their distinctive qualities and in this way diminish the richness of insights which was developed in this and the previous chapter.

In our synthesis on complexity we highlight the following notions:

1 Three connected sub-systems in LIPs have the characteristics of detail complexity:
   a. Stakeholder system
   b. Product system
   c. Activity system
2 The stakeholder network, as a complex adaptive system, has the characteristics of dynamic complexity. The key of this dynamic complexity can be found in:
   a. The diverging interests of stakeholders that stimulate ambiguity.
   b. The dynamic interests of stakeholders
3 Shifts in stakeholders' preferences are triggered by dissatisfaction. This dissatisfaction can be caused by both:
   a. External factors: external events or independent changes in context
   b. Internally developments: resulting from the evaluation of the effects of past decisions in the process
4 The dynamically complex stakeholder system drives changes in LIPs. This makes dynamic complexity the core of complexity in LIPs. A series of change events can lead to a new system state.
5 Decision making in uncertainty is related to uncertainty about:
   a. the stakeholder network
   b. the product
   c. the activities
6 The practitioners' perception and the scientific perception on complexity both offer useful but different insights regarding complexity in LIPs

1 Three connected sub-systems in LIPs have characteristics of detail complexity

Detail complexity is the view that defines complexity as 'many components with a high degree of interrelatedness'. This type of complexity is clearly present in our cases, as can be witnessed by the overwhelming list of facts and figures of our studies cases which was presented in Chapter 3. This view has also allowed us to distinguish the three sub-systems which are present in LIPs:

1 Stakeholder system
2 Product system (infrastructure facility)
3 Activity system (process of implementation)

All three of these (connected) subsystems in LIPs show the signs of detail complexity. They comprise numerous elements with a high degree of interrelatedness.

2 The stakeholder network, as a complex adaptive system, has the characteristics of dynamic complexity

From the three sub-systems in LIPs, we have shown that the stakeholders' system shows the presence of dynamic complexity. Dynamic complexity refers to situations where cause and effect are subtle, and where the effects of interventions over time are not obvious. The stakeholder system evolves with the passage of time and produces variety, novelty and can show improvement. It has the characteristics of a complex adaptive system.

In the previous chapter we have demonstrated that the core of complexity in LIPs is social. Social complexity is visible in diverging stakeholder interests, most notably local stakeholders and shareholders that meet at the level of the project delivery organisation. In this chapter we built on this by introducing the concept of ambiguity. Ambiguity, defined as the lack of shared meaning is prominently visible in LIPs when conflicts of interest arise between stakeholders. This deviates slightly from the literature on ambiguity which puts less stress on conflicts of interest between stakeholders. Within LIPs we see that stakeholders tend to interpret reality in line with their own interests, especially when the stakes are high.

Not only do the interests and preferences of actors diverge, our analysis has also shown that they change. The changing interests and preferences of stakeholders cause the stakeholder system to evolve over time. From our case studies we have shown examples of how interests and preferences of stakeholders can evolve over time.

Within LIPs we postulate that the three related sub-systems within LIPs are both complex and complicated: This is illustrated in figure 5.6.

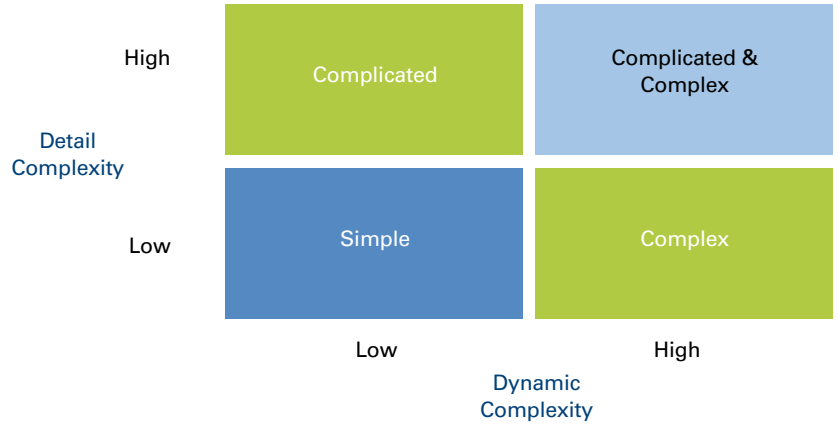


Figure 5.6: Complexity in LIPs

Figure 5.6 provides us with a basis for project managers within LIPs to understand complexity and its management. We will use this basis to distinguish management strategies in the next sections.

3 Shifts in stakeholders' preferences are triggered by dissatisfaction

The changing preferences of stakeholders are driven by dissatisfaction. These changing preferences can originate from both external factors and internal developments. External factors can be external events or independent changes in context such as policy changes or socio-economical changes. The importance of external factors shows that many factors outside the project manager's control influence the outcome of decisions and processes. Internally, developments are mainly the result of the evaluation of the effects of past decisions.

4 The dynamically complex stakeholder system drives changes in LIPs

Changes in LIPs can be described in terms of a shift in system state. An actor starts actions to change the system state to fit his interests in a better way. This is the core of complexity in LIPs. As a result of the interaction with other stakeholders, a new equilibrium could be formed as the result of a series of change events. This new equilibrium, or system state, is defined by a new stakeholder constellation, often accompanied by a changed product system and activity system. So changes in the stakeholder system lead to actions that may lead to changes in product and activity systems. This means that the three sub-systems in LIPs are dynamically connected.

Stakeholders, when sufficiently motivated by dissatisfaction, try to exert their influence to achieve the best possible fit between the object system and their preferences. This is visualised in figure 5.7.

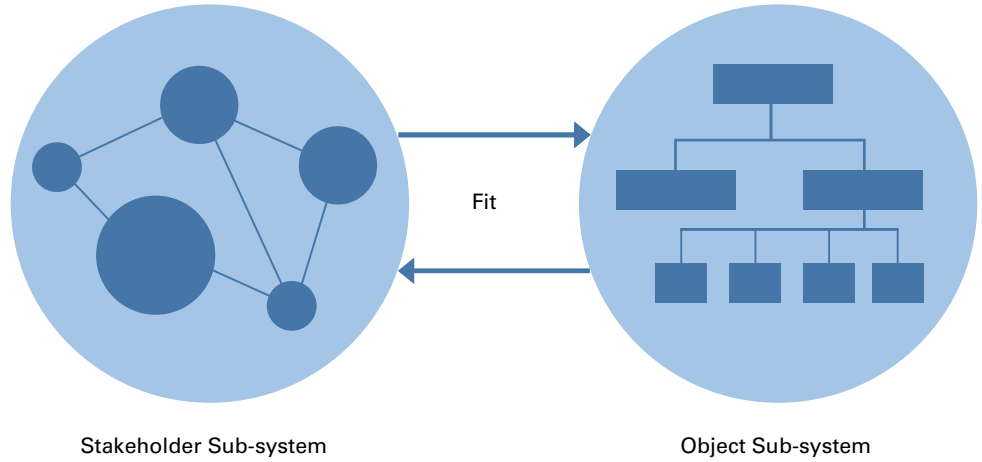


Figure 5.7: The stakeholder sub-system and the object sub-system within LIPs

The system is complex because it is has multiple structural elements – the stakeholders – that interact and change behaviour and preferences as the project progresses. As stated earlier, these changes in behaviour result from both evaluation of past decisions and changes in preferences that occur because of change events outside the control of the project manager. This brings us to our overall statement on complexity in LIPs:

> *Key elements of LIPs are both complicated and complex. Complexity within LIPs is mainly social which means it is strongly related to the dynamics of the stakeholder system: the changing preferences and behaviour of the stakeholders involved. Key in this social complexity is the dynamic balance between the interests of stakeholders and the new infrastructure facility which is being implemented. Decisions within LIPs are often made under uncertain circumstances which are related to new insights based on the evaluation of past decisions and external change events that change the preferences of stakeholders. A change in preferences may result in a change in stakeholder behaviour to better safeguard their interest in the project. Changed behaviour of one stakeholder can in turn trigger responses from other stakeholders and eventually lead to a new system balance. These dynamics make that stakeholder system, product system and activity system evolve over time in a non linear fashion.*

5 Decision making in uncertainty

Dynamic complexity means that decision makers within LIPs have to decide under circumstances of 'limited understanding and predictability'. These decision makers have to deal with uncertainty. Because of this uncertainty the outcome of decisions

and actions can be impossible to predict. We also note that uncertainty relates to the stakeholder network, the desired end product and the process of implementation. During the deployment of LIPs we gain more knowledge on both the desired end product and the implementation process. These new insights can trigger changes. For example we can discover that a new technology delivers the promised results but that it has also other unforeseen benefits. Or we can discover that a previously developed contracting model is no longer appropriate. Decision makers are hampered not only by a 'lack of information' but by their own 'bounded rationality'. Uncertainty in decision making is also connected to the fact that minor factors, coincidences and the initial conditions (historical path dependency) can greatly impact the final outcome. These are the uncertain conditions, which were often observed in LIPs, that mean that decision makers have to decide without knowing the final infrastructure product or knowing the exact route to final implementation.

6 The practitioners' perception and scientific perception on complexity both offer useful but different insights regarding complexity in LIPs

In this thesis we presented two complementary views on complexity in LIPs. The first is the practitioners' view with the six elements (chapter 4), which is directly linked to elements of LIPs that determine the complexity for a project manager. The practitioners' view shows managers which elements require management attention, e.g. unproven technology and / or conflicts of interest. Such elements also enable us to undertake a 'complexity scan' of LIPs. In such a scan, the main elements of complexity for a project manager can be identified for a unique project. The second view is the scientific approach of detail and dynamic complexity which we outlined in this chapter. The distinction between these views is an anchor to the selection of appropriate management strategies for dealing with this complexity. An overview of the two complementary views on complexity in LIPs, is given in figure 5.8.

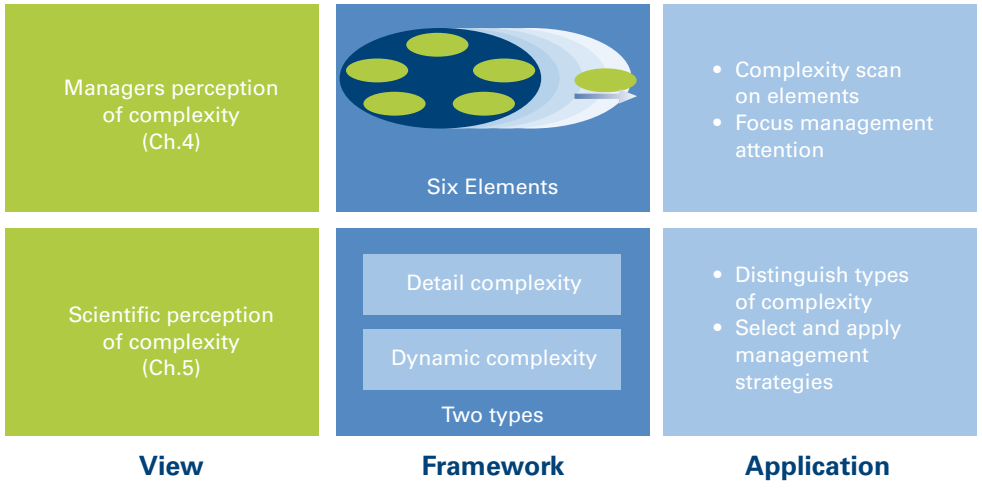


Figure 5.8: Two complementary views on complexity in LIPs

5.6 MANAGEMENT IMPLICATIONS OF COMPLEXITY

In this and previous chapters we argued that LIPs are complex undertakings. First we presented a practitioner's framework on complexity (chapter 4) and later we introduced a conceptual (or scientific) framework of complexity in LIPs which was built on both theory and practice (chapter 5). In the previous section we formulated our synthesis on complexity in LIPs. But what does the appearance of complexity mean for managers? It is time to shift our attention to the management side of this observed complexity.

From our conclusions on complexity in LIPs from both the practitioners' and scientific perceptions we have developed a set of basic requirements for management strategies in order to be able to manage this complexity. In general the question we answer in this section is:

> *Which management requirements originate from the observed complexity in the implementation of LIPs?*

In the previous chapter we outlined the core of complexity based on the following characteristics:

1 Detail complexity: many components with a high degree of interrelatedness:
   - In the stakeholder network
   - In the product
   - In the activities
2 Dynamic complexity:
   - The potential to evolve over time: self organisation and co-evolution.
   - Limited understanding and predictability.

How do the involved stakeholders handle this complexity? Based on the characteristics of complexity we can outline the demands for management approaches in order to deal with it. For both detail and dynamic elements there is a need for appropriate management strategies. These are based on:

1	Detail complexity	Need for control
2	Dynamic complexity	Need for interaction

1 the need for control

Detail complexity is visible in the stakeholder network, infrastructure product to be delivered and the activities to be able to deliver this product. Sheer volume of activities and the large number of relationships means that we cannot rely solely on our own overview to make arrangements: a more structured approach is needed to coordinate our efforts. In order to manage these large numbers we need to split

up tasks and monitor progress closely. If this were not done we would quickly loose our grip on the project to be delivered. We will refer to this need, originating mainly from detail complexity, as 'the need for control'. Although many other phrases (like planning, designing, monitoring etc.) come close to describing this requirement, we felt the word 'control' best covered the required management approach. The term was chosen after discussions with practitioners and scientists.

2 the need for interaction

An important finding on complexity with significant implications for the management of LIPs is the importance of factors outside the control of project managers. As noted in this chapter and the one previous, possible factors include political changes, policy changes, economic changes, incidents and accidents. These factors influence whether or not the project manager within a project delivery organisation can achieve the stated objectives of the project and fulfil his own assignments.

It is interesting to note that projects experience dependencies on the 'outside world'. The projects cannot be observed outside their context, because the context has an important continuous influence on the implementation process of LIPs.
In other words: projects are not closed systems as we already demonstrated in section 3.6.

> *LIPs have a non-linear implementation process, where the context has an important influence on the realisation process of LIPs.*

In the words of Professor Harry Dimitriou of University College London:

> *"The context is part of the problem."*

Often project managers are assigned to deliver projects within the constraints of budget, schedule and quality (scope). The application of these strict constraints in judging project management performance however does not fit well with the conclusion that many factors outside the project manager's control can influence project results. How can someone be accountable for something that is, at least partly, out of one's control? This brings us to the following conclusion:

> *The influence on project results of factors outside the control of project managers, causes friction with the traditional measurement of project manager's performance in terms of budget, schedule and quality.*

A second implication of the impact of external influences, is that project managers need to respond to these externalities. Since these influence project performance, project managers need to be aware of the impact of change events and respond to safeguard the accomplishment of project objectives:

> *Project managers need to cope with external influences to safeguard the accomplishment of project objectives.*

Another important implication of the management of complexity is related to the uncertain conditions for decision making in LIPs noted earlier in this chapter. Project managers, when dealing with complexity in LIPs, need to be aware of this uncertain condition and their own bounded rationality. It means that decisions can have a different impact in the short run then in the long run which making evaluation necessary to assess the impact of past decisions in considering future actions.

> *Complexity in LIPs means that decisions of project managers can have different consequences from those intended. As a result, evaluation of alternatives can be a fruitful strategy, in addition to adapting competences to changing conditions.*

Control strategies have assumed that the project evolves in linear fashion from a fixed problem towards a clear goal. The project is executed by applying control in terms of 'work break down' and tight management of schedule, costs, quality and risks in a stable environment. However in the previous chapter we demonstrated, amongst other things, that many of the factors influencing the outcomes of LIPs fall outside the control of project managers. In addition the dynamic development of the stakeholder network means that strategies of control are needed, but are not sufficient to tackle all types of complexity observed in LIPs. We can identify a second need in the management of complexity, especially to deal with the impact of external influences and uncertainty in decision making. We will label this need: the need for interaction.

So we have a need for control – based on detail complexity – and a need for interaction – based on dynamic complexity. We will now look how these needs can be combined with suitable management approaches.

5.7 MANAGEMENT APPROACHES

Given the needs for management strategies are now clearer, the next question we address is: 'How can managers responsible for the implementation of LIPs manage the complexity inherent in these projects?' In our answer on this question, we introduce a framework of management approaches that can be used to deal with complexity. This framework, based on the need for both control and interaction, distinguishes 4 types of management approaches in LIPs (with reference to the chapter where the strategies are detailed):

1 Internal & Content focused approach (Chapter 6)
2 Systems management (Chapter 7) strategies focussing on control
3 Interactive management (Chapter 8) strategies focussing on interaction
4 Dynamic management (Chapter 9,10) balancing control and interaction

These four approaches are described in detail from both a theoretical and empirical viewpoint in chapters 6 to 10. In each of these chapters we describe the strategies used and their effectiveness – we also provide conclusions on the application of these strategies in practice. In this section we introduce a general framework and demonstrate how the four approaches are linked to detail and dynamic complexity.

Based on the distinction of systems management and interactive management we now have the building blocks to fit management strategies to detail and dynamic complexity. The four approaches are graphically presented in figure 5.9.

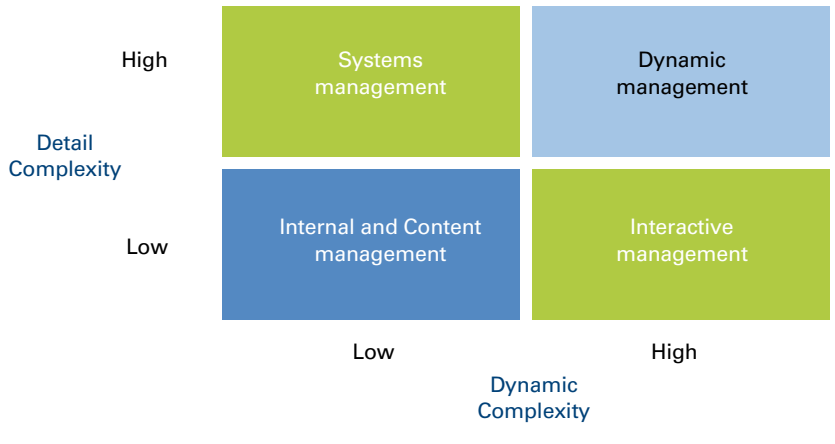


Figure 5.9: Four approaches on the management of complexity

The distinction into four separate management approaches results from a merger between theory and practice, based on our case findings.

1 Internal and content focused approach

In our case analysis it quickly became clear that there was a frequently used approach which was not a part of our theoretical framework. We labelled this 'the internal and content focused approach' because it involves a lack of clear management strategies but relies on a pure focus in finding a technical solution to a perceived problem without paying too much attention to strategies of control and interaction. The approach is highly internal: the satisfaction of involved stakeholders is not regarded a major concern.
Our findings on the internal and content focused approach are described in chapter 6.

As we saw, the Betuweroute in the first years of the 1990s was 'a showcase' of this internal and content focused approach. In The Netherlands in the mid 1990's projects, especially the Betuweroute, but also in its slipstream some others, stimulated a conviction that a new approach was needed that would pay more attention to the needs of local inhabitants, (local) governments, private companies and interest groups (NGO's). This led to the development of the theory of 'interactive management'.

2 Systems management

The second approach observed, is that of systems management. Here strategies are focused on control. In many of our observed cases strategies of break down and control were successfully used. These strategies were found especially successful in the management of detail complexity: many components with a high degree of interrelatedness. Strategies of control originate from the field of systems management – which in turn can be linked to the field of organisational design – and are outlined in chapter 7.

Systems management can be classified as an approach based on a 'deterministic' perspective as described earlier in this chapter. Project control is basically tight monitoring and steering of costs, time and scope. This is intended to make sure the project will be delivered according to the set specifications and within the set boundaries of costs and time. Tools and techniques have been developed to structure the collection of information to as to minimise the chances of unpleasant surprises.

These control strategies have proved to be less suitable in dealing with dynamic complexity, especially of dynamic development of the stakeholder system in LIPs, but this is where our third approach, 'interactive management' comes into play.

3 Interactive management

Interactive management as an approach, was originally developed as an alternative or supplement to systems management. Traditional systems management strategies turned out to be insufficient to deal with the dynamics of (mainly local) stakeholders, often found in LIPs. Interactive management in essence focuses on interests of all stakeholders so as to improve their support of the project. But interactive management goes further than creating support for a decision that already has been made: it also covers joint initiative, co-production and co-financing.

The strategies of interactive management have an external focus – looking at stakeholder satisfaction – and also focus on the flexibility required to deal with the many changes within LIPs. This makes these strategies better able to deal with dynamic complexity. Interactive management addresses the social complexity which characterises the stakeholder network and the dynamic development of stakeholder preferences over time. The theory of interactive management which we used originates from the scientific fields of 'proces management' in The Netherlands and complexity management.

Based on the analysis of the available Dutch theory of 'proces management', two interesting strategies are available to help managers deal with complexity in LIPs: redefinition of the problem and the alignment of relevant players. The shared interpretation of information by stakeholders is important. Complexity management looks at how to deal with existing complexity in an effective manner. Literature on complexity is theoretical and recent, however interesting strategies which can be used in practice include: using short term predictability and applying variation. The strategies and findings of interactive management are described in chapter 8.

4 Dynamic management

Our fourth and final approach is called 'dynamic management'. This approach is based on a synthesis of our findings in the successful management of complexity. It is our answer to the question: 'How to manage complexity in LIPs'.

Dynamic management is based on:

1 Balancing control and interaction
2 Doing the extraordinary

1 Balancing control and interaction

Balancing means that there needs to be a fit between the strategies and structure of the project delivery organisation and the context of the project. This involves deploying an effective combination of strategies of control and interaction. Sometime more routine structures have a better chance of success and in other situations an organisation with a greater degree of freedom is more suitable. LIPs show both the characteristics of high detail and high dynamic complexity. This means that strategies of control and interaction need to be balanced in order to be successful (figure 5.10).

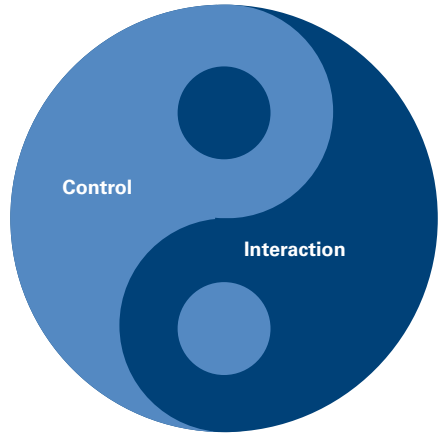


Figure 5.10: Balancing control and interaction

The strategies of control and interaction do not always mix well. Building in a new round of interaction might cause serious conflict with your project's time schedule. Based on the strategies derived from systems management and from interactive management we have developed an overview of dynamic management strategies which originate from control and interaction. This overview contains both the strategies from systems management and from interactive management (table 5.8).

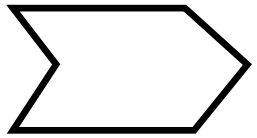
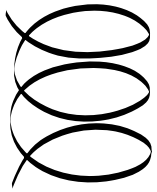
Strategy	Control	Interaction
Illustration		
		
Basis		
Fit for	Detail complexity	Dynamic complexity
Problems are	Unambiguous, fixed and independent of stakeholders	Ambiguous, changing, determined by stakeholders
Problem solving	Linear	Iterative
Theoretical basis	Organisational design Systems management	Interactive management Complexity management
Management strategies		
	1 Break down in terms of • in time • in end product • organisation	1 Alignment
		2 Redefinition of the problem and change of scope
	2 Management processes • schedule • costs • quality • risks	3 Using short term predictability • systematic evaluation • selection of successful strategies
		4 Variation • in strategies • scenario building & pattern analysis

Table 5.8: Strategies of control and interaction

De Bruijn et. al. concluded in 2004 that control and interaction are complementary (De Bruijn, Hertogh, Kastelein, 2005). Both are needed. The challenge is to balance both approaches: when do you use elements of the one and when of the other? How do you switch? See text box 5.7.

Case Hilversum: From control towards interaction

In the medium-sized city of Hilversum, The Netherlands, the traffic situation was a big problem. In 2005, the project organisation of the city developed a solution for these problems and started 'consultation evenings' with stakeholders to promote their developed solution. During these evenings interaction took place between members of the project organisation and inhabitants of the city. Through the discussions that took place, the members of the project organisation got a better grip on the problem and moreover the inhabitants gave suggestions to improve the solution. What started with a promotion of the plans of the city, resulted in an improved plan with more support from inhabitants than the original solution, because of the use of 'local intelligence'.

Text box 5.7: Case Hilversum

2 Doing the extraordinary

So one key to the successful management in LIPs is clearly the effective combination of the strategies of control and of interaction. But is that all there is? When looking at our case material we found that the answer to this question is clearly in the negative. In order to be truly successful in the management of complexity we need, what we refer to as, 'extraordinary efforts'. This is the second element of our dynamic management approach which we present in chapter 10.

These extraordinary efforts can be at the following levels:

a Stakeholders system – achieving a higher degree of co-operation
b Level of the 'actor' or 'player' – going the extra mile, the project delivery organisation working as project champion
c Personal level – competent people making a difference

Apart from working at these levels we also need:

d extraordinary new management solutions
e participants in LIPs to recognise and use momentum in projects. They need to use the apparent windows of opportunity that occur within the lifespan of LIPs. Many times events perceived as threats may lead to 'golden opportunities'.

But now we turn to the management of complexity in our studied cases. What lessons and recommendations can be formulated? This is addressed in the next chapters in which we describe our four management strategies into more detail.

6 INTERNAL AND CONTENT FOCUSED APPROACH

6.1 INTRODUCTION

In the previous chapter we presented an overview of four management approaches to the management of complexity in the implementation process of LIPs. In the following chapters we start with outlining each of these four approaches in more detail, beginning in this chapter with the 'internal and content focused' approach.

At the start of our research we distinguished several management approaches. After our analysis we have divided these into strategies of control (systems management) and strategies of interaction (interactive management). But in many cases we observed an approach which was clearly not present in our theoretical framework at that time: the internal and content focused approach.

In our overall scheme we classified this as an approach fitting contexts with both low detail and low dynamic complexity - i.e. situations which are neither complex nor complicated. This might seem strange because our research is especially aimed at situations with high complexity. This should as a result mean that this internal and content focused approach would be less suited for the specific situations we have studied. But while this argument is supported by our findings, it is surprising how often the internal and content focused approach is used in situations of both high detail and dynamic complexity – often with devastating impact since the capabilities of the internal and content focused approach to deal with complexity are highly limited.

In many of our sub-cases we noticed a basic reflex in tackling complex matters in a project by zooming in on the technical issues (sometimes financial issues) without using the strategies of systems management and interactive management at all. The key element of the internal and content focused approach is a unique focus on the technical (or financial) solution for the issue at hand – interaction with the involved parties or project control is to all intents and purposes largely disregarded.

To underline its importance we established that the internal and content focused approach was found more often than both the strategies of control and of interaction! The internal and content focused approach is an often used strategy in the management of complexity within LIPs which makes it hard to neglect, even when it

does not involve the use of management strategies as were drawn from theory. This key observation therefore posed new questions for investigation. After review of the sub-cases, several conclusions can be drawn on the nature, origin and consequences of the internal and content focused approach.

We continue by outlining the basis of the internal and content focused approach (6.2). In the remainder of this chapter we will use the phrase 'content focused approach' without adding internal. We will also provide an interesting example of how the content focused approach was used in the TTI case of the Betuweroute (6.3) after which we sum up our main findings and conclusions on this approach (6.4). We close out the chapter with a summary and conclusions (6.5)

6.2 THE CONTENT FOCUSED APPROACH

We will illustrate the content focused approach by figure 6.1 (Hertogh, 1997).

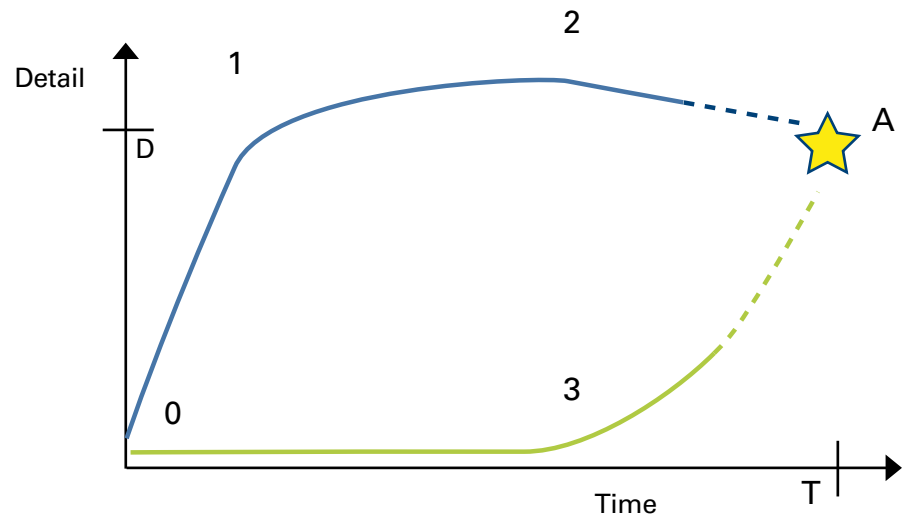


Figure 6.1: The content focused approach

The horizontal axis shows the time, the vertical axis the level of detail. The upper (blue) line represents the specialists, the lower (green) line the client.

At the start of the project the client asks a team of specialists to develop a plan with detail D by time T. The specialists work enthusiastically and sincerely, usually organised in separate disciplines, and soon they develop a basic design (1). When the client asks the specialists how things are going, the specialists may answer that they

are progressing, but that the plans need to be worked out in detail and need to be balanced between disciplines. As a result the group of specialists starts developing the plan into more detail (2), often more than is actually needed to meet the client's initial request. At this point in time they proudly present their design to the client. The client now quickly needs to catch up in the design process (3). He has to make sure that the specialists have interpreted the question in the right way and if the design matches the client's needs. Sometimes, the client will be satisfied with the design (point A is reached), but often a conflict will arise because the client is not satisfied with the chosen detailed solution, due to the fact that it does not match his needs and expectations. In that case the client will be dissatisfied. A possible explanation for this dissatisfaction results from the process, in which was no interaction between client and specialists (between point 0 and point 2).

When looking at management theory, there have been descriptions found of management strategies that at a first glance appear to be similar to the content focused approach. One approach which quickly comes to mind is the 'Muddling through' approach which was introduced by Lindblom (1959) when looking at the field of policy making. In the muddling through approach we see that the rational management principles, which we labelled the 'strategies of control', are also lacking in similar fashion to that we have described as the 'content focused approach'. However there is a major difference with the approach Lindblom describes since muddling through is an approach which is characterised by small incremental steps in progress with a strong focus on bargaining and interaction between the various involved participants. This incremental interaction is lacking at the content focused approach where the problem solvers (technicians in our example) are operating largely in isolation and later find out that their proposed solution does not meet the requirements of stakeholders involved.

The content focused approach can be illustrated by describing a programme that created opposition around 1990 in The Netherlands. The programme related to the raising of the dikes of the Rhine and Maas in the Province of Gelderland, to diminish the probability of floods. The determination of the project requirement and the design process were a closed process. Engineers worked enthusiastically with minimal interaction with local inhabitants. When the engineers presented their mono functional (safety) plans, founded on a technical point of view, people noticed that a lot of the traditional dike-houses were scheduled to be removed and that as a result the unique environmental, natural and cultural values of the Province would be adversely affected. This resulted in massive opposition (Hertogh, 1997).

Another example from 2006 was the heavy resistance that occurred in the Italian 'Val di Susa' manifest in popular protests and strikes for both ecological and economic reasons against the building of the high-speed Turin-Lyon rail connection and tunnel. The citizens doubted the benefits of the project and in addition were completely dissatisfied with the proposed solution designed to cross their valley.

We have already seen the content focused approach at work previously in this thesis. Especially in the early years of the 1990's the Betuweroute became the symbol of the content focused approach. The needs of many local parties, individuals, interest groups, environmental groups and local governments were not denied, but simply neglected. This led to heavy opposition to the Betuweroute in the later stages of the project (see section 3.1.2). We will discuss this in more detail in section 6.4.

Another illustrative example is the approach of Railtrack at the West Coast Mainline that viewed the project as purely financial (section 3.5.2, Round II). In addition the tunnel safety case of the A73-South (section 4.2) will be recalled, when the Ministry decided to eliminate hard shoulder provision without reference to the regional participants.

In 10 of our sub-cases we observed the content focused approach (table 6.1):

	Case	Sub-case
1	Betuweroute	Organising 1990-1995
2	Betuweroute	Preparation of operation
3	Betuweroute	TTI
4	Betuweroute	Gorinchem
5	A73-South	Tunnel Safety
6	A73-South	Environmental Compensation
7	Gotthard	Canton Uri
8	HSL-South	Noise screens (birds)
9	HSL-South	Bos Alternative
10	West Coast Mainline	Round 2, Railtrack

Table 6.1: Sub-cases in which the content focused approach was observed and analysed

The basic example we will use for our analysis and conclusions is the Betuweroute Tunnel Technical Installations (TTI) case. We first introduce the sub-case in section 6.3 and then present our key findings on the content focused approach in section 6.4. Also in 6.4 we will present two more examples from our sub-cases: the preparation for Betuweroute operation and the Canton Uri / Gotthard case.

6.3 TTI AT THE BETUWEROUTE

Complexity at TTI

As we argued in chapter 5: social complexity is dominant within LIPs. In addition social complexity is fuelled by other types of complexity. This is also the case with the TTI example. At the start of the Betuweroute the issue of tunnel technical installations was relatively new. At that time there was neither applicable legislation nor standards (legal complexity). The technology on TTI was still largely unproven and in an early stage. The level of safety that could be obtained with specific solutions was very uncertain. Another element of complexity was that choices made on TTI solutions had a direct impact on the structural works of the tunnel elements that were part of a separate design stage. Thus TTI technology can be classified as 'tight coupled' thereby increasing the complexity (see section 4.3). Because of the uncertain technology, the costs of TTI were very hard to estimate – which can be typified 'financial complexity'.

Apart from this there were important emergent events - the tunnel disasters in Kaprun and the Mont Blanc tunnel - which heavily affected tunnel safety discussions.

The aforementioned complexities (legal, technical, financial and emergent events) fuel social complexity. Stakeholders involved include the fire brigades, the Betuweroute project delivery organisation within ProRail (POBR), the Ministry of Transport and communities along the line. Communities and the fire brigades had as their basic interest the maximum protection of citizens. The Ministry and project delivery organisation on the other hand, also had an interest in keeping the costs within budget and in reaching a timely solution. During the various phases of the discussion these interests often conflicted. One of the main topics in the discussion was whether a deterministic or probabilistic approach should be used (similar to the TTI case at the A73-South, section 4.2). The communities and fire brigades wanted to apply a deterministic approach in which the worst possible event – a burning cargo wagon filled with fuel – was the reference point for the safety measures to be taken. The Ministry and POBR argued for a probabilistic approach in which measures were based on the probability of occurrence of the several possible safety incidents and their effect.

To summarise things an overview of the complexity found in the TTI case is given in figure 6.2.

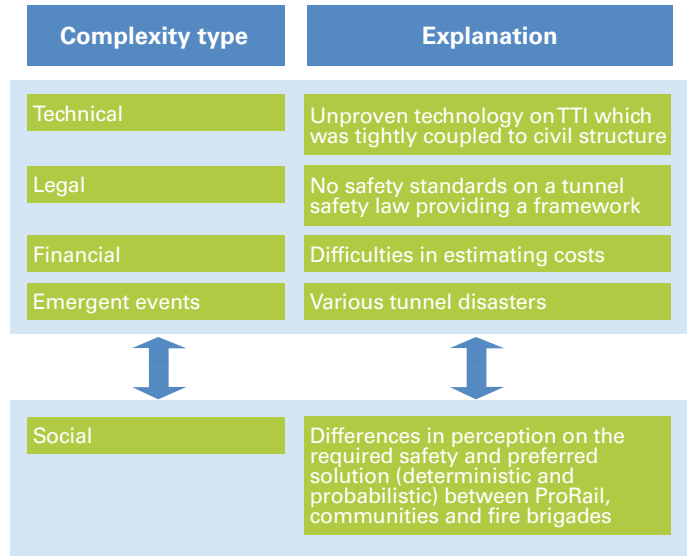


Figure 6.2: Complexity at TTI at the Betuweroute

We now describe how the complexity shown in figure 6.2 was handled by the project delivery organisation and the other involved stakeholders.

Management of TTI

The Betuweroute Project Delivery Organisation (POBR) within ProRail handled the apparent complexity in the first phase (1995-1999) by installing a separate project team of specialists which was responsible for developing a first set of TTI specifications. At that point it was unclear where this project team should be placed in the project delivery organisation. Finally it was decided to make the specialists report to the manager responsible for the substructure of the tunnels.

The responsible project manager within the project delivery organisation commented:

> *"It was difficult to see where TTI should be placed within the project organisation. It was neither part of the substructure (civil part) nor part of the superstructure (rails and electricity)."*

The TTI project team comprised two consultants hired from a firm specialising in the field of TTI who operated in the main outside the view of the project manager and other members of the project delivery organisation.

The specialists interacted with stakeholders such as the Ministry of Internal Affairs, communities and the fire brigades in an effort to develop a standard for tunnel safety in The Netherlands. The result was a standard which is generally referred to as the 'Green Booklet'. The Green Booklet contained a deterministic view on safety which meant that measures taken should be based on a 'worst case event'. Further the Green Booklet was characterised by a high level of detail regarding the technology which should be applied: it was not really a set of functional requirements but more a detailed specification of the preferred technical solution. The level of detail was illustrated by the fact that the application of sprinklers was regarded as mandatory to achieve the demanded safety level.

The TTI specialists used this content to guide the design of the Betuweroute TTI. After the Booklet was finished, interaction with stakeholders decreased significantly. Project control seemed to be a non factor, the focus of the specialists was more on the technical design process. The fact that cost estimates for TTI started rising was not at that stage a major reason for concern. There was a lack of management attention on TTI during this first phase. The focus of POBR seemed to be more on the design of the substructure meaning that TTI did not get sufficient management attention. Another indication that TTI was not regarded a key issue is that POBR decided to send out a letter to the communities along the line confirming that the Green Booklet was to be used as the basis building permit decisions. This formal letter turned out to have a major impact later on during the process because it mandated sprinklers for Betuweroute TTI.

A manager from within the Betuweroute project delivery organisation on this first phase for TTI:

> *"We had a general lack of project management for TTI. It was handled as a technical and scientific problem."*

In essence the first phase of the TTI application for the Betuweroute shows almost no signs of defined strategies from either systems management or interactive management. The approach is best described as content focused: finding a technical solution for the tunnel technical installations.

Premature convergence on TTI

From a research standpoint it is interesting what happened in February 2003. A discussion in parliament led to an investigation ordered by the Minister of Transport so as to cut back on Betuweroute construction costs. TTI was one of the topics that was investigated. The investigation of possible cost savings for TTI was undertaken by the Bouwdienst – the part of the Ministry of Transport responsible for building projects. The Bouwdienst proposed a much cheaper alternative using heavy ventilation instead of sprinklers. It is important to note that the Bouwdienst study used a probabilistic approach instead of the earlier deterministic approach and that it was not predicated on sprinkler technology.

The Bouwdienst claimed the same level of safety could be achieved by heavy ventilation. However the heavy ventilation alternative was never subject to detailed design. POBR did not agree with the Bouwdienst's conclusion and stated that the required safety level could not be achieved by the alternative. However the Bouwdienst and the Ministry of Transport decided to propose the heavy ventilation solution to the Minister. As mentioned earlier, the new solution did not contain the originally proposed sprinklers but was described by the Ministry as "a new interpretation of the Green Booklet's demands". The application of heavy ventilation offered a possible cost reduction of € 65 mio. In subsequent discussion however, the proposals turned out to be unacceptable to the heads of the communities because all building permits required sprinklers to be used. Also a further study, ordered by the communities and performed by a specialist firm – on the measures proposed by the Bouwdienst 'proved' that the proposed alternative did not meet agreed safety levels. The Minister of Transport concluded as a result that the 'heavy ventilation' solution was not tenable because it would result in heavy delays as the result of the new building permits that would be required. The extra time needed for this, would, in addition, lead to large cost overruns. In a House of Representatives debate, this caused difficulties. Members of the House supported the heavy ventilation alternative and urged the Minister to restart new talks with the heads of the communities. The results of these were presented by the Minister in a letter that showed that the talks with the heads of the communities had not resulted in any agreement on the application of sprinklers in the Betuweroute tunnels. The local authorities would not accept a solution based on heavy ventilation because they considered this solution as less safe.

During various discussions that followed, the Minister reminded Parliament that the preferred level of safety was defined in the 'Green Booklet' that had been agreed by all stakeholders including communities. Finally when the Minister showed that the amount of extra costs resulting from a delay would exceed the possible savings, the House of Representatives approved the necessary additional budget to install sprinkler installations. This ended discussion.

6.4 KEY FINDINGS ON THE CONTENT FOCUSED APPROACH

6.4.1 Premature Convergence

In the previously described sub-case of TTI, the content focused approach was dominant during the early stages. This was also the case at the preparations for Betuweroute operations (see text box 6.1). In both cases the content focused approach

led to what we call 'premature convergence'. This means that a solution is chosen early in the process, thereby 'killing off' the many other options present at that point in time. The difficulty lies in the fact that the chosen solution might seem logical when selected, but would cause problems later on because of the changing preferences of stakeholders. These changing preferences are caused by the introduction of new technologies but also – in this case – by the occurrence of tunnel disasters. In these situations of high dynamic complexity it is preferable to delay choosing a final solution and keeping options open longer, so as to avoid being caught 'on the wrong track'.
In all of the 10 sub-cases where we observed the content focused approach, we recognised this tendency towards premature convergence, see table 6.2. That is why we conclude:

The content focused approach leads to premature convergence of solutions.

	Case	Sub-case	Premature chosen solution
1	Betuweroute	Organising 1990-1995	Routing
2	Betuweroute	Preparation of operation	SPRI Model
3	Betuweroute	TTI	Technological solution
4	Betuweroute	Gorinchem	Tunnel
5	A73-South	Tunnel Safety	Removal of hard shoulders
6	A73-South	Environmental Compensation	Solution of West Bank
7	Gotthard	Canton Uri	Alternative with cost savings
8	HSL-South	Noise screens (birds)	Transparent noise screens
9	HSL-South	Bos Alternative	Routing from Key Planning Decision (PKB)
10	West Coast Mainline	Round 2, Railtrack	Package of financial and technological innovative solutions (e.g. moving block signalling)

Table 6.2: Premature Convergence in 10 studied sub-cases where we observed the use of the content focused approach

With the Betuweroute TTI sub-case we see a very early convergence, with the formulation of the Green Booklet. The Green Booklet not only contains a set of functional requirements for tunnel safety but also contains detailed prescriptions to apply sprinklers. The sprinkler solution was adopted during a time where very little was known on how to tackle safety within tunnel technical installations. But at the same time this green booklet, containing the premature solution, was the basis on which building permits would be granted, and the starting point for the design. This made every other possible technological solution almost impossible (or at least extremely expensive) to implement. The subsequent emergence of 'heavy ventilation' shows the effects of premature convergence: an effective discussion on the alternative of heavy ventilation is impossible because of an inability to deviate from arrangements previously made. Whether the heavy ventilation would achieve the required safety level is another matter. We can only conclude that because of very early convergence on the chosen solution, new and promising alternatives could not be considered without causing major problems for planning or for interaction with stakeholders.

Premature convergence was also observed on the case for the preparation of operations [TCI, 2004] which is described in text box 6.1.

Premature convergence on the preparation for operation of the Betuweroute
At the end of the 1980s interest in private financing of infrastructure projects was growing. Within the Ministry of Transport several initiatives were started to study possibilities for the involvement of private parties in infrastructure projects. One of these initiatives was the appointment of a steering committee ('SPRI') by minister Maij-Weggen in April 1990 to investigate the possibilities for the private funding of both the Betuweroute and the HSL South. In June 1992 the SPRI commenced preparation of operations by planning interviews with 17 different institutions. These interviews were used to test the feasibility of a pre-developed SPRI privatisation model. The conclusion of the investigation was that the model tested was not feasible. None of the possible partners offered a direct financial contribution in the construction of the track.

Partly based on the analysis of the interviews it was decided within the Ministry of Transport to separate the preparation of operations from the construction project. The SPRI model remained largely intact which meant that a government owned firm would bear the risks of the building project. Operations would be contracted by tendering a 20 year concession to market parties. Also on the basis of the interviews the SPRI gave positive advice to the Minister of Transport on the possibilities of obtaining private funding up to an amount of 1,5 bio guilders (€ 680 million) for the construction of the Betuweroute. This advice however did not mention many uncertainties surrounding the market for railway freight transport that would negatively influence the predicted financial benefits.

Because of growing concerns within the ministries involved at the expertise available within the SPRI, the bank 'Salomon Brothers' was hired to assist. In September 1993 Salomon Brothers sent a letter to the Ministry of Transport commenting on the SPRI model. The letter stated that the contribution of 1,5 bio guilders was unlikely for two reasons. Firstly there were no natural bidders in the market for this type of 20 year concession. Secondly, the forecasting of future cash flows, 5-10 years in advance, would lead to massive discounting of whatever returns a bidder expected because of the high levels of uncertainty. The solution to these problems was to treat the project as a whole – not separating construction and operations – and to define it very carefully from the start. The Ministry of Transport did not agree with Salomon's recommendations and instead decided to stick to the SPRI model developed earlier.

In the Project Key Planning Decision 3 (PKB3) published in May 1993 it was stated that it was possible to obtain private funds up to an amount of 1,5–2 bio guilders. The Minister was confident this was possible because of the conclusions in the SPRI report and the results of the interviews. In a discussion with the House the Minister even stated that the construction of the Betuweroute: "Would not start if the private funds were not secured".

During the discussion on the Key Planning Decision within the House, concerns grew within the Ministry of Finance. Civil servants wrote a letter to the Minister of Finance drawing attention to doubts raised about the Betuweroute economic return calculations. These doubts however never reached the House of Representatives.

Text box 6.1: Premature convergence on the preparation for operation at the Betuweroute

In their market consultation the SPRI showed an approach that could be typified as 'interactive management'. However the interaction in the approach was limited because market parties were presented with a fixed and pre-developed model for operations. Future users such as the Port of Rotterdam played no active role in the process of preparing for the operational phase. In addition there is no evidence that a process was set up aligning the interests of market parties and government. On the contrary: the overall lack of interest of market parties in participating was largely ignored in drawing conclusions from the consultation. Again we see the elements of a content focused approach leading to premature convergence. Remarks from the Ministry of Finance and Salomon Brothers that criticised the SPRI model were quickly dismissed. As a result of the convergence, various other potentially promising models were not discussed. This meant that a climate was created in which challenging the current solution was not encouraged.

An interesting case of ambiguity concerning project history was observed in the preparation for operations at the Betuweroute. During the early phases of the project it was calculated by SPRI (previously referred to) that the private funding of the project could reach a level of 1,5 bio guilders (€ 680 mln). This figure was based on various assumptions and was not regularly updated during the project. In the discussions between the House of Representatives and Minister however, the Minister repeatedly stressed that there was still confidence the 1,5 bio would be attained. It seems that some of the main political stakeholders had different interpretations of this figure and how it was calculated. Later reviews showed that many of the assumptions on which the 1,5 bio was founded, were outdated and far too optimistic. The case shows how important a figure can become and how great the tendency to forget about its origins - tendencies stimulated when the content focused approach is applied.

6.4.2 Factors causing the content focused approach to occur

The main factor that characterises the content focused approach is the pure focus on solutions, particularly technical, but also financial - see the Railtrack example from the WCML. The problem is seen as technological or financial and the solution can therefore be found by focussing on technology or finance. There is less attention to management in terms of putting effort into understanding interest of stakeholders and building a relationship. The basis of belief is that there is one perfect solution.

The main factor that causes the content focused approach to occur is that the responsible organisation treats the project as a technological or financial challenge whilst paying minimal attention to the interests of stakeholders or project control.

An example is the Betuweroute TTI sub-case. But this is also perfectly illustrated by the way the Betuweroute team interacted with local stakeholders during the first stage of the project. We have described this in section 3.1.2 in round 1. The content focused approach applied by the Ministry of Transport and the Dutch Railways (NS) was not only observed in the interaction with local stakeholders but also in the sub-case management of scope and cost developments. It could also be found in the development of the relationship with client and parent organisation as well in the preparation of operations as previously described. So in all these four sub-cases we found that the overall management of the first years of the Betuweroute can be seen as content focused. To investigate the consequences of this content focused approach, we will take the first phase of the Betuweroute as the prime example to show that the content focused approach is of very limited effect in the management of complexity.

In the first phase of the Betuweroute (Boom, 1997) and [TCI, 2004] the spatial planning procedures were started swiftly and, in the communication towards local stakeholders, the Dutch Railways (NS) showed little doubt that the project would be realised and who was in charge of the project. The intention was for the project

delivery organisation to give information to local stakeholders rather than in opening a discussion with them. At information meetings in 1991, the NS showed those attending a movie on the benefits of the Betuweroute for Dutch society in general and Rotterdam harbour in particular. The attendees however simply came to hear what the consequences would be for their individual situation. New laws such as the Route Decision Law ('Tracéwet') and Nimby-law are mentioned as arguments to show local stakeholders that resistance will be fruitless.

An interesting observation during the first stage of the project is the lack of visibility of the Ministry of Transport. The Ministry participated in a steering committee for the Betuweroute but the committee is dominated by NS. When Minister Maij-Weggen received heavy negative responses from the Gelderland region as to the way the project had been presented, she finally decided to take a more active role in the communication process. This more active role did not mean a different approach however: the way of working was still to inform local stakeholders on progress and not to discuss possible alternatives. Also the damage was largely already done: the initial approach had created intense opposition.

The content focused approach caused heavy opposition and political turmoil, partially because of the contents of the project – the obvious and mostly inevitable inconvenience to those affected – but also because of the attitude of the NS and Ministry. The content focused approach greatly influenced the attitude of local stakeholders.

The Betuweroute project became more and more expensive during the planning phase. The estimated costs for realizing the project rose from € 2.335 mio in 1992 to € 3.744 mio. in 1995 – mainly due to scope changes to meet the demands of local stakeholders. In addition cost estimates rose because of new insights into design and flaws in project control. The audit office ('Rekenkamer') later stated that the project control and management of the Betuweroute contained various flaws, both in terms of scope and in cost control and reporting. It is probable that an approach in which both project control and interaction were more important, could have produced better results.

Based on these arguments it is plausible to argue that the content focused approach observed has led to cost increases and heavy opposition from stakeholders. The comments received from people working in the project delivery organisation and those involved as local stakeholders support the view that the Betuweroute has become unnecessarily expensive - due in part to the content focused approach which was applied.

"… if the Minister had talked to us earlier and had taken us more seriously, especially in the beginning, she would have been able to arrange a deal much more easily. This could for example have meant that maybe no tunnel would have been built underneath the Pannerdensch Kanaal."
Deputy, Province of Gelderland.

6.4.3 Content focused approach in respect to complexity

As already demonstrated in the previous sections, the content focused approach has a very limited capacity to deal with complexity. Let us look again at our perceptions of complexity (presented in chapter 4 and 5). The practitioners' view mentions six complexities: technical, social, financial, legal, organisational and time. The content focused approach simplifies the complexity to technical (or financial) challenges. The crucial element of social complexity is not just seen as not being relevant, but is simply ignored, because the project delivery organisation is not aware of its importance. The focus is on reducing the detail complexity by concentrating on collecting information concerning the content and the planning of the design and the financial structures. What interaction there is focuses on giving information to 'perceived' stakeholders, in respect of those issues that are relevant to the project delivery organisation and not to the real interests and needs of these stakeholders. The content focused approach is perhaps suitable for situations with a low amount of both detail and dynamic complexity, but when complexity on both these dimensions is high, such as in our sub-cases, the content focused approach has some serious limitations.

Within the content focused approach the deterministic perspective is dominant, the project delivery organisation acts like the world is 'knowable, controllable, predictable and manageable'. Coincidences or minor factors are not important for the project success, nor is adaptability. Therefore organisations using this content focused approach do not open their eyes to other views on problems and challenges, for 'enrichment' of solutions and for new collaborations with stakeholders. In terms of complexity management it can be classified as a limited approach.

The content focused approach ignores higher levels of complexity. In terms of complexity management it is a limited approach.

6.4.4 Factors that stimulate the content focused approach

Factors that we have observed in the sub-cases (mentioned in table 6.1) that proved to be a stimulus for the content focused approach are:

- Lack of attention, due to the fact that the management lacks specific topic knowledge, as was the case with the Betuweroute TTI.
- Low priority, as we saw in the sub-case of preparation for operation of Betuweroute.
- Experts in the role of project manager with an underlying focus on content.
- Financial tensions and 'imperatives', e.g. budget or cost overruns, may lead to decisions unpopular with (main) stakeholders, without (sufficient) interaction with them.
- Organisations that are unfamiliar with each other's characteristics, causing decisions to be made without sufficient attention being paid to the relatively unknown interests of the other organisations.
- A limited internally focused group is in charge leading to 'groupthink'.

We conclude:

> *Factors that can be a stimulus for the content focused approach are: lack of management attention; specialist managers; financial tensions; organisations that are unfamiliar with each other; and a project team showing 'groupthink'.*

In the case of the Betuweroute TTI we noticed that the approach was used in a context where there was a lack of attention from the higher level project managers. This lack of attention is connected to inappropriate emphasis. During the first phase of the project, the management of the project delivery organisation was more concerned with the substructure. The organisation was dominated by managers and members with a background in civil engineering. This lack of basic specialist knowledge makes judgement of specialist decision making more difficult. A similar argument can be made for the preparation for the operational phase. Within the Ministry there was hardly any relevant experience of this topic and it was not seen as a key issue by its top management.

The new and complex technology of TTI meant that specific experts were hired to manage this sub-project. While these experts are needed to handle the technical complexity, at the same time their actions are difficult to judge and they have a tendency to focus on a specific technical solution. The use of experts was also observed in the sub-case on the preparation of the operational phase for the Betuweroute (one of the cases from the theme 'Finance and Scope'). In this sub-case many external experts were hired to develop an organisational model for the phase. The work on this model was largely done without consulting market parties and other relevant stakeholders.

Another interesting example is the case of Canton Uri at the Gotthard (text box 6.2). Here we noticed that budget restrictions or apparent cost savings, triggered the content focused approach.

Canton Uri

At the start of the sub-case, Canton Uri worked with the Swiss railway company (SBB), to develop a mutually agreed solution to enable rail track to cross the valley. Both organisations accepted this joint approach. Later in 1994 this joint solution was unilaterally abandoned by SBB, primarily because of the need for cost savings, and a new solution was presented by them. This alternative was not acceptable to the citizens of Uri and the Canton and resulted in fierce discussions.

The original joint solution was based on crossing the valley in the open but making several adjustments to meet the demands of local inhabitants. These adjustments included a tunnel and lowering of the track. All adjustments were later abandoned by the project delivery organisation because these were regarded too expensive. As a result the inhabitants of the valley started their protest and advocated a solution that would put the track in tunnel, inside the mountain, instead of being predominantly in the open.

Text box 6.2: Canton Uri

Groupthink (Janis, 1982) occurs when a limited, often coherent, internal focused group is responsible for managing an issue. The group can work sincerely and with dedication. The outcome is often a process that converges on one direction (content), without sufficient interaction (Hertogh, 1997). In the preparation for operations of the Betuweroute we observe that a solution was chosen quickly and subsequently defended notwithstanding new information showing it was unlikely to succeed. Apparently the first solution formulated, played a dominant role in the development of the process over time and the team were incapable of taking another perspective and changing their attitude.

We saw a similar example at the HSL-South when the 'Bos alternative' was first discussed (section 3.3.2, round 4 and 5). This alternative contained many interesting insights on the possible routing of the HSL-South. In addition the developed alternative met the demands of some stakeholders in a better way than the Ministry of Transport's preferred alternative. However the Ministry was initially incapable or unwilling to treat the alternative seriously.

6.4.5 Results of the content focused approach

The case of the Betuweroute shows the negative impact the content focused approach can have on a project. Similar evidence can be found at the TTI sub-cases of both the Betuweroute and A73-South. Partly because of premature convergence in the choice of solutions, both sub-cases show unsatisfactory outcomes from the application of a content focused approach.

The example of TTI at the Betuweroute is further illustrated in text box 6.3.

Results of the content based approach: TTI at the Betuweroute
With the TTI cases for the Betuweroute the cost estimates start rising dramatically with the design based on the specifications in the green booklet. A scope and budget change is proposed to deal with the extra TTI costs. After discussions, when this change has been approved , the POBR then decides to tender the TTI control and telecom system. The outcome of the tender process is that the bids are 3 to 4 times higher than estimated – causing panic within both the POBR and the Ministry. The tender process is abandoned. Looking back, the content focused strategy led to uncontrollable increases in cost estimates and a delay in the planning of the project because of the failed tender. The approach has caused major dissatisfaction to the Ministry of Transport as well as the POBR and involved fire brigades and communities.

Text box 6.3: Results of the content based approach: TTI at the Betuweroute

The TTI sub-case at the A73-South (introduced in section 4.2) shows some additional evidence of negative results. The A73 contains tunnels at Swalmen (1,0 kilometre) and at Roermond (2,45 kilometres). The second is currently the longest land tunnel in The Netherlands. The tunnels have two lanes in each direction. The example is illustrated in text box 6.4.

Results of the content based approach: TTI at the A73-South
In the initial design (1995), both tunnels of the Highway A73-South were planned to have hard shoulders which was approved in the Environmental Impact Analysis. In 2003 the central office of the Ministry of Transport, Public Works and Water Management suddenly decided to remove the hard shoulders in the tunnels. Analysis of the Ministry's intervention shows signs of a content focused approach. The Ministry decided to remove the hard shoulders, without consultation with the region. Another sign of a content focused approach is the quick convergence to a solution: the removal of the hard shoulders. The decision proved to be an unpleasant surprise to the region. There was no prior consultation beforehand and the decision was not communicated directly to all those involved in the region. The fact that the decision came at a moment where the Ministry needed to save money added further to the level of dissatisfaction. The behaviour was seen as "rigid and arrogant", as mentioned several times in our interviews. RWS Limburg and the regional politicians stressed that more interaction was needed, especially because of the politically sensitive subject 'safety'.

Text box 6.4: Results of the content based approach: TTI at the A73-South

The approach used at the A73-South is contrary to basic recommendations of interactive management, and from this point of view the result could be predicted: commotion in the region and intense annoyance. That this occurred is surprising, because a better way of acting seems obvious - the Ministry could have 'used' RWS Limburg (because of their good working relationship with the regional partners) to discuss with them the background to this decision and how best to interact with the region. Of particular sensitivity was the need for cost reductions and the fact that the decision meant a change to the previously settled 1999 political agreement with regional partners. Apparently, in this case the Ministry focused on their own financial problems and 'converged' too quickly into a specific solution.

To close this analysis of the consequences of the content focused approach at the A73-South we consider the remark of a director of RWS, not directly involved in the process for the A73, in summer 2006. Looking back he judged the removal of the hard shoulders in 2003 as "a limiting consideration". Tunnels are often designed too narrow and he argued that with the removal of the hard shoulders, the future possibility of installing an extra (third) lane, was cut off making the facility less 'sustainable'. He mentioned that for the Heinenoordtunnel near Rotterdam hard shoulders provided the capacity for an extra lane. And what was the financial effect of the decision? Approximately zero, because the cost savings to remove the hard shoulders had been roughly the same as needed for the extra costs of the system of water-mist, thereby necessitated (conclusion from financial data October 2006).

In our study of management of complexity, we asked respondents to identify the 'important critical events' or 'important themes' in their projects. Most of the respondents mention two or three of these events, so, apparently, only the serious ones, which caused them severe challenges. In total we studied 14 sub-cases in detail. What surprised us is that in many sub-cases the use of the content focused approach appeared to be the initial approach used on the 'important themes' that respondents classified as 'critical'.

In 10 sub-cases we observed the content focused approach (see table 6.1). In most of the cases the client and project delivery organisation admitted that the approach was not the right one. Without exception, in these sub-cases the stakeholders were dissatisfied. From our analysis, none of these sub-cases showed positive results.

> *The content focused approach can possibly be successful in situations of low complexity. It does not yield positive results in situations of high detail and dynamic complexity where it often produces dissatisfaction amongst all stakeholders.*

6.4.6 The persistence of the content focused approach and how to change it

In our sub-cases we found that the content based approach can often exist for a long period of time - it is 'persistent'. In the example of preparing the operational phase of the Betuweroute it was observed to continue for a period in excess of five years.

> *The content focused approach can last for a long time.*

This can be explained by the fact that there was often no stimulus to change this approach, no 'sense of urgency' that stimulates change. In the case of the Betuweroute TTI the strategy was changed only after the tender for the first part of the scope failed miserably. Earlier, in chapter 5, we stated that dissatisfaction drives changes in LIPs, something which is supported when we look at the subsequent change away from the content focused approach. The high bids caused panic within the project delivery organisation within ProRail and within the Ministry of Transport. The attention from the civil principal and high level project management within the project delivery organisation meant that different strategies, from the fields of interactive management and of systems management, were adopted to deal with the problems faced. At the Betuweroute it was the heavy regional resistance, that forced a change in attitude. So in line with our conclusion in chapter 5, we can state that a key stakeholder has to become sufficiently dissatisfied in order to get the content focused approach changed.

However sooner or later in all of our sub-cases the content focused approach was forced to be abandoned, in the face of disappointing results. This means that in the end, for all but non complex cases, the organisation using this approach will be forced to change - under pressure from dissatisfied stakeholders.

> *Organisations that use the content focused approach are forced to change their attitude because of increasing dissatisfaction of stakeholders. This dissatisfaction can be caused by controversy but also because of budget constraints and schedules that cannot be met.*

After the content focused approach has been changed to a different style with more focus on interaction and/or control, the attitude of stakeholders towards the civil principal and project delivery organisation can remain suspicious for a long time thereafter. The Betuweroute experienced this. Long after the attitude of the POBR project delivery organisation had changed, the management experienced distance and lack of trust in the relationship, as illustrated in the next quote.

> *"I have learned from this project not to underestimate the societal impact of such an undertaking. The support from involved stakeholders is extremely important. The Betuweroute project got off to a false start. At the HSL-South this was very different. The false start has had major consequences for our project. You should really try to avoid a project being born under such inauspicious circumstances because it means that you are constantly forced into a defensive position. If you start a project like this again, make sure there is support from stakeholders and parliament."*
> Project manager, Betuweroute.

We have already mentioned in chapter 5 'the importance of starting conditions', for instance at Canton Uri. This is especially true for the content focused approach, since it can leave its mark on the project for an extended period of time, hampering the delivery of project objectives.

> *Dissatisfaction of stakeholders towards the civil principal and project delivery organisation about the use of the content focused approach, will influence their attitude in a negative manner long after the content focused approach has been changed.*

6.4.7 Content focused approach used by stakeholders

The content focused approach was not only observed within the civil principals and project delivery organisations but also by other involved local stakeholders such as communities.

> *The content focused approach can also be applied by other stakeholders in situation of high detail and dynamic complexity with a similar low rate of success.*

The expected rate of success for local authorities is similarly low when applying the content focused approach. An interesting example of the content driven approach applied by a local stakeholder is the city of Gorinchem at the Betuweroute. Earlier we mentioned that a content focused approach was used by the Ministry and Dutch Railways in the interaction with local stakeholders during the first phase of the Betuweroute. As a result heavy resistance arose from local stakeholders in Gelderland as well as in Zuid-Holland as we will show in the Gorinchem case (text box 6.5).

The content focused approach of Gorinchem

Gorinchem is a middle sized community located in the Province of Zuid-Holland. The track of the Betuweroute runs through the community on its north side. During the first phase of the Betuweroute project there was a lot of resistance within the community because of the large negative impact the project would have. In addition the local inhabitants were highly annoyed by the directive attitude of the Dutch Railways (NS) and the Ministry of Transport. As a result the community chose to apply a conflict strategy focussing on content. For example, this meant that the community stated that a different route was more suitable which, as a result, meant that Gorinchem would not be crossed. Studies were executed and funded by the community to convince the national government that these alternatives were superior. In the meantime the community refused to talk to the project delivery organisation. The efforts of Gorinchem to get a different route approved were unsuccessful; the final decision included a track that ran through the city. After the House of Representatives decided to plan the route through Gorinchem, the community opted to keep its conflict strategy and next demanded a tunnel crossing of the river 'De Linge'. The community still refused to co-operate with the Ministry, for example by frustrating the spatial planning process. The tunnel demand however was considered to be unrealistic by the Ministry because other parts of the track were thought to pose more problems for citizens, such as – for example – in Barendrecht. The final result was that in the negotiations on mitigating measures for the Betuweroute, Gorinchem was not able to get its tunnel wish fulfilled.

Text box 6.5: Content focused approach applied in Gorinchem

In the example we see the signs of the content focused approach applied by Gorinchem developing a solution with very limited interaction with a key stakeholder – the POBR project delivery organisation – to tackle the problem. Also we see the element of premature convergence: the community puts all its efforts into changing the routing of the Betuweroute instead of developing a back up plan in case this would fail. And this is exactly what happened: the planned route through the community boundaries of Gorinchem was confirmed, which left the community with a need to review its strategy. This review did not cause many changes because in the second phase again the community chose a conflicting strategy once again with their demands for a tunnel. In the end, the community got only very limited compensation, which is partly caused by the ineffective content focused strategy.

6.5 SUMMARY AND CONCLUSIONS

In this chapter we have shown that the content focused approach is often used in the management of complexity in LIPs and is prominently visible in the management of the complex sub-cases we have studied in this thesis. We have shown how the content based approach may lead to premature convergence which removes the possibility of exploring other, possibly promising, alternatives. It proves the extreme importance of the starting conditions. In addition, because the negative impact of the approach, animosity can last long after the approach has been changed to one focussing more on control and/or interaction.

While the content focused approach might possibly be successful in situations of low complexity, the likelihood of success of this approach in situations of high detail and dynamic complexity turns out to be fairly low. Overall the approach has very limited scope for dealing with both detail and dynamic complexity – in addition leading to dissatisfaction amongst stakeholders.

We will now look into the second array of management strategies that seems to offer more benefits: systems management.

7 SYSTEMS MANAGEMENT - MANAGING DETAIL COMPLEXITY

In the previous chapter we have shown that the content focused approach is very often used in the management of complexity in LIPs. It is prominently visible in the management of the complex sub-cases we have studied in this thesis. We have shown how the content focused approach may lead to premature convergence, and that for instance 'groupthink' can trigger this approach – which reduces the possibilities of looking into other, possibly promising, directions. This is the first, but certainly not the only, negative effect of a content focused approach. The approach is of very limited benefit in the management of both detail and dynamic complexity in a large infrastructure project. So we have to look for approaches that are more promising. We will now look into the second array of management strategies that offers more benefit, especially in the management of detail complexity - namely systems management. The approach however seems less well-equipped to deal with dynamic complexity - especially that of the stakeholder system in LIPs.

Because the theory of systems management can be linked to organisational design theory, we start out with a description of organisational design and link it to our studied object: large infrastructure projects (7.1). After this we introduce concepts of systems management and how these are placed in the general field of project management (7.2). We then introduce the strategies of control, based on systems management theory, in section 7.3. In section 7.4 we then present the findings on the success of the systems management approach in the management of complexity in LIPs. This chapter closes with a short summary and an overview of the main conclusions.

7.1 THEORY ON ORGANISATIONAL DESIGN

A seemingly endless list of papers and books has been written on the management of organisations. Some of these books have presented general overviews of the historical development of theory in the field of management. Shafritz et. al. (1992), Hellriegel et. al. (1989) Stoner et. al. (1992) for example present general overviews of the development of management theories.

Modern management theory starts near the end of the 19th century, when a revolution took place in organisational theory. The increase in size of organisations and more specifically *industrial* organisations demanded more managerial skills than were present in the small organisations that existed up to this period. This led to a development from a structured, scientific, approach (Taylor, Fayol, Weber), to the belief that the motivation one has in one's work strongly influences productivity. Some important movements or themes during the last fifty years have been the contingency approach (i.e. Mintzberg), best practices (i.e. Peters and Waterman), quality management (i.e. Deming), core competences, leadership (i.e. Covey 2009). Of course multiple other streams can be identified as well. We do not wish to give an overview of all this theory but to focus on those elements that can provide us with some relevant insights into the organisation and management of complexity in LIPs. Some of these originate from the theory of 'organisational design'.

Project delivery organisations dealing with LIPs are organisations that often employ hundreds of people. The Betuweroute, for example, had a project delivery organisation with, at its maximum, almost 600 people – dealing with the management, staffing and planning. This excluded design work, which was contracted out to engineering companies. LIPs can be likened to companies with a management team, staff departments and decentralised (sub-project) organisations. Annual planning and control cycles are used to manage the project. Robbins (2001) mentions six key elements in the design of the organisational structure: work specialisation, departmentalisation, chain of command, span of control, centralisation and decentralisation and formalisation. These six design elements can also be applied to project delivery organisations dealing with LIPs such as the Betuweroute project organisation, as shown in table 7.1.

The organisation of the Betuweroute:		
1	Work specialisation	Of all the 600 people working at Betuweroute in 1997, different types of engineers, contract-lawyers, financial controllers, Primavera planners, secretaries, all had specialised education and training.
2	Departmentalisation	The Betuweroute has used departmentalisation several times: contract teams for the substructure have been regionally divided along the line. Planning and staff functions (schedule, costs, quality, personnel, ICT) and overall activities were centrally clustered in early stages, before they were partly moved to the regional contract teams. The contracts for the superstructure have been split up on a functional basis: for example noise screens, electricity and tunnel technical installations.
3	Chain of command	The organisation was designed according to the unit-of-command. A concept of hierarchical, functional and operational bosses was used to structure the project organisation. In the quality manual this was explicitly addressed.
4	Span of control	The span of control was an explicit design criterion in setting up the organisation structure.
5	Centralisation and decentralisation	The centralisation – decentralisation discussion was dominant in the organisational design, according to the leading principle, especially to organise the realisation phase: "decentralisation, unless ...".
6	Formalisation	For every position, job descriptions have been set up. Every job description concerns one (project director) to almost twenty people (controllers).

Table 7.1: Six design elements applied to the project organisation Betuweroute

Strikwerda (2000) presents 10 classic organisation principles and recognises these as hygiene factors that can be applied to every organisation. These factors are more 'moral' than 'operational' or 'scientific'. But according to the author, one thing is clear: 'when these 10 principles are not used in an organisation, it will lead to a dysfunctional culture within the company'. The 10 principles are briefly described (table 7.2), again making a link with the Betuweroute project delivery organisation. The actual strategy, organisation and processes are reflected in the project quality manual.

10 Classical organisation principles (Strikwerda, 2000, p. 45)	
1	**The organisation needs to be derived from the stated objectives or the assigned tasks** This means the project organisation needed to focus on building the Betuweroute according to the set scope, within the stated constraints of time and costs. These objectives were agreed with the Ministry of Transport and formed the basis of the organisation structure: the objectives have been translated into milestones and work packages that have been assigned to the various parts of the organisation.
2	**Activities need to be coordinated in a purposeful manner** The focus in the co-ordination of the project organisation was to achieve the documented project objectives. Coordination was achieved by hierarchical structures, meetings, standards, communications systems, procedures and other measures.
3	**The total workload needs to be divided over specialised parts** Work packages have been defined which were contracted and managed in a coherent manner by specific project teams. The contract teams were organised regionally (substructure) or according to function (superstructure and overall activities).
4	**Unity of plan** The annual plan of the project organisation contained the plans for contract and staff managers. This was also the case for processes. An overall contracting strategy was formulated that served as a guideline for the specific contacts.
5	**Unambiguous accountability** Separate budgets have been delegated to the contract managers. The budget for overhead (man hours, engineering) was delegated to the managers of the staff based on yearly planning until project completion. Project, contract and staff managers were responsible for the control of their budget. Every year, the project organisation required approval from the accountancy department of the Ministry of Transport.
6	**There has to be a balance in authority, tasks and capacities** At the Betuweroute this balance was especially important in structuring the contract teams. Each team had a list of tasks, a defined authority and capacities to be able to perform its tasks.
7	**Each decision needs to be delegated to the lowest competent level: this is the level that can understand all – 'decision relevant' – aspects, that can oversee all consequences of the decision and that will be judged on the consequences of the decision** This rule was used to set up the project delivery organisation, as described in the quality manual.
8	**Minimised span of *imposed coordination*. Coordination by use of formal hierarchy (imposed co-ordination) needs to be minimal** The aim was to give managers a large measure of autonomy within overall coordination. However because of the large number of substructure contracts, regional directors were installed as a sublevel between the project director and the contract managers.

9	The line of command from top to bottom of the organisation needs to be unambiguous and as short as possible The project organisation only has three levels of command: project director, regional directors and contract managers (in some years it had only two, without the regions). Responsibilities and tasks for each level had clearly been defined. Staff functions supported the management.
10	The various parts of the organisation need to be balanced The two regions during the construction phase dealing with the substructure were of similar size. The size was also comparable to that dealing with superstructure. This secured a balance in the project delivery organisation. In addition the 'four eye principle' was used to structure decision making. In practice this meant that a contract manager could only take a decision in line with the proposal of a staff member. In case of a disagreement the contract manager was obliged to escalate to the next hierarchical level (regional director or project director).

Table 7.2: 10 Classical organisation principles

These two examples show that a project delivery organisation dealing with a LIP, such as the Betuweroute, can use the classical principles of organisational design to structure its organisation. The theory on 'organisational design' however is not specifically tailored to the characteristics of a temporary organisation commissioned to deliver a LIP. LIPs, and projects in general, have several distinguishing characteristics that lead to specific requirements in their organisation and management. To tackle the specific issues that a project organisation needs to deal with, the theory of project management was developed.

Project delivery organisations differ fundamentally from traditional, functionally organised, permanent organisations (i.e. Turner, 1997; Wijnen et. al., 1984; Andersen et. al., 1995; Koolma et. al., 1974)) Some distinctive characteristics of projects compared to the characteristics of permanent organisations are listed in table 7.3.

Project organisations	Permanent organisations
Novel / Unique	Routine
Finite	Infinite ('going concern')
Effectiveness	Efficiency
Phased execution	Growth stages
Flexibility and change	Stability and status quo
Changing personnel	Set personnel

Table 7.3: Different characteristics of projects and permanent organisations

Projects are unique, are novel and have a clear finishing date. The control of permanent organisations is often directed more at continuity and long term growth. This results in projects being more specifically aimed at *effectiveness* (producing certain project objectives) while a permanent organisation primarily tries to achieve *efficiency* in its routine processes. Processes in a project delivery organisation often have a low level of repetition. This difference makes the slogan "Doing things right first time" highly relevant in projects, as often there will be no second chance.

Projects follow set phases: initiative, feasibility, design, execution, and operation. Permanent organisations have no phased execution but are often characterised by general stages of growth and development (i.e. Hardjono et. al., 1997; or more famously, Mintzberg, 1997). Because the phases in a project often are significantly different, projects require flexibility and a changing project team. A project organisation starts small, builds up and then slowly cuts back in personnel. Also the project team members will have different roles during the project because the nature of the work will change in each project phase. Permanent organisations are more stable, working with a fixed set of functions and roles over time.

Projects and permanent organisations can be positioned as two extremes in a continuum. They both create a certain attraction and create a certain tension. Projects offer a way to act quickly and flexibly. Routine work gives a starting point for efficiency and coordination. This means projects such as LIPs will often have the characteristics of both project and permanent organisations as was already shown earlier in this section.

A project can be defined as (Turner, 1997):

> *"an endeavour in which human, material and financial resources are organised in a novel way, to undertake a unique scope of work, of given specification, within constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives".*

Large Infrastructure Projects fit all of the characteristics that are mentioned in this definition. For example the Betuweroute: *"an endeavour in which human* (people manning the project delivery organisation), *material* (needed for construction) and *financial resources* (basic funding from the Ministry of Transport) *are organised* (project delivery organisation) *in a novel way* (the project organisation and processes are designed especially for the project), *to undertake a unique scope of work* (there is only one Betuweroute), *of given specification* (e.g. length, maximum speed etc.), *within constraints of cost* (budget from parliament) *and time* (Rotterdam part in 2002 and from Rotterdam to the German border in 2007), *so as to achieve beneficial change defined by quantitative* (e.g. number of trains within a certain timeframe) *and qualitative objectives* (i.e. hinterland connections of the harbour of Rotterdam).

7.2 THEORY ON SYSTEMS MANAGEMENT

Because projects have different characteristics from permanent organisations it becomes plausible that projects require specific management strategies in order to complete them successfully. Managing projects has over the years become an important part in the general theory of the management of organisations. In this section we give a short introduction to the field of project management, mainly focussing on an important area of project management - that of systems management. This area was chosen because this part of project management theory, seems to be tailored to the management of detail complexity.

A detailed overview of the development of project management over time can be found in Morris (1994). In this section we will use this historical basis to introduce the field of systems management.

The need for control was recognised right from the start when theory in the field of project management emerged. The profession of project management in practice originated before the 1950's, but from the 1950s the tools and techniques used in project management were introduced in management literature. This was stimulated at this time by the appearance of a large number of major projects such as the Atlas Missile Program and the Polaris Program, that were undertaken in the US defence industry as a response to the perceived threat posed by the Soviet Union. A new approach emerged that saw the end-products of these complex projects as 'Integrated Systems'. These end products had to be specified, designed and scheduled from an integrated viewpoint which eventually led to the first project management approach, generally referred to with the term 'Systems Management'. This theory – which is still at the heart of project management theory! – was taken as our start-point to identify the management strategies to manage detail complexity in LIPs. They make a perfect match for the earlier described need for control.

The systems management approach is based on the notion that within every project the requirements of the project's end-product need to be defined. When requirements have been formulated, a detailed planning to achieve the desired end-product can be set up. So scheduling became the focal part of project management. Several techniques like the Critical Path Method (CPM) and the Planning Evaluation and Review Technique (PERT), both network scheduling tools, were introduced.

Later in the 1960s and even up to the present, the field of systems management has grown and is now a fully mature body of theory, but also and predominantly a body of practice. Over time the focus of systems management expanded and shifted from planning to to a more broad focus on the topic of control.

Control refers to managing rigidly the aspects of costs, scheduling, scope (quality), information, organisation and risks. Turner (1997) visualised this in figure 7.1.

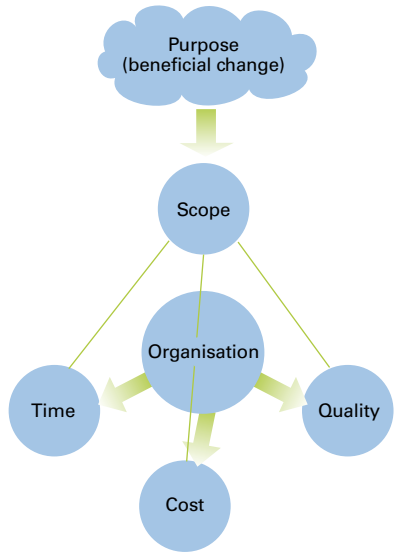


Figure 7.1: Control aspects in projects (Turner, 1997)

Even though we are fully aware that the field of project management contains much more theory than that relating to systems management alone, we have especially chosen to use this element in this thesis. The main reason for this is that it seems to meet the need for control. In addition it proved to be a fitting body of management theory on which to draw when looking at the management of detail complexity.

The state of the theory on project management at the end of the 1970s was that of "a collection of scheduling and cost-control tools" (Morris 1994) with some organisational topics added. At that time the state of the theory on project management did not reflect the situation in practice where environmental opposition, economical context and social factors began to play a far more prominent role (also Morris). In terms of our previous chapters: the major influence of dynamic complexity on projects started to be broadly recognised. It seemed that while the theory still developed a 'control perspective', in practice project organisations were looking for a more open 'interaction perspective' to manage projects in their dynamic (and sometimes even hostile) environment. This is addressed in the next chapter, in which we tackle the management of dynamic complexity. We now turn to the strategies of control in the management of detail complexity.

7.3 STRATEGIES OF CONTROL – MANAGING DETAIL COMPLEXITY

"What you buy in project management is certainty in delivery of the project within agreed schedule, costs, quality, safety. How this takes place differs from client to client. If for example a project is well managed on schedule, costs and quality and one person is being killed during the works the final result is bad!"
Project Manager, West Coast Mainline, Bechtel, 2006.

Based on the description of the theory on systems management, we have identified the following management strategies that can be used to manage complexity. These strategies are focused on control.

1. Decomposition
   a. Time
      • Phased execution process to project delivery
      • Decision making
   b. End product
      • Object breakdown
   c. Organisation
      • Work breakdown, work packages
      • Organisation structure

2. Management processes
   a. Schedule
   b. Costs
   c. Quality
   d. Risks

The strategies of control, as formulated above, can be applied in the management of complexity in LIPs. The strategies of control are at the core of systems management and are especially suited for the management of detail complexity.

We now outline each of the management strategies within systems management separately.

1 Decomposition

As mentioned in the previous section, systems management is the traditional project management approach which is based on realising the stated product ('system') of the project in a controlled manner. A main strategy to achieve this is by using decomposition. Decomposition can be applied to the aspects: time (schedule), end product and organisation.

Decomposition can be applied to the time schedule. This is the division into logical steps of the project activities, necessary to reach the project objectives (Wijnen et. al. 1988). The project can be divided in sequential project phases from initiative to delivery. In figure 7.2, 6 phases are distinguished: initiative, definition, design, preparation, realisation and operation.

Figure 7.2: Project phases

The specific phases that projects follow were also observed in our studied projects. For the Betuweroute the planning was divided in stages for the whole project but also for the project parts. This means that for example the Havenspoorlijn could already be in the construction phase while large parts of the A15 part would still be in the design phase. So while in general it is hard to distinguish the set list of project phases, in reality each project can be split up. Splitting up the schedule of the project in specific parts gives a basis for its management. It allows the use of decision making gates and provides a basis for tracking the progress of the project by looking at the delivery of milestones.

A second application of decomposition is on the end product to be delivered. Generally this end product is described in terms of an infrastructure facility. This facility can be split up in various elements and sub-elements.

At the Betuweroute 'object lists' were used which contained all infrastructure elements to be build in the project. On the list the various objects such as railway line, superstructure, noise screens, bridges and tunnels could be found. These lists were used as a general reference for scoping what needed to be built and in this way served as the basis for the tender documents that were sent out to bidders.

In addition to the object list breakdown, the work activities can also be decomposed. This is the third type of decomposition we distinguish. For this reason various tools have been developed, for example the Work Break Down Structure (WBS). WBS is the technique by which the work of a project is divided and subdivided for management and control purposes (Turner, 1997).

Turner presents four advantages of work breakdown (Turner, 1997):

1 It provides better control of work definition.
2 It allows work to be delegated in coherent work packages.
3 It allows work to be defined at an appropriate level for estimating and control for the current stage.
4 It allows risk to be contained within the WBS.

As mentioned by Turner the work breakdown – in combination with object breakdown – can be used as a basis to structure the project delivery organisation with separate units being responsible for specific scope in terms of both object and work.

The approaches used to structure the organisation show large similarities with the principles of organisational design such as described in table 7.2.

The work breakdown can be used as a basis for decision making within the project. In this approach project management starts with a client ('principal') who asks the project manager to commence the project. For this purpose the project manager has an overall contract with the principal: the base document. A base document is constructed by the project manager after each phase. It contains the results of the previous phase and the plan for the next. 'Deciding' means that by signing the phase document the client agrees with these results and new plan for the next phase. The project manager will contact the client in case of deviations from the plan during the phase, that cannot be handled within his discretionary powers (or which implies a major change for the project).

So generally decomposition allows the employees in the project delivery organisation to keep control of the delivery of their project. The elements that need to be controlled with management processes, aspects generally formulated in terms of project output, will now be described.

2 Management processes

Control of the project phases takes place on management aspects: schedule, costs, quality, organisation and information. Schedule, costs and quality are the three aspects that determine the output of the project, which can be achieved by a professional organisation and information control. The management processes aim to complete the project within the stated constraints: of schedule, costs and quality. The activities of the project delivery organisation should be focused to control the project in such a way that it is delivered within these constraints.

The systems management approach focuses on the project as a process to deliver the project objectives as visualised in figure 7.3. The basis is the decomposition of phases. Each of the phases then needs to be controlled in a rigid manner. The scheme is somewhat complicated, which reflects the way of thinking: 'our project can be visualised and this is what it looks like'.

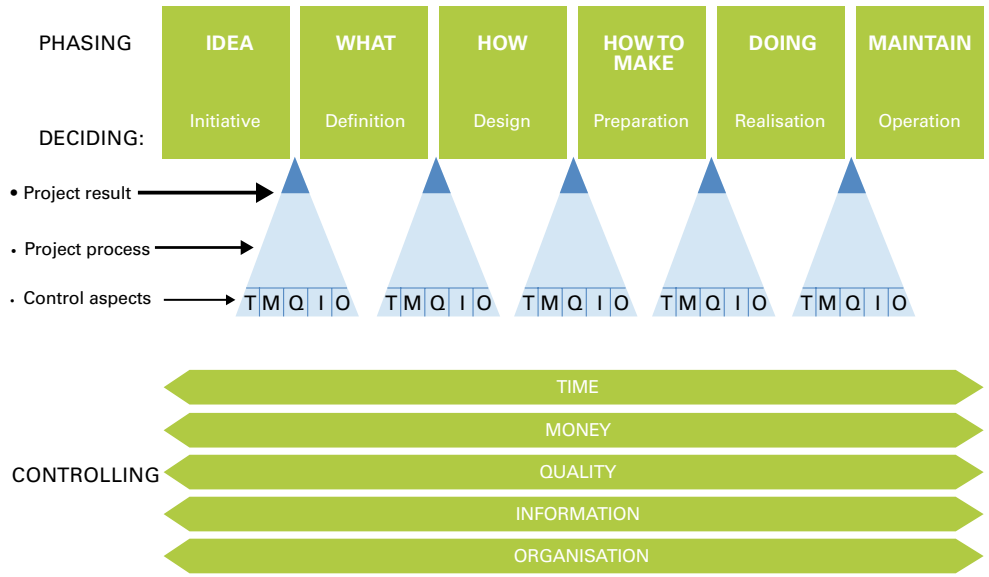


Figure 7.3: Systems Management (Wijnen et. al., 1984)

Generally a sixth control variable is often added to the five traditional ones: risk. The basic intention is that by managing risks, the project delivery organisation can make sure that the project is delivered within the set constraints. Risks are defined in such a way that describes how and to what extent they threaten the smooth delivery of these outputs.

Figure 7.3 also shows the link between the management processes and decomposition. Decomposition is used to set up both the scope of the work and of the objective. Control is then enforced by putting in place those management processes that make sure that the project is producing the required output.

In *our* framework we use the variables schedule, costs, quality and risks as those elements that should be controlled in management processes. The elements 'organisation' and 'information' were excluded because, in our view, they are not defined specifically enough to be used as a basis for control. Both the terms organisation and information are so general and hard to define, they do not allow a consistent and meaningful application to the management of LIPs.

The basic management strategies of systems management are visualised in figure 7.4.

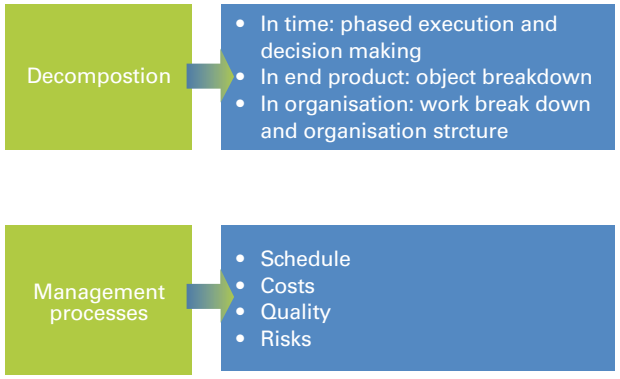


Figure 7.4: Management strategies of systems management

At the core of systems management is the application of the strategies of control. Control refers to both the decomposition and management processes. Control in terms of decomposition can be applied to the management process in terms of: schedule; the end product the project has to deliver; and to the organisation which is set up to deliver the objectives. Control in terms of management processes can be applied to the elements of schedule, costs, quality and risks. Because projects are executed within specific schedule, budget and quality constraints, these need to be tightly controlled. In order to control these constraints, a further element – risk management – is essential. This is why we included risk management as the fourth element in the key management processes of systems management.

Applying the strategies of systems management to the management of complexity it becomes clear that the strategies are mainly aimed at reducing the complexity and, more specifically, the management of detail complexity. With every step in the phased execution and decision making processes, uncertainty is reduced. By using rigid measures of control to monitor schedule, costs and quality, the uncertainty regarding the delivery of project objectives is reduced. In effect, these strategies can be related to the formulation of project objectives in terms of constraints on schedule, costs and end product (quality). The deviation from these constraints is perceived as project failure, which makes tight control a key management strategy.

Systems management is a strict methodology. It perceives projects as having a clear objective, a limited number of stakeholders and no major changes in objectives, interests and positions. However, as we have seen in chapter 3 to 5, such changes and complexity are important characteristics of LIPs. This means that control strategies originating from systems management are useful and necessary but might not be sufficient to manage, especially the dynamic complexity within LIPs. This is why

other strategies need to be considered as well. These strategies, based on interactive management, are outlined in the next chapter. In this chapter we now present our findings on the strategies of control in the management of complexity in LIPs.

7.4 KEY FINDINGS ON THE STRATEGIES OF CONTROL

In the previous chapter we saw that the content focused approach is the most frequently observed approach to the management of complexity. In terms of frequency, systems management is the second most often observed. Systems management appears to be the traditional management reflex of project delivery organisations managing LIPs. The strategies belonging to the systems management approach were more often observed than those of interactive and dynamic management which we come to later.

In our investigation we have found that the systems management approach can be very useful in the management of complexity. On the other hand we found that the use of this approach alone has some major pitfalls which we will also describe in this section.

Our main finding regarding systems management is:

Systems management is useful in the management of detail complexity of both 'social' and 'technical' dimensions but has some major pitfalls when it is applied to managing dynamic complexity.

Systems management is a management approach that can facilitate progress in LIPs by splitting up tasks and responsibilities as well as defining the work activities and the infrastructure facility. These characteristics make the application of systems management a highly useful commodity for project managers. Because of their sheer size and duration, LIPs are enormous undertakings that require decomposition and control - otherwise they would be impossible to manage. Systems management is especially useful in managing detail complexity in such circumstances. This is complexity, or as we have also called it 'complicatedness', in the sense of many components with a high degree of interrelatedness.
Contrary to what is often believed, this approach is not only useful in managing technical complexity related to the end product to be delivered but can also be effectively applied to managing detail complexity in the stakeholder system. So it is not only an 'internal' approach but also one that can be successfully applied to the external stakeholder network. We will illustrate this later on.

7.4.1 Systems management is not a 'given'

We noticed in our study that the importance of managing detail complexity is two fold. Firstly it will create a lot of work later on when the detail has not been organised properly. A classic example can be found in the management of document systems (both hard copy and electronic information). At the Betuweroute the project organisation found that it is important to organise this professionally from the start. Secondly, when the detail complexity is not managed properly, this will influence the relationship between stakeholders in a negative fashion. In this sense it is a 'hygiene factor': it determines the context in which the work is performed. Lack of application of the systems management strategies will reduce appreciation for the project delivery organisations, but smooth and thorough application will not greatly improve it (Hellriegel and Slocum, 1989).

When starting our research we felt that the principles of systems management are broadly known and applied in LIPs. But although systems management is sometimes regarded as a basic instrument in the management of projects, it is not always a 'given'. Often it is still not applied, as evidenced by the many instances we observed the content focused approach:

> *Although systems management is often regarded a hygiene factor in the management of LIPs, its application is certainly not a given. Systems management within LIPs is a time consuming task often supported by sophisticated tools, that require continuous attention in the set-up and use of appropriate instruments of project control.*

Current systems management knowledge has been developed over the years in LIPs and it appears the application of systems management techniques slowly has turned into a 'hygiene factor' in managing these undertakings. We illustrate this with an example from the Betuweroute.

At the Betuweroute we observed that the level of professionalism regarding systems management to tackle detail complexity, rose dramatically over the years. This can be illustrated by the way cost, planning and scope developments are reported in the progress reports which were sent to the House of Representatives. During the first progress report, published early 1997, only basic figures were given concerning budget, schedule and some other very limited information regarding project control. Ten years later in progress report nr. 21, which was published in March 2007, far more elaborate information was presented on project control also including cost prognosis and risks. In table 7.4 we compare the information given in both reports to illustrate the differences.

Information	Progress report nr. 1 (1997)	Progress report nr. 21 (2007)
Scope	• Overview of requirements • (possible) Changes in requirements	• Distinctive technical and functional requirements • Overview of all scope changes (including costs) • Potential scope changes
Finance	• Reserved budget • Cash flow (yearly) • Financing • Expenditures	• Reserved budget • Financing • Expenditures and assignments • Yearly price index • Status of budget for unforeseen costs • Financial risks • Estimated final costs
Planning	• General overall planning	• General overall planning • Largest planning risks
Quality and knowledge	-	• Quality system • Learning and knowledge management • Results of research

Table 7.4: Comparison of project control information

The comparison in table 7.4 shows how much more elaborate and precise the information on project control has become from 1997 to 2007. During this ten years of development the project delivery organisation seems to have greatly improved its skills on systems management. A good example is the introduction of the field of risk management.

> *"Nowadays, risk management is a 'hype'. In the past it was largely unknown and not used. Nowadays you are asked to share your experiences with risk management on a conference."*
> Head of the risk management department, Betuweroute.

So it can be concluded that the application of various systems management strategies has increased over time at the Betuweroute. And with this, the overall level of project control has improved, much to satisfaction of the involved stakeholders such as ProRail and the Ministry of Transport. Also the budget overruns for the Betuweroute project have been marginal (less than 3 percent) during the period 1997-2007, providing another symptom of improved control.

While the level of professionalism regarding systems management has increased, there have been some major examples during the project's early stages where the lack of systems management has brought it into trouble. One prime example can be found in the cost and scope development of the Betuweroute during the phase from 1995 to 2001. During this period there is a severe disagreement between the Ministry and ProRail (POBR) project delivery organisation on the cost control of the project. This example is illustrated in text box 7.1

Project control on the Betuweroute (1995-2000)

The history of the Betuweroute was illustrated in chapter 3. Here we saw intense debate between the Ministry of Transport as the civil principal of the project and the Betuweroute project delivery organisation within ProRail. The central element in these discussions was the occurrence – and recurrence – of differences between the project budget and emerging cost estimates. Already at the start of the project execution, the cost estimates of the project delivery organisation were above the politically approved project budget. The 'tension' between the cost estimates and project budget was resolved in two agreements: 'Malle Jan' (1998) and 'Aanlegbegroting' (2000). The negotiations which led to these agreements caused heavy friction between the two involved parties. Main topics of discussion were 'Who was responsible for a scope change?' and 'How to deal with scope changes?'. This is typically a field where systems management can offer assistance: both in the administration of scope changes and in managing cost consequences and transparent budget control.

The Ministry of Transport had severe doubts about the way project control was set up by the project delivery organisation. Because of this, two audits were initiated. One was performed by AT Kearney, the other by the National Audit Office ('Nationale Rekenkamer').

AT Kearney concluded in their report in 1999:

1 Arranging a co-operative relationship between ProRail and the Ministry was difficult;
2 The administrative organisation and master planning followed the project development instead of guiding it;
3 'Back-up' options were not present in the contingency planning;
4 The organisation within the Ministry of Transport, serving as the project principal, had responsibilities that should have been allocated to higher management levels.

The Audit Office concluded that:

1 Solid design specifications were lacking within the project delivery organisation;
2 There was no standardised set of scope requirements ('Programma van Eisen') available within the project organisation;
3 Instruments to stimulate low cost design were lacking;
4 The cost estimates for the design did not fit within the fixed budget;
5 Financial and other management information provided insufficient insight in the financial state of the project.

The conclusions of AT Kearney and the Audit Office both offer clear indications that the systems management could be improved at that time.

Text box 7.1: Project control at the Betuweroute 1995-2000

The Betuweroute example shows some of the difficulties experienced that are, at least partially, the result of immature systems management. This immaturity and the earlier cost overruns, meant that there was a constant pressure on the Betuweroute project to improve project control. It could be argued that this external pressure, which is sometimes regarded as a negative factor by project managers, had a positive effect – in that it stimulated the use of improved systems management strategies to manage project complexity .

The example of the Betuweroute and the other cases we have studied show that the application of systems management techniques is not simple in LIPS. High levels of external pressure, unique characteristics of the project and huge amounts of information are some of the factors that greatly hamper the use of systems management.

Thus we see that systems management is something that cannot be implemented overnight in LIPs. It is something that requires a high level of professionalism and constant management attention since these are such large undertakings. In addition:

To be of use in the management of complexity in LIPs, systems management needs to be:

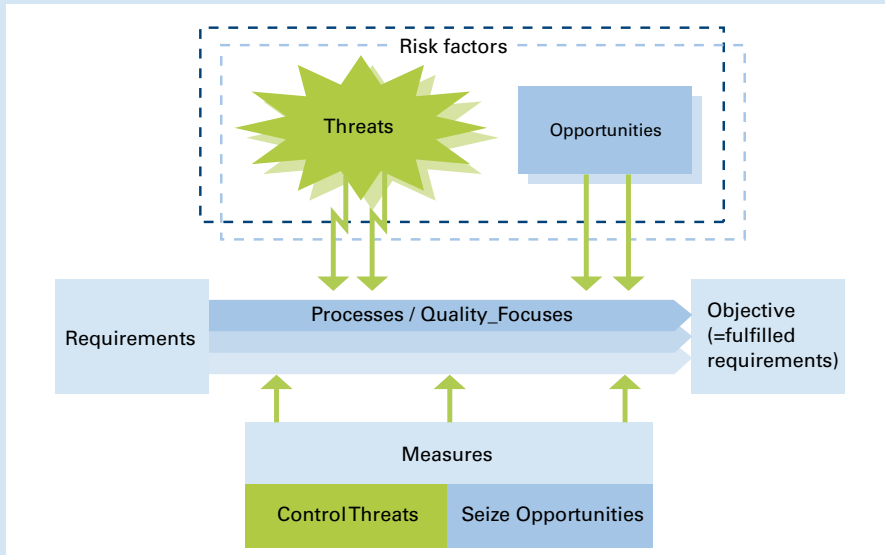
- *Applied with a high level of professionalism and constant management attention*
- *An expansion of the regular set of systems management strategies*
- *Tailored to the specific characteristics of the project.*

The unique characteristics of LIPs mean that standard system management techniques also need to be adapted to the project. Most of the LIPs we investigated used standard techniques for planning, budgeting and risk control which then have been specifically tailored to the unique project they are applied to. An example is the risk management system at the project Gotthard (text box 7.2).

Risk management at the Gotthard Base Tunnel

Risk management at the Gotthard Base Tunnel was implemented at an early stage and includes all levels from the authorities down to the contractors. Risk management is based on a generally accepted practice which has been tailored to the project.

In the practice applied at the Gotthard, the term 'risk' is used non-judgementally and can be seen as a threat (negatively) or an opportunity (positively), depending on the impact on the project objectives. This differentiation follows from the premise that threats can be controlled and opportunities should be seized (see figure). The risk management focuses on those risks, which can be influenced through appropriate measures by the project management. The residual risks are closely monitored.



The specific tailoring of the risk management approach arises from the fact that there are specific guidelines on how risks are reported to the Ministry of Transport by the project delivery organisation ATG. There are also specific guidelines, laid down in the management handbook of ATG, on how contractors report their risks to ATG. Basically the overall risk management techniques have been tied to the quality management handbook, arrangements on reporting and responsibilities of parties involved.

Text box 7.2: Risk management at the Gotthard

The example provided in text box 7.2 shows how the application of techniques of one project control element (risk) is tied to other systems management tools such as reporting structures and quality management processes. In LIPs, systems management techniques often have to be extended in order to meet the requirements of the project. In general, advanced techniques will need to be used that are normally not needed in smaller projects. The project HSL-South for example, used a detailed risk database to assist in the control of the project. This detailed database was not used at the beginning of the project but has subsequently provided managers and decision makers added value in giving better management information. For other projects this instrument can very well generate unnecessary details. It shows how the most advanced tools and techniques from the field of systems management can possibly be of use in LIPs.

Another example of advanced forms of systems management was observed at the West Coast Mainline project where systems are used to deal with the issues of optimism bias and pessimism bias. This example is illustrated in text box 7.3. This practice was developed partly because of problems experienced with the WCML and other railway projects.

Sources of error in cost estimation

The Department for Transport uses three different sources of error in cost estimation, see the table below.

Source	Description	How to address this in appraisals?
Risk	Events associated with known probabilities, measurable	Quantitative Risk Analysis (QRA). Calculating probability weighted costs.
Uncertainty	Events for which probabilities cannot be easily quantified	Describing sources of uncertainty. Adding a contingency uplift to cost (e.g. £100,000 for not obtaining planning permission)
Optimism Bias	Historically observed tendency to underestimate costs	Adding Optimism Bias adjustment to correct Bias

The corrections can be incorporated into costs. Uncertainty and risk in benefits should be treated with the use of sensitivity analysis on key benefit drivers. Cost savings should be treated as benefits and be subject to sensitivity tests accordingly.

Recently in the UK wider economic benefits of transport investments have also been taken into account in the appraisal of projects. This leads to higher benefits/costs ratio and diminishes the 'pessimism bias' in which benefits are underestimated. The idea is to develop a method of evaluation for wider economic benefits in the next 2 years, but it is a difficult task since benefits and costs cannot easily be measured.

Financial experts at the Department for Transport deal with two important types of 'human' miscalculation in project development:

- Optimism bias. The overestimation of income, especially at the go/no go decision. The optimism bias in the WCRM Appraisal Update (August 2004) was assessed as 15% of the capital costs.
- Pessimism bias. If projects are only calculated on their direct effects it may be impossible to realise projects with considerable positive effects. A good example was the Jubilee Line Extension.

The recommended uplifts of budget to deal with optimism bias are set out in the table below. The uplifts are based on the results of previous projects and will be refined once new results are gathered.

	Pre-feasility	Project Definition	Option Selection	Single Option Refinement	Design Development
Capital Expenditure	66 %	50 %	40 %	18 %	6 %
Operational Expenditure	41 %	1,6 % per annum	1 % per annum	Evidence based	Evidence based

Text box 7.3: Dealing with sources of error in estimation at the WCML

The working practice within the WCML shows a system which was put in place to deal with errors in estimation of both costs and benefits. It could be regarded as a more mature way of systems management as compared to traditional methods of calculation of both benefits and costs.

Our cases show many examples of improvements made in systems management. However the fact that the 'content focused' approach is still as dominant as we have seen in LIPs, and as shown in the preceding sections, proves that improvement still cannot be taken as 'a given'. New and advanced ways of systems management need to be applied, in order successfully to manage complexity in LIPs.

7.4.2 Benefits of systems management

More often than not, project delivery organisations fail to capitalise on the potential benefits of systems management

The application of systems management can generate large benefits within LIPs – not only in the management of technical complexity but also in managing the social complexity inherent in the stakeholder network. From our examination we have identified the following important benefits in the management of social complexity:

Systems management offers benefits in LIPs both in managing social and technical complexity. Systems management helps to facilitate progress, define responsibilities between actors or players, regulate and document changes, and improve accountability for decisions taken.

Systems management can be an especially effective way to decrease the detail complexity in the stakeholder network. Two primary examples of benefits are:

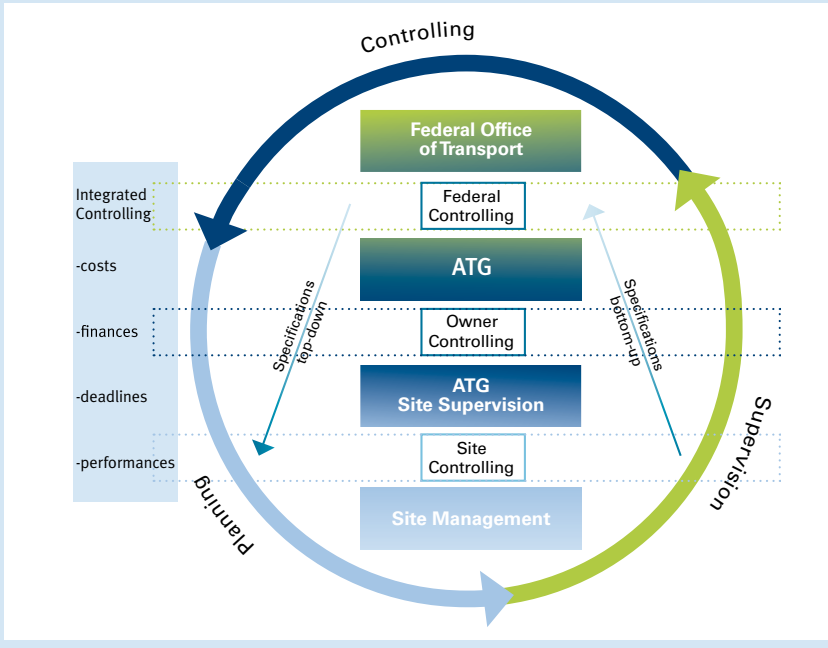
1 Increasing transparency by the regulating responsibilities between players
2 Improving accountability by tracking and documenting changes

In chapter 4 we argued that the dominant complexity in LIPs is social complexity. In LIPs there are many stakeholders involved, often with changing and diverging interests. These differences even exist in the various policy departments within public authorities that are working on project delivery. We saw that social complexity is not only visible in the external relations – with local stakeholders and NGO's but also internal relations – civil principal, parent organisation and project delivery organisation. Systems management can effectively be employed to assist to manage this social complexity - as we have observed in the cases studied. Even though social complexity seems to be more related to dynamic than to detail complexity, systems management is used in 'stakeholder analysis' thereby increasing transparency by regulating the responsibilities between players and, in this sense, decreasing the amount of (social) detail complexity.

An example of where systems management was effectively deployed to regulate responsibilities is the project Gotthard. See text box 7.4.

NEAT Controlling Regulation

All relevant controlling processes are documented within the NEAT Controlling Regulation (NCW). The NCW is generally accepted as one of the biggest strengths within the Gotthard project. It defines the processes for the supervision and controlling of the project, as well as defining reporting processes. It contains the overall work breakdown structure and defines the responsibilities of the project stakeholders on the basis of legal and contractual guidelines. Responsibilities are defined for the Federal Office of Transport as the civil principal, ATG as project delivery organisation and for contractors performing the work on site. The NCW contains a continuous improvement process and therefore is revised periodically.



Within the ATG-Controlling Cycle, reviews and audits are carried out internally and externally on different levels:

- Internal reviews by ATG
- External review commission of ATG (SIOP)
- Project meetings
- Technical review team of BAV (TBT-AT)
- ATG project management on site
- Task force for special situations
- Site supervision

Text box 7.4: NEAT controlling regulation for the Gotthard project

The 'NEAT controlling regulation' has been an effective instrument in defining responsibilities between civil principal and the project delivery organisation - ATG. Because of the sheer size of LIPs many organisations often participate in project delivery. This social complexity can be decreased by applying systems management tools to define responsibilities and tasks.

A second way systems management can be effective is by improving accountability by tracking and documenting changes. As we have shown in chapter 3 to 5, many changes occur in LIPs in both technical and stakeholder systems. The management of this dynamic complexity can be facilitated by the use of instruments of systems management dealing with administration and change processes.

Within LIPs it is crucial to keep track of changes and their rationale in a systematic way. Procedures controlling change of scope within systems management will help you do this. Sound scope change procedures and methodical administration of changes can help improve accountability and transparency within the stakeholder network. While beneficial application of such procedures can be observed in the cases studied, we also saw that very often sound procedures – especially in areas associated with change – are still missing. For example for the Betuweroute TTI case it turned out to be impossible to create a historical overview of both scope and costs developments.

At the start of the project a project scope and related budget is needed that is agreed upon by the project delivery organisation and civil principal. There should not be, as we saw at the Betuweroute, a difference between cost estimates of the project delivery organisation and the budget of the civil principal. After an agreement is made, this baseline document should serve as the main reference for the execution of the project and to administer changes (see text box 7.5).

Scope change procedure at the Lötschberg

Scope changes in the Lötschberg Base Tunnel project relate to the orders of the Federation, (as defined in the agreements between the Federation and the BLS project delivery organisation) and as they are specified in the reference base. A process of configuration management ensures that all changes are transparent and comprehensible and well documented. Based on those changes which are approved by the BAV and BLS and those changes accepted by the BAV respectively, BLS may request the modification of the reference base. In cases where the scope change does not affect the 'orders of the Federation', the BAV may modify the reference base. Where the scope change does affect the 'orders' of the Federation the Federal Council itself has to change the order.

Text box 7.5: Scope change procedure at the Lötschberg

The 'scope change procedure' is a key element of systems management because it is the most important tool within systems management in managing dynamic complexity. This change procedure relates to any change in the planning, budgeting and costing of the project. It is called the 'scope change procedure' since changes in scope often mean changes

in budget and schedule. It provides clarity to the involved stakeholders as to how the project scope can be altered. Within LIPs we saw in chapter 3 to 5 that major scope changes are inevitable because the project continually needs to be aligned with the changing preferences of stakeholders. However it is important to understand that while having a scope change procedure is useful it does not tell you how to deal with your stakeholders – it is a process that facilitates decision making but does not take decisions by itself.

A sound scope change procedure which is accepted by the involved stakeholders helps to facilitate the management of dynamic complexity.

We can see that systems management can be useful in managing social complexity in LIPs. And, because we see social complexity as the core of complexity in LIPs, this is important. Systems management however can also be extremely useful in managing the other forms of complexity described in chapter 4 – for example technical and legal complexity.

Technical complexity can be seen in the infrastructure facility to be built (product system) and the managerial process to execute the project (work activities). Systems management helps to decompose both product and process into manageable parts. Systems management helps in design and execution of building projects and facilitates progress. It relates to management of the work activities system and product system, and the link between the two.

Legal complexity is another issue where systems management can be useful –mainly n managing a seemingly endless list of necessary permits and consents. This is illustrated with an example from the Betuweroute (text box 7.6)

Legal procedures at the Betuweroute

All legal procedures for the Betuweroute are managed in one department in the ProRail organisation. The 'Route Decision' serves as the starting point for all legal procedures. Based on the Route Decision all procedures applicable to the Betuweroute were identified using a checklist developed within ProRail containing all possible procedures. The planning of legal procedures was then tailored to the project.

The specialists working on legal procedures were appointed for specific parts of the track route. This results in stakeholders dealing with the same specialist for all procedure in a specific region. These specialists are assigned to the relevant regional contract teams.

Within ProRail the list of procedures that are applicable to the project is updated regularly. Updating this list, adding new procedures and removing obsolete ones, within ProRail is absolutely vital, both for land acquisition and site access during construction. In-house specialists are needed to keep track of changes, both formal and in the 'case history'. The Betuweroute was the first time the new 'Route Decision' process was used. This made establishing the legal procedures even more complicated.

Text box 7.6: Legal procedures at the Betuweroute

7.4.3 Pitfalls of systems management

So far we have shown that systems management offers significant benefits - especially in the management of detail complexity in the technical system, but also in management of the dynamic system of involved stakeholders. On the other hand our cases illustrate that systems management has some disadvantages:

Systems management has significant pitfalls in its application that need to be addressed. Systems management tends to create its own blind spots that can result in stakeholder opposition. The systems management approach also tends to be applied in a rigid manner which militates against the flexibility necessary to adapt to changing stakeholder interests. This can make the use of systems management counter-productive in the management of dynamic complexity.

In chapter 5 we have seen the importance of starting conditions within LIPs. Opinions and decisions, especially during the very early stages of a LIP, can turn out to be extremely influential in the latter stages of a project. In chapter 5 we already concluded that the starting conditions within LIPs play an important role since stakeholders, and most importantly the project delivery organisation have the tendency to direct their actions towards the maintenance of the current developed solution. Our cases show that this tendency can be related to the use of systems management techniques within the project delivery organisation. Examples where we observed a rigid desire to stick to 'early developed solutions' are the HSL South (Bos alternative), Betuweroute (Operations, TTI), RWS 73 (TTI) and Gotthard (Canton Uri). Analysis shows that:

Starting conditions within LIPs play an important role since stakeholders, and most importantly the project delivery organisation have the tendency to aim their actions to maintain the current solution.

In general it was observed in all our cases that there is a strong tendency to stick to earlier solutions in the face of new information or insights making these earlier solutions seem highly debatable. A plausible explanation for this is that the need for control and project progress is so high, that sticking to the original plan with minimal change becomes the standard and automatic reflex. And of course, looking at the psychological elements of human nature: it can be hard for people to admit that they made the 'wrong' decision in the past.

So the standard reflex is to stick to the original plan or intention. Change in project plans seems undesirable because it causes extra work, and possibly delay for the project delivery organisation. The starting conditions, or first moves of stakeholders, create what is called 'historical path dependency'. Key 'historical events' can influence the attitude and preferences of stakeholders throughout the duration of the project as we saw in the case of the Betuweroute where the initial strategy not to interact with the local stakeholders, led to extreme opposition from the Province of

Gelderland (section 3.1.2). A similar incident was observed at the Gotthard in Canton Uri (text box 7.7)

The importance of starting conditions in the Canton Uri

The sub-case Uri for the Gotthard describes the discussion with local stakeholders on how the valley should be crossed by the Gotthard railway line. One of the first actions the project delivery organisation ATG took was to obtain the necessary land to build the new line. A calculation was made as to what prices should be paid for this property. But since the land that can be used for building and farming is so scarce in the Canton, the citizens felt that these prices were way below the going market rates. This caused citizens to feel bitterly opposed towards ATG and is one possible explanation for the heavy resistance in the valley towards the ATG proposals. The initial actions of the project delivery organisation may have had a lasting effect that perhaps it never will be able to repair.

Text box 7.7: Importance of starting conditions at Uri

Of similar significance to 'starting conditions' is the fact that often the project delivery organisation and the civil principal are regarded as 'neutral stakeholders', there to deliver the infrastructure demanded by politicians. But this is in theory only. In practice we observed that:

The project delivery organisation and the civil principal are powerful stakeholders which are certainly not neutral.

This conclusion is illustrated by the case of the Porta Alpine from the Gotthard project (text box 7.8)

Porta Alpina at the Gotthard base tunnel

The community of Sedrun is located in the Canton Graubunden above the route of the Gotthard base tunnel. In the community is one of the main construction sites of the tunnel which is accessed by an elevator that takes machines and other resources to the construction site located 1000 meters below. The access elevator was used for construction purposes only but has triggered interest in providing such a facility on a permanent basis during operation of the tunnel. This would mean that a giant elevator would be in place which gave access to an underground railway station in the tunnel below. This idea was first considered by SBB (Swiss Railways) in the 1940s. The elevator could quickly transfer passengers from tunnel to the alpine region above which attracts many tourists. The idea to make and use such a elevator was called 'Porta Alpina'. The Porta Alpina initiative quickly gained the support of surrounding communities and the Canton. The Canton then contacted ATG and BAV requesting a feasibility study on the project, a request which was received with heavy scepticism, mainly because it was not part of the project scope at that point. In order to advance the idea the Canton then decided to execute their own feasibility study on the subject. The study reached a favourable conclusion – a Porta Alpina would have major benefits for the region, and this was used to promote the idea among the responsible politicians within parliament. This was done by setting up a special foundation in 2002. While the idea has gained some political support it has not been made part of the project scope –One of the main reasons being that BAV does not support the idea. Or as the head of the community of Sedrun says:

„BAV did not really support this initiative, I can tell you this based on my experience. But they have become a little more supportive over the years."

This demonstrates that BAV is certainly not neutral in its review of the feasibility of such an initiative. When a project delivery organisation does not want to incorporate certain scope elements, for whatever reason, it is able to obstruct them. While it cannot be proved that BAV has blocked the Porta Alpina initiative, its attitude has certainly reduced the chances of a successful inclusion within the project scope.

Text box 7.8: Porta Alpina at the Gotthard

In the example of Porta Alpina we can see that the civil principal does not want to co-operate with the initiative because it does not fit with its perceived role in the project. This is one of the drivers for the fact that project managers within civil principals and the project delivery organisations have a tendency to stick to the planned status quo, with an inbuilt reluctance to accept plan change. A project delivery organisation is, in most situations, requested to deliver a project of a set scope within the formulated

constraints of time and budget. When the scope changes, such as in the case of Porta Alpina, this means that delivery within the pre-set constraints is prejudiced causing a negative response from the project delivery organisation – and, in this case, also the civil principal. Changes in a project are regarded as undesirable because they might threaten project delivery within the stated parameters even though these changes might mean added benefits for stakeholders. This led us to the following conclusion.

> *A project director who will be judged by previously defined goals (cost, time, quality) might act counter productive, because LIPs are characterised by the occurrence of new developments and new insights. That means that the project director will have insufficient room for change and optimum.*

This resistance to change is also linked to the techniques of systems management which are used to deliver the project within these boundaries. These techniques are based on 'control' as we saw earlier in this chapter. Control is aimed at staying within the defined project boundaries, so the basic strategies for control – even though they certainly offer benefits as we saw earlier – do not blend well with the notion of change connected with dynamic complexity. In projects this can cause major friction between the need for control and the need for interaction as we show in chapter 9. Systems management is, apart from the change procedures mentioned previously, not very well suited to deal with – potential – changes.

Another way to look at the effect of managing complexity with strategies of control, is by making the distinction between 'uncertainty' and 'ambiguity'. Pauly (2001) mentions that the importance of the distinction between uncertainty and ambiguity is that for each, different solutions are applicable. In addition, solutions from the perspective of uncertainty create problems when applied to circumstances of ambiguity. Uncertainty means shortage of information and knowledge. Pauly argues that the solution is clear: close the information gap. Closing the information gap is a typical strategy of control. However by looking for more information, problems emerge in the case of ambiguity, linked to dynamic complexity. Ambiguity refers to different interpretations, based on the norms and values of the players. These interpretations will be fed by new information, that maybe further worsen ambiguity, and sharpen the conflict rather than to prevent or resolve it.

An example may illustrate this. A medium sized city in The Netherlands had planned a light rail project with alternative routes for the line. At presentation of the options, a dispute arose about the inconveniences to citizens living next to the lines (e.g. visual impact, noise nuisance, access barriers etc.). The preferred option of the alderman was financially more attractive than that of opposing parties, who had focused on overcoming the inconveniences. To get more insight into these inconveniences, engineers were asked to make further calculations about frequency of the trams and the noise nuisance. But when the outcomes were presented to the two parties, each party found something to their liking and the conflict further sharpened. More investigations and calculations followed, even though a local counsellor lamented: "Does politics need all these calculations? I don't want to see this detailed information, because it will start a discussion about details with calculations on calculations on calculations ..." In the event the parties could not reach an agreement. The new information did not 'put out the fire'; it poured gasoline on it. The result was that the funds to be provided by the central government were withdrawn even though all involved supported the light rail connection between the centre of the city and the newly developed part of the town.

The differences on how to deal with uncertainty and ambiguity are summarised in the table 7.5.

	Uncertainty	**Ambiguinty**
Nature	Shortage of information and knowledge for grounding action	Presence of diverging frames from where problems and solutions judged.
Operational concepts	Risk, uncertainty, ignorance.	Confusion, contradiction.
Way to handle	Information gathering, use experts, conducting research.	(Joint) sense making, Joint production of meaning.

Table 7.5: Differences between uncertainty and ambiguity.

Another example from our case studies on the behaviour of the project delivery organisation (and the civil principal) was found in Uri. Here, motivated by the potential for cost savings, the project delivery organisation ATG proposed a project scope change in the spatial planning procedures that was totally unacceptable to the local community but fitted within their own requirements for project delivery. Again this caused a heavy delay to the project because ultimately many adjustments had to be made in order for the project to continue.

So resistance to change can cause stakeholder opposition as we saw at the Betuweroute and in Uri in the face of the attitude of the project delivery organisation 'to stick to the original plan as far as possible'. Especially during the early stages of the project this attitude meant that there was insufficient room to accommodate the demands of involved stakeholders which caused conflict. At the end of the day it turned out that many of the original stakeholder demands would eventually be incorporated into the project. With its initial resistance to change, the project delivery had lost valuable time. Here we see the pitfall of systems management: in order to fit the changing preferences of stakeholders, flexibility is needed and change is inevitable. So systems management does not work well in dealing with dynamic complexity. Of course the key in this matter is to be able to judge accurately when to

incorporate a change and when to stick to already developed routines in the project, as we will show in the remaining chapters.

This brings us to another notion regarding the behaviour of the project delivery organisation in LIPs: the project seems to create its own 'vested interests'. As we stated the project delivery's raison d'etre is the delivery of the project. But as we saw in chapter 5, one element of complexity in LIPs is that objectives of a project change over time because of shifting preferences in the stakeholder network. When objectives shift, some earlier objectives might become obsolete and sometimes even the whole project's existence will be endangered as we saw with the Hermans Committee decision in respect of the Betuweroute (see text box 7.9).

Committee Hermans at the Betuweroute

In 1995 a new government was installed that contained some political parties that were opposed to the initial decision to undertake the Betuweroute project. During the negotiations to form the new government coalition it was decided to establish a special committee led by L. Hermans to investigate whether or not the project should be continued. At that time the early objectives of the Betuweroute to achieve an economic return, a modal shift from road to rail and as a project to stimulate sustainability had become outdated because of changed circumstances. During the Committee's investigations various stakeholders advanced the pros and cons of the project. One of the stakeholders arguing for the continuation of the project was the project delivery organisation. Eventually the committee recommended to the government that the project should be continued. The main justification for the project changed to a strategic decision to connect the harbour of Rotterdam with its German hinterland. So the objectives of the project had fundamentally shifted. The committee also recommended some extra mitigating measures to be taken to reduce inconvenience to local communities. The recommendation of the committee was followed by the government and the project was allowed to continue.

Text box 7.9: Committee Hermans at the Betuweroute

With the Betuweroute, but also in our other cases, we again see that the project delivery organisation is an important player in its own right, it has an opinion and tries to influence the outcome of processes such as the recommendation of the Hermans Committee. This tends to increase the resistance to change of project scope or even abandonment. The rigid application of systems management is consistent with this and in combination these factors can cause 'lock-in' where a project is executed in such a way that even though it does not meet stakeholder needs it cannot be altered or stopped. Rigid cost control for example is of no use when the facility the project will deliver is not tailored to stakeholder needs. This is the pitfall of systems management. How project stakeholders can deal with this tendency for project lock-in is described in chapters 8 to 10 as we consider interactive management and dynamic management.

7.5 SUMMARY AND CONCLUSIONS

Project management evolved from general management theory. Note that the design principles and principles of classical organisation, such as span of control and discussions about centralisation versus decentralisation, can also be applied to large project delivery organisations. But there are also differences between operational organisations and projects thus stimulating a distinct theory of project management.

In this chapter we focused on project management in the sense of systems management, because systems management is of particular use in managing the detail complexity within LIPs. We have demonstrated the benefits of systems management, in particular in the many situations where it is necessary to shield part of the organisation from 'dynamic complexity' to create progress and maintain control. We identified two main systems management strategies: (1) decomposition in time, end product and organisation, and (2) management processes of schedule, costs, quality and risks. Although systems management is often regarded a hygiene factor in the management of LIPs, we concluded that its application is certainly not a given. Systems management within LIPs is a time consuming task – often supported by sophisticated tools –that requires continuous attention in the set-up and in the use of appropriate instruments of project control. Systems management helps to create progress, to define responsibilities between players, to regulate and document changes and to improve accountability for decisions taken.

On the other hand we also noted that systems management does not seem to be a very flexible approach to the management of complexity. Because of the need for decomposition and control of scope and time & budget constraints we often observed a tendency to stick to outdated solutions. -control is a 'design approach' - from a fixed problem and a clear goal, the project is executed by decomposition and rigid management process which presupposes a stable environment. But LIPs are characterised by the occurrence of new developments and new insights, or 'dynamic complexity' as we labelled it earlier in this thesis. So, while the use of systems management can certainly be beneficial, we need something more to address dynamic complexity. This 'something more' is the interactive management approach. Interactive management is an approach that starts with the notion that the context changes and that projects needs to be realised in interaction with all kind of stakeholders.

8. INTERACTIVE MANAGEMENT – MANAGING DYNAMIC COMPLEXITY

After our description of the strategies of control to manage detail complexity, we now turn to management strategies aiming primarily to manage dynamic complexity. We have labelled these strategies 'strategies of interaction' since the core of the strategies is to decide and manage in both an interactive manner and an iterative manner.

At LIPs many stakeholders are involved, problems are not static and solutions tend to be volatile. Coalitions are formed and broken. Decisions of project managers can, in the long run, have consequences different from those originally intended, as we saw in chapter 5. In projects with these characteristics, there is a need for interaction as we have already seen in chapter 6. This need for 'interaction' cannot be addressed with the approaches of systems management which focus on 'control'. On the contrary, in chapter 7 we saw that the use of control strategies might produce unwanted results when applied in situations with high dynamic complexity.

In this chapter we describe strategies to deal with dynamic complexity. These strategies originate from 'interactive management' (mainly), but with some strategies added from the theory of 'complexity management'. First we outline both these theoretical fields (8.1 and 8.2). After that we outline the strategies of interaction (8.3) and the key findings of the application of these strategies in our cases (8.4). The chapter closes with summary and conclusions (8.5).

8.1 THEORY OF INTERACTIVE MANAGEMENT

"Our task is to create a pearl that can shine for everyone, and to string the pearls into a beautiful chain, without making a weak compromise."
Mr. Albert de Vries, Project Manager Mediapark, Hilversum, 2006.

Project manager Albert de Vries has observed the effects of an 'internal and content focused approach' several times, see table 8.1 (De Vries, 2004).

Intention	Reality
• We start as soon as possible, without loosing any time, • We tackle the specific problem, • We find several solutions and choose the best one, • We produce a final report, • The report will be released for participation.	• Disagreement about the problem and, as a result, about the solution, • We plan without thinking about (the way of) interaction, • We hand the project over to specialists, • The solution is fixed, • Therefore, we create our own resistance!

Table 8.1: Intention and reality 'a project manager's observation'

The 'intention' (left column of table 8.1) conflicts with the kinds of social and dynamic complexity we observed in chapter 4 and 5. It is reminiscent of the 'content focused approach', described in chapter 6, but also contains elements of the control strategies of the previous chapter. This is because the approach is aimed at managing the detail complexity and there seems to be insufficient focus on the social dynamics involved in a LIP. Systems management is a 'tight' method, especially suited to circumstances when the project goal is clear, the project evolves according to regular project phases, and change is less prominent. And, as we concluded – dynamic complexity is the most dominant element in LIPs' complexity. So we need additional and appropriate management strategies. We label these strategies the strategies of 'interaction'.

Decision makers and managers of LIPs operate in a complex society, with many players involved that represent conflicting interests. Analyses of the 'players' involved show dozens are active (see section 4.4). These players are usually not related in a hierarchical way but through a network of formal and informal links. Some examples. The Minister of Transport may maintain strong ties with an environmental pressure group; a local government party is willing to support farmers in their opposition to a scheme because of the forthcoming elections; and the highway administration is willing to please a regional government so as to advance their interests in another development.

Last decades have seen stakeholders became more aware of their rights and potential influence and as a result they have found a voice. Pressure groups became professional counterparts of the project delivery organisation, with insight in the latest technical and environmental developments. They are supported by legislation, which secures rights for official consultation, but stakeholders often enter the arena much earlier than these specific 'statutory consultation moments'. In addition, there are several interested users, companies and governments who will benefit from the new facility and might cooperate with the initiator. Stakeholders therefore play an essential role in the shaping and execution of a LIP. However, as observed in chapter 7, it is this area – interaction with stakeholders – which systems management has largely neglected.

Interaction strategies are different from control orientated strategies in the sense that problems are regarded as potentially ambiguous and the goal is player related. The goal of the project is not fixed and stable. Strategies of interaction focus on satisfying needs through interaction in the network of stakeholders and through flexibility. Flexibility is the ability to act proactively in a beneficial way to changing circumstances or to the outcomes of management decisions. As we saw earlier when looking at dynamic complexity, the outcome of management strategies is uncertain. Interaction strategies try to influence the 'self-organisation' processes of a stakeholder network in a favourable manner. The process is more iterative than the application of more rigid strategies of control.

The strategies that focus on interaction mainly originate from two fields of study: the field of interactive management ('proces management' in Dutch) and the field of complexity management. The theory of 'proces management' is described in this section, in the next section we describe the theory of complexity management.

In The Netherlands the field of 'proces management' originated in the 1990s. One of the triggers for its development was the enormous problems encountered with several LIPs such as the Betuweroute. As we saw, the Betuweroute in the first years of the 1990s was 'a showcase' for the content focused approach. In The Netherlands by the mid 1990's the Betuweroute, but in its wake several other projects, had made clear that a new approach was needed, one that would pay more attention to the needs of local inhabitants, (local) governments, private companies and interest groups (NGO's). This led to the development of the theory of 'proces management'.

The management of LIPs was claimed to be too focused on control and as a result produced unsatisfactory results. Van Twist (2003) indicates the relationship between control and interaction (table 8.2). This shows that control is appropriate in certain situations while interaction is more suited in other situations.

Control fits when:	Interaction fits when:
• (Sub)problems can be isolated. • There is a consensus between players about preferred solutions. • The number of involved players can be reduced. • Stakeholders have the same interpretation of project facts. • Questions of power are less relevant.	• Many players are involved with different interests. • Players have a large degree of autonomy, there is an incomplete hierarchy. • Mutual dependencies between involved players. • Unstructured problems. • Interwoven issues. • Unpredictable decision making process. • Deadlock in project progress.

Table 8.2: Suitability of planning and development

Several authors discuss the differences between strategies of control and interaction although they often use different – but similar – terminology for the words 'control' and 'interaction' (Bekkering, 2001, De Bruijn et. al., 1998; De Vries, 2004). We present an overview in table 8.3.

Strategy	Control	Interaction
1 Problem	Unambiguous and fixed problem.	Ambiguous perceptions of the problem.
2 Goal	Fixed goal, determines direction and course.	Goal is related to players and is likely to change. Fixed goals block creativity.
3 Focus of management	Optimising content (schedule, costs, quality).	Satisfying needs.
4 Structure	Unravelling makes sub-solutions possible (break down structures). From selection of alternatives, one best alternative is chosen.	Broadening and linking of needs leads to new opportunities. Variation of strategies (e.g. scenarios) leads to the ability to respond adequately to changes.
5 Information	Objective, robust and analysable.	Subjective, player related and negotiable.
6 Schedule	Linear. Start with agreements on the content.	Iterative. Start with process agreements.
7 Decision making	Decision assures result and determines new phase.	Decision is related to a specific moment (in time). Durability depends on forthcoming interactions.
8 Relationship	Hierarchy, formal.	Network, informal.
9 Environment	Stable, independent players.	Volatile, a network of interdependent players.
10 Complexity	Threat.	Opportunity.

Table 8.3: Comparison of the strategies of control and interaction

The difference in approach is interesting, not just because Van Twist indicated that there is not 'one best way', fit for all circumstances, but that both approaches can be useful and have to be aligned to the circumstances faced. So, in our terms, we have a need for both interaction and control – which fits nicely the distinction in detail and dynamic complexity. In chapter 9 we go into more detail on the combination of these strategies, when we present our approach of 'dynamic management'.

De Bruijn et. al. (1998) mention four core elements of an interactive design, which represent fourteen design principles for interaction, see table 8.4.

14 Design principles of Interaction (De Bruijn et. al., 1998)	
Openness	1 All relevant players are involved. 2 Choices are agreed upon in process agreements. 3 Transparency of processes and interaction.
Safety	4 Core values of players are protected. 5 Commitment to the process, not to the result. 6 Players can postpone commitments. 7 Exit rules.
Progress	8 Incentives for co-operation, especially at the completion of processes. 9 Top level players. 10 The context is used to accelerate the process. 11 Try to remove conflict from the centre of the interaction. 12 Command and control as an accelerator for interaction.
Content	13 Content facilitates process. Experts and stakeholders have different roles. 14 The process develops from variety of content to selection.

Table 8.4: Four core values with fourteen design principles for Interaction

These design principles focus on the alignment of stakeholders' objectives, but also mention the influence of the context (10) and the use of variety (14). This means they show some of the elements which are more often found in the theory of complexity management to which we now turn.

In chapter 5 we concluded that complexity within LIPs is in the main dynamic, which means that it is strongly related to the dynamics of the stakeholder system – the changing preferences and behaviour of the involved stakeholders. This is also the key of social complexity (chapter 4). Strategies of control are not sufficient, and are sometimes even contra-productive, to deal with this type of complexity. On the other hand interaction particularly concentrates on this dynamic complexity. Interaction can successfully be used when circumstances are uncertain and when the stakeholder system evolves over time in a non linear fashion. In the process of interaction, new rounds mean new opportunities!

8.2 THEORY OF COMPLEXITY MANAGEMENT

> *"Anyone who honestly believes that they have everything under control, is seriously out of touch with what is going on."*
> Flood (1999).

The field of complexity management offers some additional insights in how to deal with dynamic complexity. Authors from this field have outlined that the deterministic perspective (see table 5.1) – and its related strategies of control – do not allow adequate management of dynamic complexity. As a response they point us to strategies focussing on increasing organisational flexibility.

In section 5.4 we showed that the core of dynamic complexity lies within the potential of the stakeholder system to evolve over time: self organisation and co-evolution. In addition we described what effects dynamic complexity has on decision making. Decision makers need to operate in a context of limited understanding and predictability. David Levy (2000) mentions some additional implications of dynamic complexity:

- long-term planning is impossible
- dramatic change can occur unexpectedly

Long-term planning is impossible

It is difficult to justify the argument that a long-term plan is the strategic task of any (project) manager and organisation. Think of decisions on which markets to enter; long term investments to make; and possible attractive alliances into which to enter. Levy argues that advanced planning models work for a maximum period of 3 to 5 years and, after that, the accuracy of forecasts declines very rapidly. The pay off, in terms of better forecasts from building more complex and more accurate models for long range planning, may be small.

For the West Coast Mainline, in the mid 1990's Railtrack estimated the total investment cost of the West Coast Mainline upgrade as £2bn. But the budget ran totally out of control. By 2002, revised estimates indicated that the line upgrade would cost over £ 14,5 bn. At the end of 2006, the West Coast was planned for completion at £8,3 bn. (2005/06 price level). This illustrates the dramatic changes which are possible in the scope and cost development of a LIP, putting the value of long term planning into perspective.

In June 1999 the Ministry of Transport of The Netherlands sent a paper on 'Market Consultation for the operation of the Betuweroute' to over 700 firms worldwide. This consultation paper was combined with consultation to determine the level of interest in a tender for the superstructure of the Betuweroute in a 'Design Build Finance Maintain' contract. The consultation's response was disappointing. One of the reasons for this was that consultation was too early in the process, because at that stage the planned date of operation for the Betuweroute was 2005. Investors regarded this period as being too far ahead to forecast revenues for their investments.

In the projects studied we have seen that LIPs often have a planning horizon of 15 to 20 years or more (Hertogh et. al. 2008) and that planning is difficult. Experience shows that the time estimated for project delivery is normally somewhat optimistic, see the text box.

The Gotthard Base Tunnel and Lötschberg Base Tunnel show different planned dates of completion (see figures 3.13 and 3.14 in section 3.4.1). The Gotthard is an extreme example of delay. From 1996 to 2007, the planned completion date shifted from 2009 (in 1996) to 2017 (2007), so you could say that in 11 years there has only been 3 years progress. The Lötschberg, however, is a good example of 'tight' planning. From 1996 to 2007 the completion date remained 2007, although we should note that the scope underwent major changes during this time.

Dramatic change can occur unexpectedly

Levy gives examples of abrupt occurrences that cause large changes. Examples are: the entry of a new competitor, or the development of a seemingly minor technology which however has great impact (like the transistor radio). In chapter 5 we saw many similar examples from our cases.

In 2005 several infrastructure projects in The Netherlands were temporarily halted, because of failure to meet air quality objectives. The European Commission had set new standards, which stated that the air quality could not be diminished by new construction projects. Although these regulations were known to some specialists, for many decision makers and managers these came either as a surprise, or else they had not foreseen the impact. For whatever cause, because of the new regulations the planning of various LIPs was suddenly heavily delayed.

How do you manage in situations where complexity theory applies – situations where long-term planning is impossible and dramatic change can occur unexpectedly? Does this complexity only create confusion? What can managers do in a world where the many, many local interactions matter, interactions which cannot be known and are very difficult to observe and to measure? Situations where we know that emergent behaviour is dominant – a world where minor factors can have great importance and where starting conditions can be extremely important? A potential solution offered by authors from the field of complexity offer is to increase organisational flexibility. Levy mentions that some complex systems exhibit patterns and short-term predictability, and that organisations can also be 'tuned' to have more variety and as a result offer more flexibility.

In our list of strategies we will discuss recommendations especially of David Levy (2000), of Axelrod and Cohen (2001) and of Flood (1999). Although literature on complexity theory, applied to organisations, is fairly recent and the experience base is small – it has provided us some useful insights in the management of LIPs. Also the theory on complexity management is still very much linked to the field of permanent ('routine') organisations and not has been especially linked to projects in general, nor large infrastructure projects in particular.

In the next section we present strategies of interaction, which we have formulated – based on theories of interactive management, complexity management and findings from our cases.

8.3 STRATEGIES OF INTERACTION – MANAGING DYNAMIC COMPLEXITY

Control is based on a 'design approach': from a fixed problem and a clear goal, the project is executed by decomposition and management processes (schedule, costs, quality, risks) which presuppose a stable environment. The project follows successive project phases in linear fashion. Strategies of interaction however are different – problems are not unambiguous and goals are related to the players and are not fixed. Management focuses on satisfying needs through interaction in the network of stakeholders and on flexibility to have the ability to act proactively to changing circumstances and to new insights. It is an approach which is based on 'development'. As we saw earlier with dynamic complexity, the outcome of decisions is uncertain. Strategies of interaction try to influence the 'self-organisation' processes in a favourable manner. So, the process is therefore more iterative than with strategies of control. We distinguish four major strategies in the management of dynamic complexity:

1 Alignment
2 Redefinition of the problem and change of scope
3 Using short term predictability
   - selection of successful strategies
   - systematic evaluation
4 Variation
   - in strategies, solutions, organisation and personnel
   - scenario analysis and pattern analysis

These strategies are discussed in detail in the next sections.

8.3.1 Alignment

> *"Be absolutely open and honest in your communication, 'straightforward talking'. Tell the stakeholders good news as well as bad news! The easiest thing is to create false expectations, but people will remember them."*
> Manager, Project Sponsor West Coast Mainline, Department for Transport.

A main challenge for managers active in LIPs is to align stakeholders in such a way that the project has shared objectives and a shared vision as to how to accomplish these objectives. We have combined various actions and approaches which can be useful in achieving this objective which we will call 'alignment' – since these strategies aim to connect the interests of the stakeholders within a LIP.

Useful recommendations on alignment have emerged from an initial group of authors that have looked at the management of ambiguity. As we saw in chapter 5, ambiguity is very much related to dynamic complexity. Pauly (2001) stressed the need for players to find a way to deal with conflicting (or the absence of) clear interpretations; and the lack of shared norms and values. It is necessary to reach agreement on how to deal with this ambiguity. This will cost time, which not all involved think is available. They need to decide whether or not to invest in their relationship. Pauly recommends:

a Make agreements on how to deal with the ambiguity.

In addition, Noordegraaf (1999), based on a Schiphol case study, formulated some additional interesting recommendations on how to deal with ambiguity:

b Challenge people to interact, not to close down debate but try to be open to suggestions.
c Focus on the exchange of arguments and share sensible interpretations.
d View collective actions in respect of sense making and identity. "What does it mean to me?"

A central theme in these recommendations, a through d, is the interaction between the involved stakeholders, so as to increase the collective interpretation whilst reducing the ambiguity. Now, how can this type of approach be observed in our cases? An outstanding example of alignment in cases studied is the West Coast Mainline.

In the West Coast Mainline case, alignment of objectives of all concerned is crucial to making the project a success – "To try to get all the people aligned upfront", as the project sponsor told us. They called it "A method of keeping in touch, where you don't have to be innovative in informing all the stakeholders in a series of meetings". The example of West Coast Mainline shows us that stakeholders, if actively involved, can make a very positive contribution to the efficiency and improved outputs of LIPs. We will elaborate how interaction was applied at the WCML with 3 examples that originate from the third round of decision making:

- Cross-industry, open approach,
- West Coast 250 and
- Attitude towards stakeholders.

Cross-industry, open approach

After half a decade of a project at an apparent standstill with railway traffic rapidly increasing, operators had become extremely frustrated at the lack of progress. There had been no consensus either between the train operators and Railtrack, or indeed within Railtrack itself. The Strategic Rail Authority (SRA) decided to obtain an open, cross-industry approach. They wanted to inform the entire railway industry about their strategy for the West Coast Main Line and to achieve a consensus. In October 2002 a new consultation document was published. Under the leadership of the SRA (now DfT) different parties of the railway industry became actively involved in developing the consultation document and eventually signed up to it. The document included revised franchise specifications for the train operating companies.

So the train and freight operators who had been excluded for contributing to the project became heavily involved and provided the SRA with an immense amount of practical advice and guidance. This plan was not made in 'splendid isolation' as was done before, but in interaction with the whole rail industry and important stakeholders. To involve passenger and freight operators in early project rounds can yield many benefits:

- Rail safety systems and standards are complex. This is especially true when the interactions between infrastructure and rolling stock are taken into account – a lot of interfaces have to be adequately managed. There is a great deal of operational and engineering expertise in the railway industry which can be drawn on, and effectively applied – and the infrastructure will eventually be exploited by rail operating companies.

- Train operators have a clearer view on current and future customer needs.
- Construction and operation often need to be organised simultaneously. By involving the industry a better and clearer specification emerges, resulting in reduced costs, a more robust design and a more effective implementation.

Virgin is the busiest operator on the route. It is interesting to note that Virgin had an inward looking policy in round 2: "We built brick walls around us". But Virgin has subsequently found that cooperation with other train operators is better for all concerned. Network Rail has had a similar experience. In the initial years everything was done by following 'The Contract'. But, as relationships improved, communication shifted to a more informal basis, while respecting contracts and the positions of the parties. This turned out to be a better basis for cooperation and effective delivery. The important lesson is: "Cooperation with other stakeholders is better than an egocentric and contractual outlook".

'West Coast 250' (External stakeholders)

Most of the external stakeholders (in total more than 700 organisations) can be identified at three levels – County, District and Parish. These stakeholders are important because they represent the inhabitants along the line, who are also the users of the railway. They give 'local intelligence' concerning measures to be taken and they play an important role in explaining to the public what is being done on the project; also why things are done the way they are (explaining and reasoning).

West Coast 250 represents many of the local authorities along the line of route and also has a Parliamentary branch, enabling a direct dialogue with MPs. DfT, along with Network Rail and the train operators, continued to meet this body on a regular (bi-monthly) basis. West Coast 250 thus facilitated the link with external stakeholders.

In addition to 'West Coast 250' an informal network of communication has been set up. And, within the locally-based train operating companies, communication teams have been active to make sure contact with the public is of a high quality and has good coverage.

Attitude towards stakeholders

What does the project delivery organisation think is essential for the success of achieving the project objectives? The lessons learnt are:

- Alignment of objectives of the different parties involved in this project is crucial to make the project a success, to try to get all the people aligned upfront! A structural communication process is needed. The operators and maintenance people have to be aware that they all work for the same objective and that they make a difference in the success of the project.

- Regarding external communication, senior members of the government (at Secretary of State level) signed the progress reports and in this way re-committed Government, operators and Network Rail to the project. This demonstrates to stakeholders that they will get their requirements (outputs) in time.
- In communication "Be absolutely open, honest and talk straightforwardly. Tell stakeholders good news as well as bad news". The easiest thing is to make false promises; however people remember!
- Stop being party political. A project must not become too aligned with the preference of a particular party, because these projects last longer than governments.
- However much you can consult and tell people, most people don't realise the project's impact before implementation.
- With open communication diminishes the chance of "surprises" – which stakeholders in general don't like.

The alignment strategy takes the specific needs and perceptions of players as its starting point. These needs and perceptions cannot (fully) be known in advance; only through interaction we can get insight in the needs and perceptions of others and also of ourselves. Through this interaction, needs and perceptions evolve (as they also do through external developments). It is important to note that problems and opportunities need to be dealt with through this network of participants. So a stakeholder needs to be 'open' to the views of other stakeholders. The intention is that through the process of alignment, solutions with a wider range of support can emerge. In this sense the process reduces ambiguity – and, by the same means, complexity – by aligning the interpretations and perceptions of stakeholders.

In the highway project A73-South core values of the regional partners were respected. Through interaction a package for solving the mobility and safety problem of the region was developed. Another example from this project, is the interaction with local people in the city of Roermond. How to deal with the local inhabitants? We can refer to two aspects. First a committee had been established composed of people from the district, RWS Limburg and the contractor. The goal was not only to keep people informed, but also to interact with them to use the local intelligence, as we were told by the Roermond co-ordinator. Important issues were traffic circulation and safety for cyclists and pedestrians. The second aspect is about the attitude to communication. The co-ordinator mentioned as important features in communication:

> *"… openness, tell why you are doing it, understand the inconvenience and have an eye for details, every traffic sign is important."*
> *"They (local inhabitants) know what is best for their district."*
> *"When people wanted to complain: be accessible, 24 hours a day."*
> Co-ordinator, City of Roermond.

The experiences in Roermond are in line with the recommendations from the West Coast Line upgrade project. In both projects the participants experienced a strategy of alignment leading to improved working relations, better solutions, and more satisfied local stakeholders.

8.3.2 Redefinition of the problem and change of scope

The second strategy of interactive management to deal with dynamic complexity originates from the view that the content of the discussion between stakeholders needs to be flexible instead of fixed (Kickert 1997; Teisman 1997). This strategy is very much linked to the strategy of alignment described in the previous section.

As mentioned earlier, the strategies of control assume that scope is fixed at a certain point in time, but in our sub-cases we observe that scope is volatile. Just take a look at our case histories in chapter 3. The scope of LIPs change because the preferences of stakeholders shift over the course of the project. As a result the issues (problems) addressed by the project need to be redefined. In the process of continuous interaction and collaboration, issues will become inter-connected and things will often be seen in a new way and therefore views need to be reformulated. This was one of the main conclusions of chapter 5 where we argued that the changing preferences of stakeholders is one of the key elements of complexity in LIPs. Changes in preference can result in interesting developments: redefinition of the problem and changes of scope.

Two examples of redefinition of the scope are the Gotthard and Lötschberg tunnels (text box 8.1) and the A73-South (text box 8.2)

'The biggest environmental project in Switzerland'

In Switzerland we saw two examples of the 'redefinition of the problem' and 'change of scope' with the Gotthard and Lötschberg tunnels. The first is that by the mid 90's awareness was rising among responsible politicians and civil servants that both tunnels were not only a transport facility, but were of important environmental importance and this reshaped the expressed purpose of NEAT. To express this thinking, the slogan 'The biggest environmental project in Switzerland' was developed and has been used since then

The second example of a major redefinition is the FinÖv-Fund, that was important to secure NEAT's future. The FinÖv fund is a financing programme that enlarged the scope from the two projects, to a package which also embraced high speed connections, noise protection measures and Bahn 2000. It is possible that this fund will be extended beyond the current period of 20 years.

Text box 8.1: Redefinition of scope at the Gotthard and Lötschberg

Redefinition of the scope at the A73-South

The government decision to put the A73-South project on hold triggered a whole series of events in which the Province of Limburg, in co-operation with other stakeholders, initiated a process to restart the project. The approach used proved to be successful, because the project restarted and funding was later approved. It is interesting to examine the approach used to manage the complexity and to see what caused this success.

The regional partners in the Province of Limburg were disappointed that the Minister postponed the project not just once, but twice. After the second postponement in 1998, the deputy and the director of RWS Limburg took the lead and in cooperation with the aldermen of the cities of Swalmen, Roermond and Ambt Montfort they tried to find a solution. They knew the minister had budget problems and they judged their chances as low when they protested against these delays. They had to find a means of persuading the minister with a convincing and feasible alternative plan. A two step approach was formulated. First regional partners needed to reach agreement – to become aligned – and then they would try to make a deal with the Minister of Transport.

All relevant regional players were involved in the effort to restart the project. The key players knew each other well, had respect for each other and shared a mutual interest. The perception of the problem was shared by all partners and the process of collaboration facilitated their 'joint sense making'. They shared their disappointment at the decision of the Minister. Those involved and responsible had sufficient mandate and knowledge – about interests, local situations, engineering, procedures and so on – so ambiguity was not an issue and progress could be made. This all laid the regional foundation for the deal. The deputy told us: "it was a matter of wheeling and dealing", to look for mutual benefits and so that at the end of the day, each organisation could show sufficient benefits and return for their backing.

The basis of the solution was found by expanding the project scope from that of a single project, the A73-South to a solution embracing the mobility problem of the region. A package of four projects was proposed (later on a fifth, Haelen was added), which contrary to what you would expect made 'the project' feasible. The broadening of scope had has two major advantages.

1 The Province could realise three (four) new projects;
2 Because of the combination important cost savings were possible.

The Political Agreement between the Ministry of Transport and the Province of Limburg, which captured the redefined scope, laid the basis for the realisation of the programme in terms of scope, costs, planning and risks.

Text box 8.2: Redefinition of scope at A73-South

The examples show how interaction can provide benefits in the management of dynamic complexity by redefining the problem and facilitating scope changes that increase the benefits of the project to involved stakeholders. Interaction makes it possible to look beyond individual interests and 'to break through the borders of individual responsibility'.

8.3.3 Using short term predictability

Even though LIPs experience non-linear implementation patterns, their development is often predictable in the short run. This knowledge can be used by project managers. Using short term predictability embraces the following strategies:

1 Selection of successful strategies
2 Systematic evaluation

Both these strategies deal with dynamic complexity by paying regular attention to the issue at hand and by constantly adjusting the approach where necessary, so as to align strategies with the context and objectives of the project or the issue at hand. So it is not so much a strategy to reduce complexity, but by monitoring complexity over time, responding to developments accurately. As we conclude in chapter 5, a key element of complexity is that preferences of stakeholders shift over time. These changes can both be caused by external events – such as disasters and government elections – and by the effects of past decisions. The strategies we describe here are most relevant to addressing the effects of past decisions.

Developing new alternative approaches based on the effects of past decisions can especially be achieved with strategies using short term predictability.

1 Selection of successful strategies

In the theory of complexity management we find that selection can be crucial in finding which agents (people, organisations) and strategies must be copied and which can be ignored. Important factors are (Axelrod and Cohen, 2001):

1 Definition of success criteria.
2 Determination of the level of selection: agents or strategies?
3 Assign credits to success and failure.
4 Creation of new agents and strategies.

Interaction is an important driving force in choosing the right strategies. Through this interaction, people experience what is successful and what is not, they see possibilities for new combinations.

Two recommendations attract attention (Axelrod and Cohen, 2001):

- Define success criteria for the selection of agents or strategies. It is better to search for more detailed success criteria for the short run than broader success criteria for the long run.
- Use social interaction to spread successful strategies.

To do nothing or not to react immediately, can be a strategy in itself. In 2002 and 2003 a risk analysis was carried out into the Betuweroute's organisation. Many risks were found to be management related. It was striking that some of the risks named at the project director's level did not lead to any specific actions. The project director decided to do nothing, and only observe how others would react. Often the sensitivity diminished because other issues came up and/or the issue 'resolved itself' in due time.

One approach that fits the strategy of selection is learning from other projects by using best practices and lessons learnt. But we found that this type of strategy was rarely found in our cases. One example however is presented below.

Projects are finite, with less repetition in processes than in routine, permanent organisations. However, we also see a desire in large projects to learn from mistakes and to improve. The Betuweroute is a quality certified organisation with regular internal and external audits and management reviews. The Betuweroute started a knowledge programme around 2005 to record best practices and lessons learnt, and to exchange this knowledge with other organisations. The programme covers knowledge meetings and publications (in print and by means of a website).

Apart from the example provided, evaluating and learning from similar and past projects does not seem to be at the core of the management focus of project delivery organisations. This can be said of both internal evaluations as well as of learning from other similar projects. Even though learning from past successes and failures is a concept supported by many project managers as being very useful, in practice it is not something that is seen as part of the routines of project managers (Hertogh et. al., 2008).

So our conclusion regarding selection and learning, is a paradox:

> *LIPs experience the 'learning paradox': Learning from your own and other similar projects can offer great benefits, but in practice is a rarely applied strategy.*

A possible reason for this lack of reference to successful strategies is that learning from others is often defined as being outside the tasks of the project manager. It does not fit with the traditional constraints of budget, schedule and quality (Hertogh et. al., 2008). Other possible explanations are that starting from scratch, rather than with 'lessons learnt' from another projects or from a different team, can create the sense of cohesion needed to start things up. In addition, one of the difficulties is that experiences from one situation can never be directly transferred to another situation. This is one of the characteristics of complex systems – such as the stakeholder system within LIPs. A best practice from elsewhere can never be copied without:

- Understanding why it was applied at a certain place and certain time.
- Understanding the characteristics of the context in which the best practice did work and the differences from the context in which you are trying to re-use the successful practice.

So for every situation a tailor made solution should be developed, even though using past experiences can be useful in the process of getting there.

2 Systematic evaluation

In the complex projects studied often the most that can be done, is try to manage the project at the local)level and consider continuously 'What is going on at other levels involved?' Improvements can only be defined locally and are 'stakeholder based' but should take the broader 'whole systems perspective' as their focus. Our starting point is the player (agent), who interacts on a local level. What can he really do? He has to focus on his own organisation: to set objectives, plan his own actions, execute and evaluate and act again. This reminds us of the continuous Deming Circle: Plan – Do – Check – Act. As we demonstrated in chapter 5, complexity means that decisions of project managers can have consequences different from those expected. A possible explanation for this, is that their actions are aimed at only one part of the system without taking the effects on the whole (or broader) system into account. As a result a process of constant evaluation and weighing alternatives can be a fruitful strategy.

Flood stresses the need for systematic evaluation to handle complexity (Flood, 1999). Four types of measures can be considered:

- Measures of efficiency and reliability of systems and processes
- Measures of effectiveness of systems of structure
- Measures of meaningfulness of agreement in the context of sense making
- Measure of fairness of systems of knowledge-power.

In order to manage complex issues, systematic evaluation is an indispensible instrument. It can help project managers in LIPs to assess their current position and to

determine future strategies. While this concept seems to be a 'no-brainer', in practice this is easier said than done. Often we see that project managers within LIPs are dogged by such an overload of information and tasks that picking out those issues that are key to the achievement of project objectives is difficult. The attention of project manager is not an unlimited resource.

> *"Only five or six monkeys can sit on the shoulders of the project manager at once, all others will drop off."*
> Quality manager, Betuweroute.

This is why it can be beneficial to get an overview of the most complex issues in a project. The categories presented in chapter 4 might be helpful in this respect.

> *Project managers can benefit from a complexity scan in order to identify issues of complexity within their project. This can help by focussing the appropriate management attention in terms of systematic evaluation.*

The Betuweroute project organisation was the first large infrastructure project in the Netherlands to receive the ISO 9001 certificate. The working processes within the project organisation have been outlined in the quality system. The quality system has changed many times over the years. The initial versions proved to be too detailed to provide project employees with adequate support in their work. This has led to a decision to cover only the most important issues. As a result the quality system has become more and more practical. The system helps the project organisation to work effectively, efficiently and accountably in a uniform way, unless there is a reason to deviate from standard processes. This approach fits the project context: you have to treat people and issues along the line consistently. For example, contract teams needed to comply with the fixed rules set in the system. Within this quality system, evaluations by means of internal and external audits were regularly carried out. The outcome of the audits appeared to be starting points for improvements. This is an example where a system was improved due to systematic evaluation.

In addition sponsors use systematic evaluation as a means of external audit of the project delivery organisation. However, often audits aim more to judge than to learn, looking back instead of looking forward. Audits might give an overview of what happened in the past, but not necessarily how to approach things in the future.

8.3.4 Variation

To protect against what is to be said to be 'the unknowable nature of things', variation can provide some redundancy and increases the chance of well-fitted actions. Axelrod and Cohen (2001) mention that variation in a population is a crucial requirement for adaptation. Uniformity, such as is sometimes found in a project team, can be a

disadvantage in a changing world, such as in LIPs. But even in a static world, variation is needed to stimulate improvements. Variety plays an important role in Darwin's theory where evolutionary adaptation is the result of mutations and differential reproduction (Axelrod and Cohen, 2001). This way of approaching dynamic complexity can also be applied to LIPs. Again the strategies of variation do not seek to reduce complexity but aim to handle complexity or, in the words of Professor H.R. Schalcher, 'play with complexity'.

On the topic of variation, Axelrod and Cohen (2001) present two additional notions:

- liberalisation of constraints
- eternal cooking versus premature convergence.

To find solutions to difficult problems, Axelrod and Cohen recommend trying to free yourself from certain constraints. By breaking through constraints, new variations can occur, variations that might be better and more successful. This is very much in line with the previously described strategy of 'redefinition of the problem' (section 8.3.2).

In chapter 7 we have already seen that 'premature convergence' was found in several sub-cases examined (table 6.2). Axelrod and Cohen advise: be aware of 'premature convergence' because this means you will loose variation too early in the process and promising future improvements are cut off. 'Variety should be treasured'.

On the contrary 'eternal cooking' can take place when the organisations are in a permanent state of upheaval. New outstanding ideas can however be lost as a result of new waves of change. When to choose for convergence – exploitation – or to continue innovation – exploration – is a fundamental decision, see the example below.

In case of the West Coast Mainline in the United Kingdom, at the end of the 1990's, the project organisation wanted to use ERTMS, but the development of this new technology turned out to be too costly and time consuming. When to abandon this potential development and to go for a more proven technology? Development stopped, because otherwise the project would have been unacceptably delayed and the completion date would have slipped even more. The ERTMS alternative was abandoned and a more traditional train safety and communication system was chosen.

Variation is a strategy that has been observed in cases studied, in order to address dynamic complexity in particular. Applying variation as a strategy is, again, not so much reducing complexity but matching complexity by betting on several horses instead of only one. This is different from the complexity reduction approach. In the use of variation we distinguish two tactics:

1 Varying strategies, solutions, organisation and personnel
2 Scenario building and pattern analysis

1 Varying strategies, solutions, organisation and personnel

Varying strategies of control and interaction is a core element of the dynamic management approach which we will describe into more detail in chapter 9. The combination of the strategies by the project delivery organisation has already been illustrated with examples from the WCML and the Betuweroute. But variation in strategies can not only be successfully applied by project delivery organisations and civil principals, it can also be of benefit to external stakeholders. A first example of this can be found in textbox 8.3 where the MFL used a combination of strategies to successfully manage their interest in environmental protection for the A73-South project.

Variation in strategies applied by NGO's at the A73-South

The need for Highway 73 itself wasn't controversial, but the discussion whether to build it on the west bank or the east bank of the river Maas was. After years of debate, in March 1995 the Dutch parliament finally decided to construct Highway 73-South on the east bank by a majority of one vote. The discussion between west bank and east bank turned out to be a balancing act between ecology and economy. The ecologists were defenders of the west bank route, so the highway wouldn't affect the ecologically more valuable east bank. The supporters of the east bank route focused on the importance of the connection to the city of Roermond, located on the east bank. In addition the existing road on the east bank was felt to be very unsafe.

At the A73 two major interest groups were active in protecting environmental interests: Stichting Milieufedratie Limburg (MFL) and Das&Boom that both favoured the west bank route. While the focus of MFL was a more general one, Das&Boom chose the badger and later on the common hamster ('korenwolf') as symbols of their efforts. But what strategy to use as an ecological interest group after the decision of parliament in 1995 to build on the east bank? MFL and Das&Boom both chose different options. MFL decided to co-operate with the project delivery organisation for the east route to discuss the best mitigating measures for road construction. "We live in this area", a representative of the MFL said "and we were trying to make the best of it". The feeling of the MFL was that in the first stages there is more to arrange and to gain than at a later stage when the design is more detailed and every change is difficult to obtain. So MFL focused their efforts on this early design stage. The co-operation with the project organisation worked out well. RWS established an advisory committee for ecological compensation in 1995, which MFL joined. Interestingly, whilst the MFL co-operated with the project organisation on east bank mitigating measures they also started legal procedures – also in combination with Das&Boom – to contest the east bank decision at the Council of State. This is an example of how variety can be used as a strategy by a NGO in respect of an LIP.

Das&Boom had an opposite strategy to that of MFL. They considered the east bank location as fundamentally wrong and were not prepared to discuss mitigating measures. Instead they focused on using legal procedures to contest the decision of Parliament. After intensive efforts their appeals turned out to be unsuccessful and Das&Boom chose to completely withdraw from the issue. On the other hand MFL had the flexibility to switch from an opposite attitude, to a co-operative one. The project delivery organisation accepted the two-way approach of co-operation to get environmental compensation. In the end MFL, even though the road was built on the east bank, got many mitigating measures for the road approved.

Seen from a higher level, the variation in strategies of both NGO's are a form of variance between organisations.

Text box 8.3: Environmental compensation at the A73-South

A similar strategy of variety applied by a NGO was observed at the HSL-South. Here a local interest group ('West Brabantse Vogelwerkgroep') was alerted when numerous dead birds were found along the noise barriers of the HSL-South. Apparently the barriers blocked main migration routes with major consequences. The interest group applied a variety of strategies in order to serve their interest in the best possible manner. Firstly, they send a letter to the project delivery organisation addressing the issue. Second they sought support from other environmental interest groups at both regional and local levels. In addition, they organised public protest walks along the route so people could see the effect of the noise barriers with their own eyes. These walks drew a lot of media attention. Fourthly, they started to keep track of bird casualties by researching the matter. Fifth, when cooperation did not lead to satisfactory results, they commenced legal action. The government legal counsel concluded that it was possible that a judge would decide in favour of the interest group and, to avoid the risk of this happening, the project organisation decided to take adequate remedial measures.

This broad array of strategies embraced co-operation with the project delivery organisation while at the same time seeking extensive media coverage that would engage political attention and, in the end, initiating legal steps. They concentrated on their interest and didn't occupy themselves with looking for solutions; they saw this as the task of the project delivery organisation. The strategies applied have been successful from their standpoint. The strategies have resulted in a redesign of the noise barriers: now vertical stripes have been added to the barriers to provide a visual warning to the birds.

These provide successful examples of both NGO's and of a project delivery organisation in applying a variety of management strategies.

Applying a variety of strategies can be of benefit for both the project delivery organisation and external stakeholders such as NGO's.

This is certainly not the only example of the application of variety. For example variety can also be applied to specific technical solutions (scope). Strangely enough in many of the observed sub-cases we found that project delivery organisations failed to use this variety in solutions: a 'Plan B' was found neither in our TTI examples nor in the vast majority of the other sub-cases.

This brings us to the following conclusion:

Project delivery could benefit from the development of several alternatives in dealing with technical complexity, especially during the early stages of feasibility and design.

During later stages of a project, keeping a Plan B at hand is often impossible or extremely costly, but during the early phases of a project keeping a Plan B seems a good idea. This is illustrated with the Øresund case from the NETLIPSE research (text box 8.4).

Øresund Crossing: take a plan B into account

ØSK, the project delivery organisation of the Øresund Crossing, employed a systematic and proactive approach to risk management. A number of notable risks, such as the effect on scope and schedule of the Swedish Water Court process and ruling were assessed and flexibility was built into plans to mitigate this. Even the delay caused by the unfortunate accidental sinking of one of the tunnel elements was overcome with a new 'Plan B' to ramp-up tunnel production capacity. In fact the innovative prefabrication process for the tunnel elements was considered to be the only area where ØSK had not had a serious 'Plan B' alternative immediately available.

Text box 8.4: Plan B at the Øresund Crossing

A third application of variety in the management of complexity found in our cases, is in the mix between private and public drivers in managing the project. Within the WCML project, it was shown that using only public drivers (round 1) or private drivers (round 2) did not lead to good results. In round three a mix between public and private initiatives proved to be more suitable (text box 8.5)

Variety in public and private institutions working on the WCML

During the third phase of the project, 'public-private' cooperation was reinvented. The renewed role for government did not lead to a return to the British Rail regime, as many aspects of privatisation had proved to be very successful. In the first period of this phase the responsibility for finding new approaches was handed over to the Strategic Rail Authority (SRA) – a non-departmental body. The SRA managed, in cooperation with the industry, to define a more realistic plan. The passenger and freight operators – who had earlier been excluded from contributing to the project – became heavily involved and provided the SRA with an immense amount of practical advice and guidance. This plan was not made in splendid isolation as before, but in collaboration with the whole rail industry and important stakeholders. This led to a complex institutional arrangement once more combining public and private drivers. This time, the managers in charge were able to deal with this complexity. They focused on desirable outcomes, managed support and dealt with the ongoing institutional change, like the abolition of SRA and the division of tasks between DfT, Network Rail and ORR.

This third period has led to an intriguing combination of public guidance and private production. An effective network of parties was built up, capable of dealing with the network characteristics and interdependencies (strategies of development) of the current physical rail network and future planned delivery. On the one hand there were clear formal divisions in tasks and responsibilities (strategies from a planning view), but there also were adequate informal networks and methods of collaborative planning, building up sufficient knowledge and support.

Text box 8.5: Variety in the mix of public and private at the West Coast Mainline

To summarise this (compare section 3.5.3), the lesson of the West Coast Mainline is:

> *Applying a hybrid form of joint public-private responsibility creates a balance between public guidance and private realisation power, which can lead to successful implementation. This variety in organisation fits dynamic complexity better than the less advanced structures involving purely public or private dominance.*

Another aspect to which variety can be applied is in project personnel. In text box 8.6 we give the example of the Betuweroute where a conscious strategy was followed to attract a diverse mix of contract managers.

Variety in selection of Contract Managers at the Betuweroute

In the Betuweroute project, Contract Managers were recruited for the execution phase at the end of the design phase. The contracts were very similar and so were the requirements of the Contract Managers, which were described in a single job description. The manager responsible for recruiting the Contract Managers chose not to select one type of Contract Manager for all the contracts. She thought it would be too risky. What would the consequences be if a job description was used that did not turn out to be successful? Moreover, she believed that introducing a variety in the personalities and competencies of Contract Managers, would promote 'learning from each other' through inter-departmental/cross work stream consultation, improving their adaptation skills and setting an example to others.

Text box 8.6: Variety applied in the selection of contract managers at the Betuweroute

A similar strategy was observed at the HSL-South:

> *Our project team contains a lot of diversity: in age and experience, male/female, disciplines such as finance, safety, contracting and technology. We also try to plan this variety in personnel by looking ahead at future tasks.*
> Manager Transport, HSL-South.

So an important lesson for project managers within LIPs is that:

> *Employing a variety of project team members, differing in background, expertise and competences, can enhance the management of dynamic complexity.*

2 Scenario analysis and pattern analysis

Interestingly, amidst all the confusion, complexity researchers also see patterns. Levy says that we can observe patterns that give the system 'a degree of order'. The system cannot be predicted in detail, but can be predicted in terms of patterns (Brukx and Wackers, 2001). For patterns to emerge we need to know which variables are important to look for. Levy refers to the concept of "attractors". He gives the example of a weather system, determined by three variables: temperature, air pressure and humidity. From any starting point, the outcome might tend to be a stable equilibrium: 'the attractor'.

Attractors are preferred situations (Krohn et. al. 1990 in Geldof, 2001). Attractors are the equilibrium which a system might tend to move towards, but will not necessarily reach (just as the earth does not crash into the sun). As Levy explains: "Outcome variables such as prices or output, fluctuate within certain bounds that are determined

by the structure of the system and by its parameters but not by its initial conditions." For example, tendencies towards monopolistic behaviour might be restricted by antitrust actions of the government. Levy argues that strategic planning can be focused on a limited number of scenarios, defined by the systems' 'attractors'. When the state of a system is near a so called critical point, then a small manipulation can end up in another attractor (Geldof 2001).

Levy argues that observing patterns is especially useful if we can associate different phases of the system with other specific characteristics. In LIPs we have different stages with different characteristics, e.g.: initiative and feasibility, design, execution, operation and maintenance. And indeed, these stages can be observed, but not in a linear way, see text box 8.7.

Similar development over time within LIPs

To look at whether this academic idea of 'attractors' can be seen in practice within projects, we tried to find some common rounds in the development of an infrastructure facility. By doing this we wanted to apply the idea of attractors to LIPs. Based on a short analysis of our cases we can distinguish four rounds that are generally found in LIPs. The first round is that a public body feels the need for a new piece of infrastructure (for reasons of mobility, problem mitigation etc.). The initiator formulates a rough scope, makes a feasibility study and tries to reduce costs so that the chance of approval increases. Because of the pressure to keep costs low, there is often limited interaction with local stakeholders since the feeling is that this interaction will make the project more expensive and will delay the decision. So, as we saw in chapter 7, a management approach is stimulated which is internal and content focused. In the second round many stakeholders enter the arena. The result is that the scope expands – sometimes even 'explodes' – and the costs rise (like in the Gotthard example). This leads to a third round of cost cutting and looking for additional financing. Some projects don't survive this round (e.g. the HSL-East in The Netherlands), others do (with years of delay, the A73-South passed through this round). The fourth round is one of relatively calmness where the project is realised (the Betuweroute is a perfect example of this). At the end of this round (e.g. the period immediately preceding implementation) problems can arise as delivery gets closer. There are, for example, issues with tunnel technical installations (also ERTMS/ETCS) and matters related to the transfer to operators and other practical issues.

Text box 8.7: Similar development of LIPs over time

The attractor analysis which led us to identify four common rounds is based on a quick first analysis which means it lacks sufficient evidence. However we feel that it could be the starting point for future research.

Another way to use variety that we address separately is by using applying concepts of variety to think about the future (a 'variety of futures'). One approach to do this is by scenario analysis which is based on pattern analysis and pattern building.

What is a scenario? Storm defines a scenario as a set of actions and reactions of main stakeholders which might occur, given specific parameters (P. Storm in De Bruijn et. al. 1996). Traditionally, scenarios can be very detailed including an in-depth risk analysis. The pitfall of in-depth scenario building is that the more detailed the scenario, the less probable that the scenario will demonstrate any notable degree of accuracy (MacIntyre in Flood). This means that the scenario builder needs the ability of identifying the main driving forces and to be able to foresee how they influence the results in which we are interested (Axelrod, Bach).

Scenario building helps people to learn about the kinds of things that can happen and why they happen, not what will happen (Flood, with reference to De Geus 1997). It is impossible to foresee and secure the future, but we can try to draw a range of possible factors that we think do matter; with possible relationships, with possible actions, and with possible outcomes.

Courtney, Kirkland and Viguerie (1997) differentiate four discrete levels of uncertainty, figure 8.1. Uncertainty in a traditional way is viewed as binary. The world is either certain, and therefore open to precise predictions about the future (level 1 in figure 8.1), or uncertain, and therefore completely unpredictable (level 4). In fact there is a range of potential outcomes (level 3) or even a discrete set of scenarios (level 2) possible.

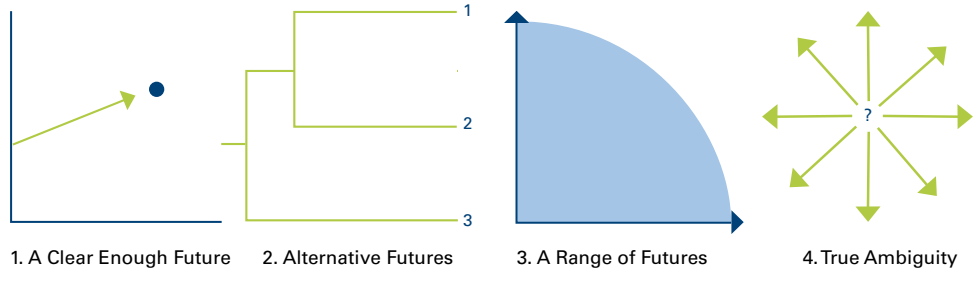


Figure 8.1: Four levels of uncertainty

Level 3 is the most common, level 4 is scarce. Level 3 has a range of possible outcomes, with often no natural scenarios. Scenarios at the extreme points in the range rarely provide much guidance. The authors give three interesting recommendations for level 3:

1 Develop only a limited number (four or five) of scenarios.
2 Avoid developing redundant scenarios that have no unique implications – so that each scenario offers a distinct picture.
3 Develop a set of scenarios that collectively account for the *probable range* of future outcomes, not necessarily the entire possible range.

In level 4, instead of purely going by a 'gut feeling', try to identify:

- at least a subset of variables with favourable and unfavourable indicators
- patterns indicating possible developments (by reference to the attractors Levy mentioned)
- interesting information that can be collected about the future.

Within our cases we only identified one example of systematic scenario building. The transport project team of the HSL-South regularly used scenario analyses to overview alternative developments relevant to the transport contract. These analyses appeared to be helpful in finding answers to questions such as: What are the possible futures for a specific issue? What are the main drivers (influencing the future of this issue)? How will our stakeholders act and react? Which strategies are possible and how effective will they be? Are there any 'no-regret' measures that can be taken? The scenario analyses were used as input for decision making on several issues within the project delivery organisation. Based on the analysis it became clear that certain decisions would have a completely different effect within one scenario than within another. It helped to get more insight in alternative developments within the stakeholder network or, as we called this earlier – the dynamic complexity.

The need for scenario analysis is illustrated by a quote from the responsible manager of this transport project team:

> *'We do not know exactly what we are going to do next year. You can only speak about scenarios. Many of the things we need to deal with are not known in advance. To deal with this, our project team develops scenarios and waits for them to unfold. When a certain scenario unfolds we are prepared with the right capacity and competences so we can respond rapidly.'*
> Project manager transport, HSL-South

The experience of the project team was that scenario-analyses created better awareness of both risks and opportunities and that they were helpful in coping with LIP complexity. The experience proved that reality tended to be a mixture of what was foreseen in the distinctive scenarios. In this context scenario building proved to be very fruitful.

8.4 KEY FINDINGS ON INTERACTION

8.4.1 Results of interaction

Are strategies of interaction successful? In our sub-case examples we have observed many cases both with interaction, or a lack of interaction. A lack of interaction was seen when describing the content focused approach in chapter 7.

In the three countries we talked to managers with a clear vision on interactive management and how to operate it. But this was not a widely practiced way of doing things. Interactive management was in many sub-cases still a pioneering approach. Therefore a main conclusion is:

> *The strategies of interaction represent a relatively new approach – with first experience gained over the past ten years.*

In the analysis of our cases we found some interesting examples of 'alignment' and 'redefinition of the project' strategies. Experiences with the use of short term predictability and variation were not as prominent. In fact we found very few examples of these in our sub cases. But when we did observe them, see 8.3.4, these strategies seemed to offer an added value:

> *The strategies of using short term predictability and variation can be valuable in the management of complexity in LIPs but are still hardly used in practice.*

To review the results of the strategies of interaction we analysed our sub-cases and looked at the strategy and related this to the satisfaction of the initiator (civil principal or project delivery organisation) and the external stakeholder(s) (e.g. NGO, city, province). In the selected sub-cases in the table these external stakeholders had important roles.

We have distinguished two strategies. First is an 'internal' approach, where an organisation acts from its own perspective, focuses on the content (content focused approach) or control, the organisation does not use interaction but (if it has a focus) focuses on detail complexity. This strategy is often related to strategies involving conflict. The second is 'interaction', in which an organisation has an intention to cooperate and to develop the process.

The satisfaction of stakeholders in the table is presented as: '+' = satisfied; '0' = indifferent; '–' = dissatisfied. Sometimes the satisfaction is '–/+', which we clarify in the text. The results are presented in table 8.5.

	External Stakeholder: Internal		External Stakeholder: Interaction	
Initiator: Internal	Province Gelderland	: I – S +	Birds	: I 0 S –
	Gorinchem	: I – S –	Bos-alternative	: I – S –
	Pannerdensch Kanaal	: I – S +/ –	Political agreement	: I 0 S –
	West Coast Mainline	: I – S –	Tunnel Safety	: I –/+ S –
			Uri	: I – S –
Initiator: Interaction	Environ. protection (D+B)	: I + S –	Barendrecht	: I + S +
			Birds	: I + S +
			Environ. protection (MFL)	: I + S –/+
			Frutigen	: I + S +
			Political agreement	: I + S +
			West Coast Mainline	: I + S +

I = Satisfaction of the Initiator

S = Satisfaction of the external stakeholder

Table 8.5: Results of internal and interactive strategies (interaction)

From table 8.5 we can conclude that:

Client and project delivery organisation have the tendency to use an internal approach more often than external stakeholders. External stakeholders' behaviour tends to be more based on the strategies of interaction.

The civil principal generally supports the project and has established a project delivery organisation achieve the project's objectives. In section 7.4.3. we already demonstrated that the project delivery organisations are not 'neutral' in the sense that they only execute what they are ordered by the civil principal. In fact they tend to safeguard their project against the influence of external stakeholders, maintaining the status quo in terms of scope of the project, planning and budget. This could possibly explain why project delivery organisations tend to use an internal approach towards their external stakeholders.

From table 8.5 we can also draw the following conclusion:

Interaction pays off: It can improve satisfaction for both the civil principal, project delivery organisation, and the external stakeholders.

With this we also see a confirmation of our conclusion in chapter 6 that the content focused approach – a contrary approach to interaction – does not yield positive results in the management of complexity. It often leads to dissatisfaction of all stakeholders. De Bruijn et. al. (2005) investigated the impressions of ten years of interactive management (indicated as 'process management') in The Netherlands. A round table conference was organised with 16 top project managers and academics and decision makers in The Netherlands and in parallel a questionnaire was completed by a wider population (35) and 5 extra managers were interviewed so as to be able to provide more background analyses. From the results of this research, the general conclusion was (De Bruijn, Hertogh, Kastelein, 2005): 'interaction generally leads to more support, as well as more decisiveness.'

An additional lesson from the Betuweroute is that decisions that are fulfilling demands of external stakeholders without interaction will be less appreciated than with interaction, see text box 8.8.

Missed opportunity at Betuweroute:

During the early stage of the project the scope of the Betuweroute greatly changed. At first an upgrade of the existing single track Betuweline was planned. Later the NS (Dutch Railways) presented a totally different project with an upgrade of the Havenspoorlijn (the line through the harbour and city of Rotterdam) and constructing a completely new dedicated double track Betuweroute alongside the A15 (east of Rotterdam). The decision to move to the A15 alternative was taken solely by the Dutch Railways (NS) and the Ministry: it was not a decision which was the result of substantial interaction with local stakeholders.

"The regions had formulated their demands towards the project delivery organisation but these were all rejected. At that time research already showed us that building a new line along the A15 was better from a human environmental perspective because no city centres were crossed. With hindsight as a project we should have held back this conclusion and focused on upgrading the traditional line. Later, following interaction with the stakeholders, we then could have proposed the A15 line as a better solution."

Project manager, Betuweroute, commenting on the scope change from Betuweline to Betuweroute:

The decision on the move from Betuweline to Betuweroute shows that the NS approached the scope of the project as a 'technical issue'. Based on analysis the best possible solution was developed. However, because of the lack of interaction, this solution never got the chance to receive general approval. In addition the NS always appeared 'suspicious' to the local stakeholders because of their obvious interest in realising the Betuweroute project.

Reflecting on the original approach used by NS and the Ministry the former project manager demonstrated that a different approach could possibly have resulted in a different attitude.

Text box 8.8: From Betuweline to Betuweroute

From our analysis, we conclude:

> *Decisions that improve benefits for stakeholders are more welcome when they are the result of interaction instead of an internal approach.*

To illustrate the strategy of the potential benefits of interaction further we compare the sub-case of the city of Frutigen with the one of Canton Uri.

Frutigen is a good example of the success of interaction (for a general description see section 3.4.2). A solution to cross the village was developed which embraced a covered track with two tunnels through the station of Frutigen. This solution however was unilaterally altered by BAV which, in order to save money, decided instead to build one tunnel first and a second tunnel later. This caused protests in the village because it meant that the village would be adversely affected by construction activities for two long periods instead of one. After further talks between BAV, BLS, Frutigen and the Canton of Bern, a new solution was reached. It was decided that both tunnel tubes would be constructed at the same time but that only one tube will be technically equipped for operation. This meant that the citizens would only experience one 'inconvenient construction period. In addition changes were decided with construction activities so as to include new infrastructure facilities – such as a bridge crossing – that would benefit the local community. There was even an initiative developed to use the hot water coming out of the Tunnel for a 'Tropenhaus' in which tropical fish would be held. All these measures increased support for the project – a direct result ofthe open and constructive attitude of all involved. Through interaction they reached a joint solution which they then fully supported so it could be effectively achieved.

In contrast is the example of 'Canton Uri' at the Gotthard (for a general description see section 3.4.2), where the focus was on confrontation and the discussion concentrated on content for many, many years. The involved parties such as BAV and ATG chose not to interact and work on a joint solution with Uri, and Uri resisted the ideas set out by BAV and ATG. So a situation of deadlock existed for a prolonged period of time. Here the shift to interaction has only recently been made. The result of the deadlock has been a massive delay of the project – similar to what was found in some of the sub-cases involving local Betuweroute stakeholders.

An interesting example of interaction was found in the city of Barendrecht. In Barendrecht the HSL-South and the Betuweroute run parallel. The number of tracks increased because of the two railway projects. But even when Barendrecht had to accommodate two mega projects, why was the response of the local community relatively calm there, compared to other cities? A main reason was a shared formulation of the problem between the civil principal, project delivery organisation and the city. All stakeholders involved realised that the city was heavily affected by the two big projects. The city of Barendrecht was co-operative, while being clear about their interest and at the same time reasonable to negotiate with. It was striking was that Barendrecht was very well prepared in discussions and negotiations with the project delivery organisation, more so than most other cities. The result was that the project delivery organisations of the Betuweroute and the HSL-South worked together to find the solution: to cover the tracks by a giant roof to form a tunnel.

In summary, the reasons found as to why both sides were cooperative at Barendrecht were:

- Organisations involved were unambiguously focused on the problem and its solution
- The city was co-operative, clear about their interests
- Barendrecht was one of the few cooperative cities
- Barendrecht was able to organise the response of its citizens
- Barendrecht was well prepared at discussions and negotiations which was appreciated by the client and project delivery organisation.

Apparently:

> *To be open and reasonable are necessary conditions for a successful interaction.*

At the opposite end of the spectrum from Barendrecht was Gorinchem (see section6.4.7), because they wanted too much compensation and persisted in resistance instead of developing some form of co-operation. Similar diversity of approach was found in the cases of Uri and Fruttigen.

Leendert Bouter, former project director of Betuweroute and HSL-South, responded on the question: "What have you learned so far?" in respect to the NETLIPSE-research [NETLIPSE newsletter #2, July 2007]:

> *"The main issue learned so far is that the core of good project management is not to create false expectations about the project objectives and to be clear and predictable."*
> Leendert Bouter, Chairman NETLIPSE Executive Board.

All concerned, particularly stakeholders, do not like surprises. Not just bad surprises, but also from what we observed in our sub-cases, good surprises as well. People want to be involved in the process.

> *"With open communication the intention is to diminish the chance of 'surprises' which stakeholders in general don't like."*
> Project Director West Coast Mainline, 2006.

8.4.2 Pitfalls of interaction

In the previous section we described the benefits of strategies of interaction and showed how these can be successful. But, as always, there are downsides as well. The greatest pitfall we see is when there is too much focus on meeting all the various

needs of stakeholders, without balancing this with control. The risk of such an approach is that the organisation will create false expectations. There will be time consuming talks and discussions without substantial progress. An example is the HSL-East in the Netherlands, see text box 8.9, were there was too much focus on interaction.

Expectations at HSL-East in The Netherlands

An example of focussing too much on interaction is the HSL-East in The Netherlands. This was not one of our sub-cases, but we found it to be useful as an illustration for this conclusion. In the second half of the 1990's, discussions about the HSL-East focused on the track between Utrecht and Arnhem, which was for the large part next to the highway A12. The Ministry of Transport set up an iterative process with all local communities and citizens, and used workshops for creativity. This consultation led to all kinds of mitigating measures being proposed. One well known example embraced ideas for a bypass of both rail and highway in the little city of Maarn, that had been split by the pre-existing railway and highway into two. But in addition other measures like lowering the (open) track were popular. As a result, the cost calculations rose spectacularly and were unacceptable to the Minister of Transport. In the meantime civil servants of the Ministry recalculated the forecasts and compared them with the capacity of the existing two track railway line and found out that only limited measures were needed. Basically the construction of a full four track railway between Utrecht and Arnhem was found to be unnecessary. The project was cancelled and changed to a much smaller project to utilise the existing railway line. The local communities were disappointed because of the expectations that had been raised when alternatives were discussed. The project delivery organisation created these expectations by focussing too much on interaction and being insufficiently clear on other alternatives that involved far less investment.

Text box 8.9: HSL-East - too much focus on interaction

Based on this we can conclude that:

> *An over application of interaction might lead to false expectations and time consuming processes that in the end offer no benefits to those involved.*

In consideration of the project scope the interests of involved stakeholders come together at a natural point: it is here where the interests of stakeholders are transferred into a physical infrastructure facility. It is here that co-operation between stakeholders on paper leads to actual benefits resulting from a tangible infrastructural facility. The project delivery organisation has the main responsibility in this process of transfer from theoretical interests to realisation of benefits from an infrastructure facility. From our research we reach the following conclusion as to how this role should be fulfilled:

> *The project delivery organisation should look for scope solutions that are 'fit for purpose'. Scope solutions should serve the interests of stakeholders in most effective manner possible without causing an unnecessary waste of resources.*

In our cases we saw that in particular, strategies based on interactive management have a tendency to aim for acceptable joint solutions. But the question is: are solutions that are jointly developed always the 'best solutions'? Or approaching the issue differently: 'Are these solutions best fit for purpose'? We do not necessarily think so. But answering the question of what scope best fits the interests of stakeholders without wasting resources is tricky. Who is to judge this? Isn't the final decision of politicians the best manner to judge this? Let us look at some more examples from our cases.

An interesting start is to look at the province of Gelderland and the Pannerdensch Kanaal sub-case. Here as the result of discussions with the province of Gelderland and other local organisations, the proposed Betuweroute crossing of the 'Pannerdensch Kanaal' (a canal south of the city of Arnhem) changed from a bridge to a tunnel, which was a more expensive solution. At that time stakeholders were satisfied with this decision. About a decade later, the province planned the extension of the A15 highway next to the Betuweroute, with a crossing at the Pannerdensch Kanaal. The province disliked the fact that now they could possibly be forced to take the same (costly) measures as for the Betuweroute (a tunnel instead of a bridge). At the time of the Betuweroute tunnel decision, the Minister of Transport told a deputy that at some time in the future the province "would regret this decision'" Even though the decision to build a tunnel was politically approved at the highest level, it is debatable if the chosen solution was 'fit for purpose'. A bridge would have been cheaper, would have provided an architectural landmark – as the coordinator of the local wealth committee told us – and would provide a cheaper alternative for the new A15 highway (see table 5.7, section 5.4.1). We feel this was a wasted opportunity and can be seen as a failure of the implementation process – even if we cannot 'prove' the decision was wrong and show how it exactly could have been altered.

When we look at our cases we saw that applying strategies of interactive management might also lead to solutions that afterwards can be considered too costly. An example of this was found at Barendrecht. Here the outcome of interaction is that the tracks of the Betuweroute are covered by a giant roof: a box at ground level. Safety is an important issue for tunnels, as was the case for this tunnel as well. The fire brigade wanted sufficient of water available in case of an emergency. For this a small lake has been build next to the land tunnel. The requirements formulated for the size of this lake were onerous: it even had to take into account that more that one meter of ice should pose no problem in extracting enough water for fire extinguishing purposes! On the tunnel technical installations similar arguments can be used that possibly show an overkill, as illustrated by the following quote:

> *"The Barendrecht roof has introduced a safety concept that is far much more advanced then the complete tunnel safety system used in the Channel Tunnel."*
> Stuart Baker, project director West Coast Mainline (when he researched the Betuweroute for NETLIPSE).

So based on this we state that:

> *Focussing too much on the strategies of interaction can lead to scope overkill and solutions which are too expensive.*

So while a consensus process is definitely important in reaching joint solutions, we feel that consensus alone can never be the only or final judgement as to the extent of project scope. Arguments that look at the scope from a technical/rational point of view are also necessary for sound decisions to be reached. Project delivery organisations should however always be aware that these rational arguments in favour of scope they feel is 'fit for purpose' are not fixed and universal. Instead they are flexible and subjective which means they need to be discussed with involved stakeholders. Again we see a combination of the two worlds of control and interaction. By using interaction strategies, the project delivery organisation can make sure that the scope fits the interests of stakeholders. By using strategies and arguments of control, the project delivery organisation can safeguard against scope solutions that mean a waste of resources. This striking of a successful balance is one of the central elements in fruitful co-operation with local stakeholders in LIPs.

To return to our example of the Pannerdensch Kanaal, the project delivery organisation had the chance to build a consensus process in evaluating the environmental impact of both a bridge or a tunnel solution. In this process, the project delivery organisation had the opportunity to reach a jointly accepted solution which could mean a bridge. However the project delivery organisation decided to do the impact assessment in isolation, immediately making the outcome suspect to the regional stakeholders. We feel this was a missed opportunity in demonstrating the potential added value of a dynamic management approach which we come to in chapter 9 and 10.

The pitfall of interaction is that it cannot be seen as a sufficient approach. It can focus too much on alignment of interests and flexibility, without controlling the project. Interaction is not a bad thing, because we can combine interaction with control into 'the best of both worlds'. This will be discussed in the next chapter.

8.5 SUMMARY AND CONCLUSIONS

In this section we have discussed a complementary view to control: interaction. Control is a 'design approach': from a fixed problem and a clear goal, the project is executed by decomposition and rigid management process which presuppose a stable environment. Interaction strategies assume that problems are ambiguous and that goals are related to the players, and are not fixed – in fact changing as the context changes. It is a 'development approach'. Management focuses on satisfying needs through interaction in the network of stakeholders, and on flexibility – so as to have the ability to act (favourably by anticipation) in the face of changing circumstances or specific outcomes of management strategies. Interaction especially can be used to manage dynamic complexity within LIPs.

Interaction consists of the following four strategies:

1 Alignment
2 Redefinition of the problem and change of scope
3 Using short term predictability
   - selection of succesful strategies
   - systematic evaluation
4 Variation
   - in strategies
   - scenario building & pattern analysis

In the sub-cases studied we saw that the most dominantly visible strategy within complexity management is 'alignment'. We demonstrated that using a strategy of cooperation has a greater chance of success than an 'internal' approach.

Experience of using short term predictability and variation were not as prominent. We found few examples in our sub-cases. On the other hand we did find that when used, these strategies seem to offer added value.

Our analysis shows that the strategies based on interaction are mainly suitable in dealing with dynamic complexity. The use of scenario analysis is an example of this. By predicting possible future scenarios, the development of the stakeholder 'world' over time can be discussed and made visible – it is directly linked to the dynamics of the stakeholder network.

Even though there is little empirical evidence to evaluate its effectiveness, we believe that strategies of interaction have the potential to provide added value in the management of complexity within LIPs. Project managers and other stakeholders can benefit from practical application of these strategies. But managers also need to be aware of the potential pitfalls of strategies of interaction. The most important pitfall is that pure and unique focus on stakeholder demands may seriously limit project progress or lead to over expensive solutions emerging because difficult decisions are avoided and not confronted.

Now we will specifically describe these strategies as an integral part of the dynamic management approach. Dynamic management involves both the combination of the strategies of interaction and control (chapter 9) as well as 'doing the extraordinary' successfully to manage complexity in LIPs (chapter 10).

9. DYNAMIC MANAGEMENT – BALANCING CONTROL AND INTERACTION

9.1 INTRODUCTION

In this thesis we started (chapter 1) by outlining the current problems, ambitions and challenges within the implementation process of LIPs. Major issues that appeared were budget overruns, planning overruns and a general dissatisfaction from participating stakeholders with the outcomes of LIPs . While both national and international ambitions are huge, the capability to deliver these ambitions appears to be insufficient.

Complexity and its management emerged as a main viewpoint from which to look at the current implementation challenges within LIPs and to find suitable potential improvements. Complexity is recognised by practitioners as a main issue in the management of LIPs. In addition the term complexity offers many interesting theoretical insights on its nature and strategies to deal with this complexity. The complexity in LIPs is both visible in the characteristics of the projects as well as in the evolution of the implementation process which was investigated by using the 'rounds model' in chapter 3. The rounds model views the implementation process in terms of various rounds of decision making amongst participating players. We illustrated that the complexity found in the characteristics as well as the implementation process is comparable on an international scale. This makes international knowledge exchange and comparison of management strategies potentially fruitful.

In chapter 4 we then presented practitioners' perception of complexity. This was illustrated by showing how complexity is visible in various forms - technical, social, financial, organisational, legal and time. In chapter 5 we used this basis to present the theoretical views on complexity and making a comparison with practice. We distinguished 'detail' and 'dynamic' complexity as two main sources of complexity needing to be tackled by managers active in LIPs. The distinction between detail and dynamic complexity allowed us to develop a management model for LIPs that is based on control and interaction.

In chapters 6, 7 and 8 we outlined three approaches to the management of complexity in LIPs: the 'internal and content focused approach', 'strategies of control' and 'strategies of interaction'. In our analysis we have shown that while the internal and content focused approach proved to be very limited in its ability to handle situations with high detail and dynamic complexity, both systems management and interactive management can offer benefits to those applying them. In addition we have shown that both systems management and interactive management have major pitfalls that need to be addressed. But the good thing is that it appears that the benefits of the one approach can help to deal with the downsides of the other!

So this is where we now stand. In the final two chapters of this thesis we will look for the keys to successful management of complexity as we have found them from our cases. It is time to give our answer to the question 'What lessons can be drawn for the successful management of complexity in the implementation processes of large infrastructure projects?'. Our answer to the successful management of complexity lies in the concept of 'dynamic management' which comprises two distinctive elements (see figure 9.1).

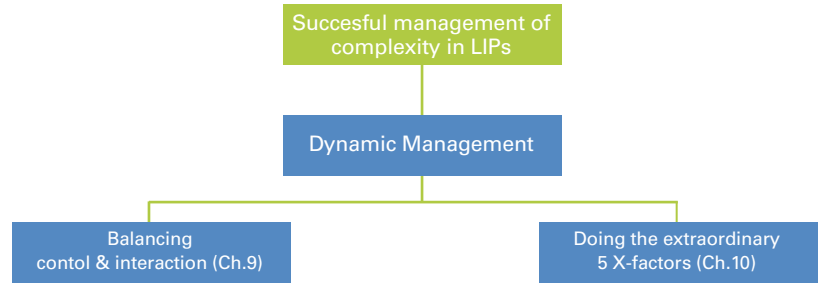


Figure 9.1: Successful management of complexity in LIPs

To answer our main research question we introduce the concept of dynamic management. This concept embodies two approaches which are needed to manage complexity successfully in the implementation process of LIPs:

1 Balancing control and interaction (outlined in this chapter)
2 Doing the extraordinary – 5 X-factors (chapter 10)

A well balanced match of strategies from 'systems management' and 'interactive management' which were described in chapters 7 and 8, was observed in some cases. We have labelled this approach: 'balancing control and interaction' and we will describe its contents in this chapter as the first element of dynamic management.

But we do not think that balancing the strategies of control and interaction is all that is needed. In the analysis of our empirical material we have investigated those cases in which successful results were achieved in more detail. Here we discovered that something more, something additional, is needed in order to be successful. These

additional ingredients that can enable managers to 'brew' their own unique recipe for success in the management of complexity, involve the introduction of extra-ordinary solutions. We feel these extraordinary solutions, or X-factors as we have called them, are key to dealing with complexity in LIPs. These X-factors are the element of dynamic management. These extraordinary solutions are outlined in chapter 10.

As introduced earlier in chapter 5, the four management approaches to complexity can be linked to the concepts of detail complexity and dynamic complexity in order to show their most favourable conditions of application. This link is again shown in figure 9.2.

Figure 9.2: Four approaches on the management of complexity

In the previous chapters we noticed that certain strategies, mainly originating from systems management, are more suitable for dealing with detail complexity - "many components with a high degree of interrelatedness". Other strategies, that we have labelled 'interactive management', were found especially suitable for dealing with dynamic complexity: situations where cause and effect are subtle, and where the effects over time of interventions are not obvious. We will now introduce the first element of a dynamic management approach. This first element is based on the effective combination of elements of both systems and interactive management, making it a potentially suitable approach to deal with both detail and dynamic complexity.

In this chapter we first describe the theory and strategies of dynamic management (9.2 and 9.3). Then we move on to the key findings from our cases (9.4). The chapter closes with the summary and conclusions (9.5).

9.2 THEORY OF DYNAMIC MANAGEMENT

The theory on dynamic management that we used has been drawn mostly from the fields of:

1 contingency theory;
2 complexity theory;
3 adaptive governance.

1 Contingency theory

In management science there has been a long tradition of finding a single 'best way' of organisation. Various schools of research, like the scientific management approach initiated by Taylor, postulated that there was one best way of organising. However as early as in the 1960s, authors like Burns and Stalker (1961) and Thompson (1967) noted that finding one best way is a utopian ideal. Instead their research showed that organisations under changing and uncertain conditions, respond by adopting more complex and flexible structures. Their research marked the start of a new paradigm generally referred to as 'the contingency school' in which organisational structure should match the internal and external context in which the organisation operates. Thus the 'contingency school' breaks radically with the 'one best way of organising' approach which was predominant in the early stages of management science. The contingency approach was a dominant approach in management science especially regarding organisational structure ('structural contingency theory') during the 1970s.

Lawrence and Lorsch (1967) (in Rainey, 1997), in a study of businesses in the United States found that the best-performing firms have structures that are as complex as their environment. Firms in environments with low levels of uncertainty (more predictable, less complex) operate well with less complex internal structures. Firms in more uncertain, less predictable, more complex environments have higher levels of differentiation (variation among units) and integration (arrangements for co-ordinating units, such as task forces and liaison roles). This principle of organisation, where internal complexity needs to match the complexity of the context, is often called 'requisite variety' which is a term that originates from biology (Ashby, 1956).

When applying the structural contingency approach to large infrastructure projects and to the management of complexity, the approach tells us that the structure of the project delivery organisation (and the organisational structure of other participants in LIPs) should match the context of the project and strive for some form of fit or equilibrium. And, since we have shown that this context has the characteristics of dynamic complexity, this would mean the structure of project delivery organisations should match or mirror this complexity in some form.

2 Complexity theory

The notions of the contingency school are still reflected and expanded by several authors in the field of complexity management. For example Levy (2000) refers to many writers who suggested the need for 'flexibility, creativity and innovation in organisations - instead of expecting a lot from, and spending much energy in, forecasting. Closed, mechanistic and routine-based organisations are successful in stable environments and with stable technical conditions. However they are less successful under changing and uncertain situations than are open, organic and non-routine based organisations. In the former, the emphasis is placed on communicating vertically, following the chain of command - superiors controlling subordinates' behaviour and with strict adherence to job descriptions and organisational charts. In more adaptive and innovative organisations, the emphasis is on networking and lateral communications, the supervisor as 'facilitator' and with flexible and changing work assignments (Rainey, 1997).

These and other elements are shown in table 9.1 with a comparison between mechanistic and organic organisations (Hellriegel and Slocum, 1989).

Mechanistic Organisation	Organic Organisation
Tasks are highly specialised.	Tasks tend to be interdependent.
Tasks tend to remain rigidly defined unless changed by top management	Tasks are continually adjusted and redefined through interaction.
Specific roles (rights, obligations and technical methods) are prescribed for each employee.	Generalised roles (responsibility for task accomplishment beyond specific role definition) are accepted.
Structure of control, authority, and communication is hierarchical.	Structure of control, authority, and communication is a network.
Communication is primarily vertical, between superior and subordinate.	Communication is both vertical and horizontal, depending on where needed information resides.
Communication primarily takes the form of instructions and decisions issued by superiors and of information and requests for decisions by subordinates.	Communications primarily take the form of information and advice across all levels.

Table 9.1: Mechanistic versus Organic Organisations

Stacey argues that a good mixture between centralisation and decentralisation and between rigidity and disorder, can optimise the powers of adaptation and creativity in an organisation (Stacey 1993, in Levy, 2000). Levy refers to the need for shared organisational identity, culture, mission and values to play a powerful role in integrating a decentralised, network form of organisation in order to become more innovative and adaptive. This innovative and adaptive approach is especially needed in the management of complexity. It also means that organisations should welcome some degree of disruption rather than to strive for equilibrium within their environments, locked into stable work patterns and attitudes. It is important to have "openness to accident, coincidence and serendipity" (Rosenhead 1998). (Serendipity is making fortunate discoveries quite by accident.)

3 Adaptive governance

Within the field of public administration the approach of 'adaptive management' or adaptive governance has recently emerged, see for example Cooney (2007), Brunner (2005), Adger (2003). The term originates from the literature of environmental management of the 1970s, combined with alternatives drawn from social sciences (Garcia-Salmones, 2009). It is based on continuous learning processes rather than on 'traditional command and control regulatory frameworks'. Policymaking in the context of adaptive governance is considered to be a repetitive process because scientific knowledge is seen as provisional and subject to review in the light of new information, and thus not definitive or final. The authors' opinion is that 'no single optimal solution to policy problems exists' (Cooney, 2007). In the field of public management the adaptive management or governance approach is mostly found, used and described on the issues of climate change and environmental management in general.

Just as we observed when describing some of the strategies of interactive management, adaptive governance or management involves taking risk and uncertainty as a characteristic and not something which has to be resolved at all costs. As emerging and as envisaged here, 'adaptive governance' refers to the adaptation of 'policy decisions to real people, not the cardboard caricatures sometimes constructed for scientific or managerial purposes'. Sound policy is based on people as they are, and seeks to advance their common interest within the practical constraints of specific contexts' (Brunner, 2005). This means that policy decisions need to be adapted to 'differences and changes in experience on the ground, as real people interact with each other' (also Brunner, 2005). Adaptive management stresses that policy decisions cannot only be viewed as separate technical problems to be solved, but stresses the social or political component of these policy decisions.

The key action strategy that characterises the approach of adaptive management is 'iterative decision-making' - monitoring and evaluating results and adjusting actions on the basis of what has been learned. This means that there is a strong feedback link between monitoring and decisions which allows for effective learning. A strategy that we earlier have put under the umbrella of 'interaction strategies' in chapter 8. In addition to the focus on iterative decision making and learning, some authors add that next to adaptive qualities, 'resilience' is needed and this need could, and possibly should, be stressed more often (Teisman, 2009). As Adger (2003) states when he talks about resilience 'resilience is the ability to persist and the ability to adapt'. So in addition to 'flexibility', 'persistence' and 'stability' are necessary components for success in the face

of complexity. And it is here where the link with dynamic management can be made. Just as we noted in the 'contingency approach' and the 'theory of complexity management', there needs to be the right balance between rigidity and order on the one side and flexibility and openness to change on the other.

9.3 STRATEGIES OF DYNAMIC MANAGEMENT

When comparing contingency theory, the theory on complexity management and adaptive governance we have seen similarities that fit very well with our two types of complexity. On the one hand there is a strong argument for stability and persistence since this helps to manage the detail complexity we face. On the other hand there is a need for flexibility to deal with the inevitable changes in context and unforeseen events that we have called dynamic complexity.

Based on the theories previously described we have developed the dynamic management approach. The term 'dynamic management' was chosen to stress the dominant influence of dynamic complexity on project success. While we have clearly shown that managing detail complexity is a key issue in the successful implementation of LIPs, the core of reaching successful outcomes lies in managing dynamic complexity. In addition the term 'dynamic' illustrates that successful management of complexity in LIPs means both competent and dynamic flexibility of application between strategies aimed at control and those based on interaction. Managing the tension between both these approaches is at the core of our dynamic management approach. Now to what kind of strategies does this lead? We have come to the conclusion that the core strategy of dynamic management is balancing control and interaction. The strategy involves balancing the:

1 organisational structure
2 strategies of control and interaction over time

1 Balancing the organisational structure

Following the theories introduced in the previous section, it appears to be necessary, and potentially beneficial, to develop a structure for the project delivery organisation (and other participants) that fits its context. Within this organisational structure there has to be the right mix of stability, to create the necessary progress; and an openness to new influences and change. The strategy is very much in line with the structural contingency approach described earlier.

As we demonstrated in chapter 5, the preferences of stakeholders - such as the principal and local stakeholders - shift during the execution of the project. In order to accommodate these shifts the project delivery organisation will need some degree of flexibility so as to adapt to these changing preferences and to a whole range of other changes - in rules and legislation, the introduction of new or more efficient technologies, new contracting forms, etc. The organisational structure needs some degree of adaptivity. Key is finding the proper mixture between rigidity & order and flexibility & creativity in the structure and working processes of the project delivery organisation (see text box 9.1).

Adaptation in quality and risk management systems

In the Betuweorute a quality system was set up describing its strategy, organisation and processes. The first version of the quality manual (1995-1997) incorporated a quality system which was felt to be too detailed. In their enthusiasm to increase efficiency, quality employees and specialists described their processes in too much detail. The result was 'over organisation': the adaptation power and learning capability of the (project) organisation became too restricted. The result was that quick responses to changes in the environment were hampered. The solution that emerged was to describe the processes on a higher level, one that focused on critical items. The result was that the number of pages was reduced to approximately one third of the first version.

The Betuweroute wanted to be the first large infrastructure project in The Netherlands that has been certified in accordance with ISO 9001. The project organisation was aware that certification could limit the organisational flexibility, when systems are focused too much on control and the structures of the organisation are set out according to a 'machine metaphor' (Brukx and Wackers, 2001, p. 96), so they tried to assure sufficient flexibility. And they succeeded in this goal!

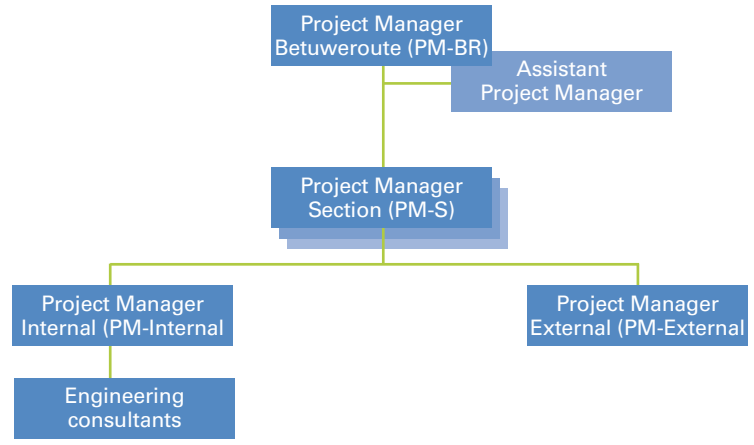
The Betuweroute project organisation also recognised the same potential difficulty with risk management systems – that have the same tendency to focus at too detailed a level and are too complicated.

The lesson learnt is that managers should beware quality management and risk management systems killing the creativity and adaptation powers within their organisation. This could be one of the explanations as to why ISO 9000 recently has been giving more encouragement to the 'learning organisation' by emphasising the need for improving and checking.

Steens et. al. (1998) mention that quality systems should be practical and user-friendly, and written in co-operation with and from the viewpoint of the user. The focus is on matters that are really essential for the professionals, minimising requirements for detail information and forms – which also have the tendency to become outdated. A quality system should be able to support the need for innovation and adaptation, by formulating methods by which the organisation handles and promotes these strategies.

Text box 9.1: Adaptation in quality and risk management systems

Now how should one align one's project delivery organisation to adapt to the context of the project? How can the tension between the need for stability and flexibility be solved? We will illustrate this by two examples from the Betuweroute. The first was to appoint different managers with an 'internal' and 'external' focus. The second was organisational structure with the use of 'tension arcs'.
In 1995 the Betuweroute project organisation of the Dutch Railways rose to more than 50 people, excluding engineering consultants. The chosen organisation had the following characteristics (1995, with improvements in 1997), see figure 9.3.



The Project Manager Betuweroute (PM-BR) was the integral manager. He had an Assistant Project Manager mainly responsible for external affairs.

The route had been divided into seven sections, each with an integral Project Manager (PM-section). The PM-S was in charge of a project team with a Project Manager Internal (PM-Internal), who was responsible for the design and a Project Manager External (PM-External), who was responsible for the co-operation with the 'outside'. 'Internal' and 'external' are defined as from the perspective of the project delivery organisation.

Figure 9.3: Project Organisation ProRail (1995-1998)

At both management levels the split had been made between internal and external responsibilities. The project manager Betuweroute (PM-BR) wanted to organise these two with sufficient attention for the internal world of design and planning, and the external world of communicating and aligning interests with the stakeholders. The PM-BR was afraid that if he didn't designate a project manager external on the same level as the project manager Internal, environmental and social issues would be seen as inferior to design and planning, especially if the going got tough.
At his own level the PM-BR had his deputy, the assistant project manager, whose main focus was stakeholders. The PM-BR himself dealt with the Ministry of Transport. This assistant project manager told us:

> *"As a manager I worked next to the project manager, he was more internally focused, I had an external focus."*

The second example from the Betuweroute is the organisational 'tension arc' scheme (figure 9.4) which shows how the organisation in 2000-2002 dealt with client and parent organisations as well as with external stakeholders. The Betuweroute client and project delivery organisation sought a way to ensure an open communication and reporting structure on the one hand whilst maintaining the ability to anticipate and steer future developments on the other.

Control was an important item, as they emphasised in the progress reports towards the House of Representatives, but they also stressed the need to be more sensitive as to signals to the environment. These two needs were incorporated in a model of what they called 'tension arcs', where control and anticipation (a different but similar term to 'interaction' which we have used) formed 'the natural tension'. Both of these functions can be found in the approach set out, with control to the left side, and anticipation on the right side of the scheme. The model reflects the dual management approach of 'control' and 'interaction'.

The tension arcs were drawn at each level in the organisation: between civil principal and project delivery organisation, towards the internal organisation of the regional departments of the project delivery organisation (figure 9.4).

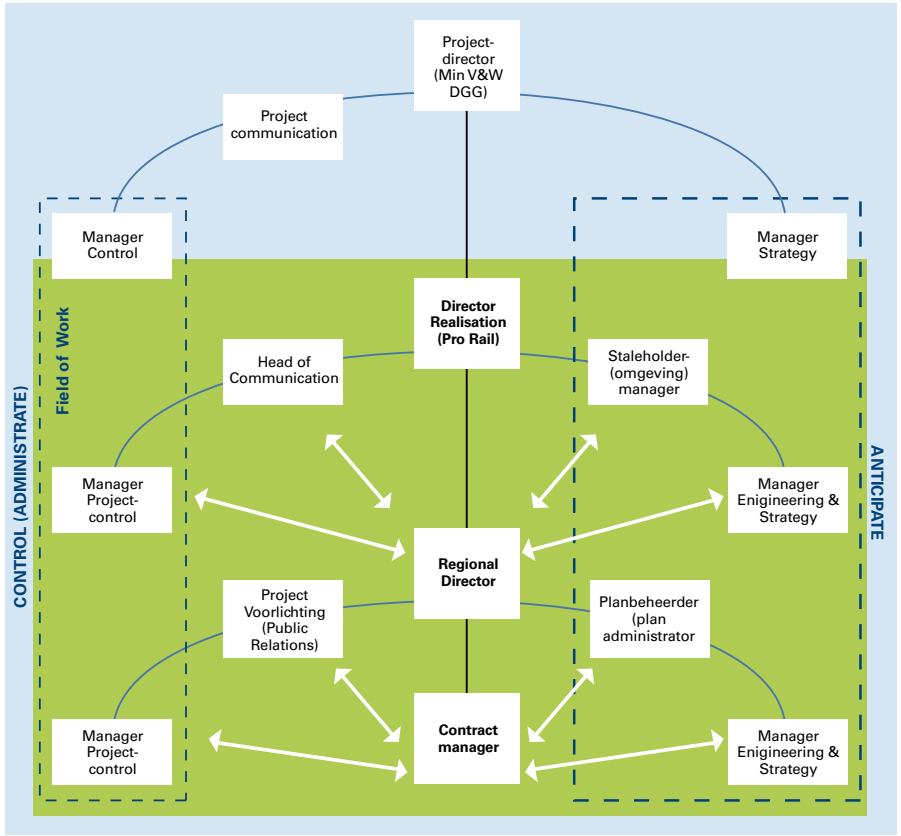


Figure 9.4: The organisational scheme of the Betuweroute with 'tension arcs'

The structure meant that the natural tension between control and interaction was recognised and two poles of the tension arcs were organised. As a manager within the project delivery organisation commented:

> *"Every part of the organisation has its own goals it wants to achieve with this project." …*
> *"The key is to accept that there is tension and you need to manage it, there are different goals and different worlds."*

The model with tension arcs reflected positive or constructive tension within the organisation. An important element of the model with tension arcs, was that co-workers of both the Ministry and ProRail had contact and worked together in a structure of vertical communication, so it also led to an increased interaction between these stakeholders. However this was not always appreciated by the directors of ProRail and the Ministry, who wanted a more formal relationship between ProRail and the Ministry for the project itself (it was "too fuzzy" for them). The more formal relationship was common practice on other projects and in issues between ProRail and the Ministry.

If we 'translate' the tension arcs model to our theoretical notions of systems management and interactive management, we get the following (figure 9.5).

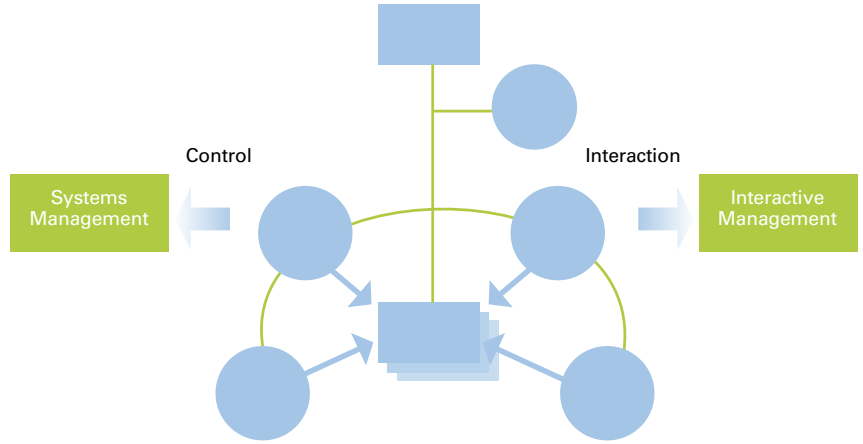


Figure 9.5: Management strategies of complexity applied on the tension arcs model Betuweroute

2 Balancing the strategies and control and interaction over time

In the first area of balancing we concentrated on the importance of building an organisational structure with sufficient focus on both control and interaction. We now move to the second element of balancing, which focuses more on the process instead of the structure.

Project managers should be aware of the wide array of strategies that can be used to manage complexity and their effect. There is not necessarily a blueprint or checklist on what to do but our sub-cases show that awareness and combining approaches often offers the best chance of satisfactory outcomes. The large number of stakeholders, their interrelationships and their changing preferences mean that a relationship based on command and control solely will not function anymore. In fact, it can be counter-productive as we saw in our analysis of systems management in chapter 7. Quick decisions may turn out to be bad decisions. Problems are not fixed, solutions tend to be volatile. Coalitions are formed and broken, no one has perfect information and insight, and no one can force decisions on their own. Too much focus on control of scope, of quality, cost and time underestimates the social dynamics involved in a LIP. However we also showed that the strategies of systems management are needed to plan work packages, define a set of requirements, make a design and correctly follow legal procedures. After all, throughout the process, scope and quality needed to be managed, as well as costs and time. It might even be necessary to isolate parts of the project delivery organisation to execute work packages and achieve results. This is the core of the balancing strategy.

This balancing approach is illustrated in figure 9.6 (Hertogh et. al., 2008).

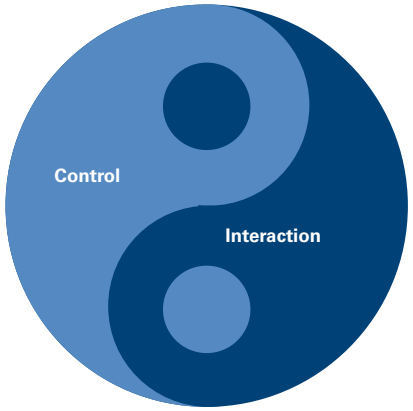


Figure 9.6: Balancing control and interaction

Interactive management proved to be especially successful in setting a scope that better fits the interests of stakeholders. In this way interaction can help to solve the issue of 'lock-in' within the stakeholder system. But on the other hand we also noticed pitfalls in interactive management in that it has a tendency to over-react in the sense of keeping stakeholders 'aboard' by setting false expectations and then making insufficient project progress. This shows that the downsides of systems management can be tackled by applying interactive management and vice versa!
To outline the strategy of balancing further we show four basic tensions between systems management and interactive management (figure 9.7).

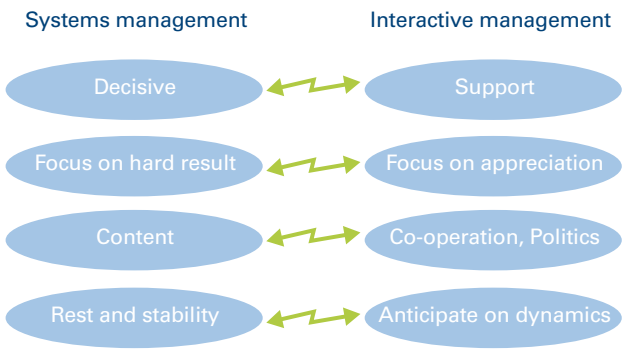


Figure 9.7: Tension between systems management and interactive management

The four tensions shown in figure 9.7 were used in a workshop (initiated by problems with birds in relation to the noise screens) held at the HSL-South to highlight the differences between systems management and interactive management.

The challenge for project managers that have a dominant orientation on systems management is to be more aware of the interests of other groups and the importance of interaction. Their challenge is to develop competences in line with the right-hand side (Hertogh and Bruijninckx, 2004) of the figure 9.8. Of course, in similar fashion, the contrary argument can be made for managers with a dominant focus on the interactive side of the spectrum.

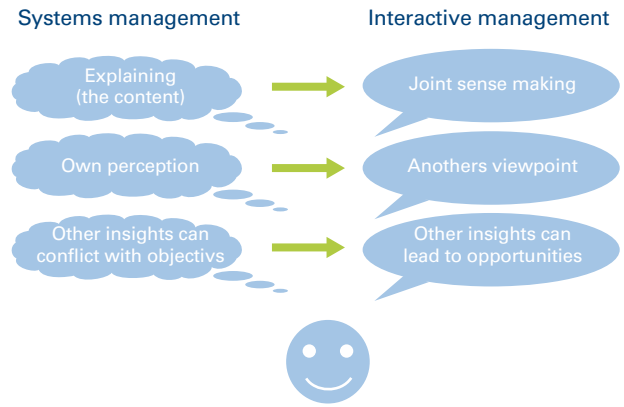


Figure 9.8: From systems management towards interactive management

Some examples from the interviews and workshop at the HSL-South.

1 From: I achieve insufficient results, I will explain it once again (content).
  To: What are the needs and motivations? How can we join our forces?
2 From: I am dealing from my own experience and goals.
  To: Try to understand the other person, while respecting individual goals and preference.
3 From: A customer who complains, doesn't understand.
  To: A complaint from a customer is an opportunity. Use their complaint, constructively.

One manager called the challenge (the right side of the figure) a "customer oriented" approach, "to look further than your own way of thinking". That seemed to be the central idea of the two days of the workshop: to create relationships based on (mutual) trust is a challenge for project managers.

Interaction strategies fit the dynamic complexity of the management issues in LIPs, where solutions that looked promising and were locked early in the process can become obsolete as a result of new insights and/or external events that change the stakeholders' preferences. These changing preferences and the importance of external events make necessary an approach embracing constant monitoring of change and reassessment

of the quality of implemented solutions, both in the approach (process) and the scope (result). Just as we saw reflected in the theory of adaptive governance in the previous section - take our sub-case on the Pannerdensch Kanaal: is a bridge still the most viable solution to cross this river? Or might a tunnel be more suitable? These issues need reviewing on a regular basis, especially after the occurrence of major change events, such as for example, election of a new government. The strategies to use short term predictability and variation, pointed out in chapter 8, can assist project managers to do this. Interaction addresses problems on the basis of constant evaluation of both the process and the desired result - in similar fashion to a craftsman working on a clay sculpture who continually reviews his work and adapts his craft so as to shape his unique piece of art. But while the craftsman will often work on his own, this luxury is not available for those active in LIPs. The fact that in LIPs many stakeholders are active means that every change influences the entire network or universe. So when applying the strategies of interaction, the relationship with involved stakeholders should be a key component. Interaction strategies are a way of working, within a changing and difficult to define problem where it is unclear how to solve it. What is clear however is that the problem should be solved by those stakeholders involved - in a co-operative manner.

In addition to the interaction approach there is a need for an approach which enables dealing with detail complexity - based on strategies from systems management. The strategies are those that focus on control. Control is a structured and linear way of working that is based on a stable definition of the problem and how to solve it. Solving the problem is something which can be done – at least partly – in isolation, facilitating the working of project delivery organisations in an efficient manner.
As an overview we list the strategies that collectively form our dynamic management approach in table 9.2.

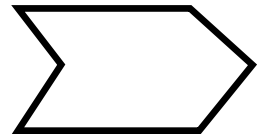
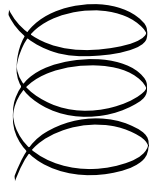
Strategy	Control	Interaction
Illustration		
		
Basis		
Fit for	Detail complexity	Dynamic complexity
Problems are	Unambiguous, fixed and independent of stakeholders	Ambiguous, changing, determined by stakeholders
Problem solving	Linear	Iterative
Theoretical basis	Organisational design Systems management	Interactive management Complexity management
Management strategies		
	1 Decomposition • in time • in end product • organisation 2 Management processes • schedule • costs • quality • risks	1 Alignment 2 Redefinition of the problem and change of scope 3 Using short term predictability • selection of successful strategies • systematic evaluation 4 Variation • in strategies, solutions, organisation and personnel • scenario analysis & pattern analysis

Table 9.2: Overview of the strategies of interaction and control

The strategies found in table 9.2 form the building blocks to manage complexity in LIPs. These strategies need to be used in the right balance to be successful. In addition, how the project delivery organisation and other stakeholders can use these strategies to adapt to the continually changing project context has been demonstrated earlier. This means that the balance between interaction and control is not fixed or a given. Since each project is unique because of its history, context and events etc., it requires a tailor made approach which will need to be changed over time. By assessing the context of a project, appropriate management strategies from the array of approaches to control and interaction can be

chosen and brought into play, in similar fashion to a cook preparing a unique recipe based on partly fixed ingredients. This unique 'recipe' will then need to be changed over the course of the project. Managers need to decide when to adapt to changes in the context.

9.4 KEY FINDINGS ON DYNAMIC MANAGEMENT

As we saw in chapter 1, in our current society 'no one is in charge'. Projects are realised within a network of organisations and persons in which there is a need to handle both dynamic and the detail complexity. The West Coast Mainline illustrated that both control and interaction were needed to achieve a successful implementation of a LIP. How strategies were combined is illustrated in text box 9.2.

Dynamic management at the West Coast Mainline

The turn-around in phase 3 of the West Coast Mainline project can at least partly be attributed to a changing management approach that shows various elements of dynamic management. In the turn-around the project sponsor – the Strategic Rail Authority – and the project delivery organisation introduced new management strategies both focusing on control and interaction.

In chapter 8 we showed that the management of the WCML used interaction strategies such as the 'West Coast 250 committee' to co-operate with local stakeholders. In addition we also saw that a 'cross industry approach' was used in which numerous organisations from the railway sector co-operated to develop a new consultation document for the upgrading of the route. Introducing these new strategies was essential to overcome the system lock-in that had eventually led to the bankruptcy of Railtrack in the preceding phase. It enabled the project to regain its credibility in the stakeholder network and to set a firm basis to start the project once again.

In addition to these 'interaction' strategies to deal with the dynamic complexity, several strategies of 'control' were introduced at the same time. Examples of implemented strategies include the introduction of a shared functional requirements document which described the project scope and a rigid change order procedure. In addition, new methods were developed for the financial management of the project with the central element being the project's business case. Network Rail, the project delivery organisation, set up a risk register and used a Project Management Information Centre (PMIC).

The strategies applied in the third round of the WCML show that the successful combination of control and interaction is possible in practice and will yield positive results.

Text box 9.2: Dynamic management at the West Coast Mainline

We saw a similar example of dynamic management in the case of the A73-South.

During the preliminary negotiations, a variety of options were considered concerning scope (broadening) and organisation (new ways), and then fixed with a political agreement. This political agreement marked the start of a straightforward way of management essentially based on control. Scope and cost control, planning, risk management and contract management were very important aspects in managing the A73-South from the start of the agreement. This is understandable, because the region wanted a fixed commitment, since as a manager of RWS told us: "nothing changes more than politics". But as a result there were far fewer possibilities for optimisation and change during the execution phase than might have been the case.

This observation of successful practice can be linked to the context of the project execution. Basically specific context factors enabled the control approach to be successful. The prognosis during our interviews (held in the Summer of 2006), was that the project would be within budget and would be completed on time. On the cost side, cost overruns could be offset by substantial positive tendering results because of favourable market conditions at time of tendering. This basically shows that in this case tight systematic control was at least partly facilitated by the favourable market conditions - an indication that 'success' is context dependent.

While the project approach might be systematic and focuses on control, this does not mean that the complexity of the whole project suddenly disappeared during the execution. In the other two sub-cases cited, environmental compensation and tunnel safety illustrated that interactive management and 'balancing' between systems and interactive management remained important. A project manager of RWS Limburg stressed that:

> *"Beforehand it is unclear how a project wil evolve, you should always look ahead and be adaptive".*

The social context of the project remained especially important, as the project director stressed. In addition he stressed the importance of a project manager with sensitivity for social matters, who can win respect and trust and who recognises the necessity of communicating in an open manner. These skills are additional to the control competences with which project organisations and their managers are traditionally more familiar.

The remaining complexity during the latter phases of the the A73-South project is illustrated by the continuing discussions on the following subjects in this sub-cases:

1 Discussion on the west and east bank that continued until the decision of the Council of State;
2 Extra compensating and mitigating measures;
3 Tunnel safety.

The continued discussions show us that:

> *The complexity of a LIP does not diminish over the project life time. Important discussions that can lead to important changes and influence the success of the project remain present. This means that strategies of interaction are also needed during the execution phase of LIPs.*

It is often believed that complexity disappears after the 'go decision' for a project. Based on our findings, this argument seems to be debatable, especially for the extremely large projects we studied. Take, for example, the main rounds of decision making which were distinguished in the case histories in chapter 3.

The WCML and A73-South examples also show us that the strategies of control and interaction can be combined in practice. But at the same time one can argue that tensions exist between both strategies. Increased interaction can limit the possibilities for control and vice-versa:

> *Due to inherent tension between them, strategies of control and interaction cannot to be deployed in full harmony but need to co-exist in the successful management of complexity in LIPs.*

The strategies of control are based on a deterministic approach to deal with complicated situations. The assumption is that structure and order will lead to project success. It has a clear procedure: start with a plan for the next phase - one that focuses on scope, budget and planning. Then the project should be managed in accordance with this plan. Strategies of interaction however take the dynamic preferences of stakeholders as their starting point. Here the assumption is that no one is in charge, but that project success is dependent of the performance of a network of organisations that are tightly related. Problems are not structured and there is not one, upfront, best, objective solution. Problems and solutions are dynamic, because of changing preferences that originate from changes in opinions or the entrance of new players or other factors. The two approaches of control and interaction need to be combined by stakeholders but also by individuals.

Or as a project manager within the HSL-South organisation states:

> *"The employees need to be able to handle the uncertainty. On the other hand they should be able to deal with the rational side such as being able to draw up quick plans. Most of our employees are well capable of switching between these two approaches."*
> Project manager Transport, HSL-South.

To provide more empirical depth to the approach of dynamic management, we use a final example, this time from the Betuweroute (text box 9.3).

Dynamic management at TTI at the Betuweroute

In August 2001 the first part of the TTI - the control and telecom system – was tendered. The outcome was that the bids were 3 to 4 times higher than the initial estimates. The tender process was cancelled. The cost estimates rose to € 345 mln. in September 2001, although some members of the ProRail (POBR) Betuweroute project delivery organisation doubted the validity of the new estimates. However, the € 345 mln estimate was reported to the civil principal within the Minister of Transport. This drew major attention to TTI both from within the organisation of the civil principal and from within the project delivery organisation. This attention provided the 'sense of urgency' that was the trigger that changed the content focused approach applied in earlier stages.

The responsibility for TTI was handed over to a new project manager in November 2001. The project manager within ProRail's POBR started several historical investigations into the rise in costs for TTI and initiated a new design process. He quickly established an archive of relevant documents. These documents turned out to be spread out all over POBR, which had previously made it almost impossible to track scope changes. Under the new approach, which focused on project control and administration, planning strategies from systems management can be clearly recognised.

In the new design process that the project manager introduced, there was more attention to the interaction with stakeholders. This meant that every step in the design process was formally approved by the local authorities. POBR tried to find alternative solutions in talks with local authorities. The Green Booklet – which was the previously developed safety standard – was still used as a reference but this time interpretation was done in close co-operation with local authorities and the fire brigades. Previously the design was undertaken independently by the project delivery organisation based primarily on a technical interpretation of the Green Booklet. As a result of the new approach, alternative scenarios for TTI had been developed, based on a modular approach. This led to new alternative requirements for TTI that were accepted by the local authorities.

In this case the content focused approach was abandoned because of an unacceptable rise in costs that caused pressure to change the management strategies. Combining the strategies of planning and development greatly improved the outputs of the sub project.

Text box 9.3: Dynamic management at TTI at the Betuweroute

The examples of dynamic management show us the promise of this management approach. But that does not mean that the full details of the approach and the benefits are already fully utilised in practice. On the contrary, we noted that the 'internal and content focused approach' and 'systems management' are observed far more frequently, and almost always with less success. We conclude that there is still a long way to go in the successful management of complexity.

Finally we would like to stress that we have simply presented some initial building blocks in balancing control and interaction. We have shown basic strategies and how these were observed in practice. But because of the limited evidence found in our cases, many questions remain such as: 'How can a project manager find the successful balance between control and interaction?' and 'In which situations is it useful to switch the approach from a focus on control to interaction or vice versa?' These and other related questions can be starting points for future research.

9.5 SUMMARY AND CONCLUSIONS

In this chapter we have introduced the concept of 'dynamic management' as our answer to the question "How should complexity in LIPs be successfully managed?". We have chosen to use the term dynamic management because of the still often neglected importance of dynamic complexity in LIPs. In addition the term incorporates the changing nature of LIPs which requires constant adjustment and realignment of strategies and structures. The dynamic management concept is based on:

1 Finding the right balance between control and interaction
2 Doing the extraordinary – 5 X-factors

In this chapter we have outlined the first element which encompasses finding the right balance between control and interaction necessary to tackle both detail and dynamic complexity. Balancing control and interaction is founded on theoretical building blocks from the contingency approach, complexity management theory and recent adaptive governance theory.

Balancing means that project delivery organisations need to find a structure to fit the project context and to accommodate the need for both interaction and control. In addition balancing also means the mixture of the two complementary and coherent clusters of management strategies: control and interaction. One is fit to deal with detail complexity (control) and one to deal with dynamic complexity (interaction). The mixture of strategies is likely to change over time, since it needs at least partially, to reflect changes in the project context.

Both the strategies of control and interaction are needed to offer the best chance of the successful management of complexity in LIPs. This is easier said than done, because these strategies bring some natural tensions between them that cannot be completely reconciled. It is essential to look at a balance which fits the unique circumstances of the project with which you are working. 'Recipe book' approaches to the management of complexity will prove impossible because of the high importance of context in the successful application of management strategies.

Practical applications of the balancing strategy are still relatively scarce compared to applications of 'content focused & internal approach' and of 'systems management'. But first analysis shows the balancing strategy can greatly enhance the chance of success in the management of complexity. However many questions remain on both the theoretical foundations and its use in practice. Future research will need to address this.

Analysis of our successful examples in the management of complexity showed us that the application of the balancing strategy does not yield a complete picture of what managers need do to be successful when dealing with complexity. Other factors also contribute to the successful management of complexity in LIPs. This is the second element of our dynamic management concept. Simply stated it means that we need extra-ordinary solutions to deal with complexity in LIPs. We will conclude this thesis with consideration of the X-factor in managing complexity in the next chapter.

10. DYNAMIC MANAGEMENT - 5 X-FACTORS

10.1 INTRODUCTION

Success in the complex context of LIPs will not be achieved by driving on remote control. Success at LIPs needs extraordinary solutions: new and creative ways to maintain progress and to overcome major dead-locks.

In the previous chapter we introduced the concept of dynamic management. There we focused on the first element of dynamic management – the dynamic balancing of control and interaction. In this chapter we will add to that by introducing the second element we feel is necessary to successfully manage complexity in LIPs – "doing the extraordinary".

When we analysed our cases looking for good practices we found that balancing control and interaction seems to offer project managers the best chance of being successful in the management of complexity in LIPs. This was something that we largely expected, based on our conceptual model and previous experiences in the working field. But in addition we discovered something that we had not previously thought of or expected. This is that our analysis of successful practice in LIPs shows that the reoccurring theme in being successful was 'doing the extraordinary'. It seems that we need extraordinary approaches, people and solutions to manage the full blown complexity present within LIPs. In particular, the major deadlocks and other problems present in our sub-cases, could only be overcome by new, as well as creative methods! We labelled this phenomenon "X-factors in the management of complexity" and will outline its ingredients in this chapter – as the second element in the concept of 'dynamic management'.

In chapter 3 we introduced our cases and concluded that complexity in LIPs is visible in both the characteristics of the project and in the evolution of the implementation process. Three main conclusions on the complexity of LIPs that followed from the characteristics that were outlined in chapter 3 are that LIPs are:

- Tightly connected to their context
- Multi player games
- Implemented in a unique context

These three findings mean that the management of LIPs cannot be deployed effectively by a project delivery organisation in pure isolation. A project delivery organisation is part of a unique context within the stakeholder constellation where many players and events influence the final outcomes of the project. So, in order to develop potentially successful management strategies, we need to take a look at both the higher level stakeholder system and the project delivery organisation. In addition, within this network of stakeholders we found that we cannot just look at the level of players as an entity but we also need to gain insight at the personal level. In this unique context, the unique competences of individuals can make a massive difference. So summing up, the 'X-factor' can be found on the following levels, described in the sections of this chapter:

1 Stakeholders system: higher order of cooperation (10.2)
2 Player level: project champions (10.3)
3 Personal level: competent people making the difference (10.4)

The second subset of conclusions presented in chapter 3 showed that complexity is found in the evolution of the implementation processes:

- Implementation process is non linear
- Unique starting position and events are of key importance
- Complexity is visible in all rounds of decision making

These elements of complexity visible in the implementation process are connected to two more X-factors. First of all we found that in order to be successful we need the:

4 Capability to find unique management solutions (10.5).

Unconventional and creative management solutions proved to be effective in the unique context of LIPs, but in addition participants in LIPs should recognise and use momentum in projects. They need to use:

5 Windows of opportunity (11.6)

Many times events perceived as threats might lead to golden opportunities!

10.2 X-FACTOR 1: HIGHER ORDER OF COOPERATION

A higher order of co-operation was achieved in some of our studied cases leading to great success in the management of complexity. This success is illustrated by good results in terms of budget and planning but also, and perhaps more importantly, in the satisfaction of the involved stakeholders.

The first key to success is all about co-operation in the dynamic stakeholder network in LIPs. We have found in our cases that:

Project delivery organisations and other stakeholders, able to develop a higher order of co-operation in their stakeholders system, greatly increase the chance of success in implementing a LIP.

A higher order of co-operation can enable the stakeholder system within LIPs to deliver outstanding results. In our sub-cases we found several instances in which the stakeholder system was able to initiate a level of co-operation that surpassed the sum of individual interests. This is what we call a 'higher order of co-operation'. A higher order of co-operation does not mean however that individual interests were overlooked. It means that the stakeholders in the system used their co-operative capacities to align their self interests in such a way that it produced system outputs that benefited them all.

A higher order of co-operation goes beyond individual interests and leads to mutual benefits.

Instances in which we found a higher order of co-operation in our sub-cases are:

1 West Coast Mainline round 3: mixing private and public drivers
2 A73-South: regional co-operation
3 Gotthard and Lötschberg: Referendum and 'NEAT Aufsichts Delegation'
4 Betuweroute: 'Colleague model'

Joint sense making at West Coast Mainline

A good example of a higher order of co-operation can be found at the third round of the West Coast Mainline (WCML) case (see Teisman et. al. 2009). In the first round, the WCML was totally located within the public domain (monopoly) of British Rail. Due to the inability of British Rail to finance innovation on the line, after privatisation a new approach was adopted, predominantly based on private involvement and private, market-oriented decision-making. The private approach however led to huge cost overruns and finally to the bankruptcy of Railtrack, the privatised infrastructure successor to British Rail. Neither pure private responsibility, nor pure public responsibility led to a successful implementation. In these first two rounds the formal structures of the project did not fit the complexity of the project. It was not able to deal with the numerous tensions between participating formal entities like DfT, Office of Rail Regulation (ORR) and Railtrack or its successor Network Rail and as between Virgin and Railtrack / Network Rail etc..

In round 3 the network management and the network of management has developed, for instance in terms of joint sessions and joint documents. The result has been that the parties involved now act with more knowledge about the reality of the rail systems as well as the possibilities for renovation, innovation and return on investment that exist in round 3. Moreover, the parties were brought together by a common objective of achievement: it was clear to the whole industry that the £5.6 bn that the UK Treasury was willing, in 2002, to commit on top of the £2.5bn already spent was a last chance for the whole industry to demonstrate that it could achieve valuable results from investment. Many observers felt that if the project had failed again, the whole network would be starved of investment. In the hybrid form that emerged the process of joint sense making led to a common understanding, created a sense of urgency and generated a higher order of co-operation in the stakeholder network which is illustrated by the 'cross industry approach' which was outlined in section 8.3.1.

In the third round the balance between innovation and sticking to proven technology, between scope rigidity and scope development, between fixed cost and added value; as well as focused classical control arrangements, contracts and interaction were all found. This led to a higher order of co-operation between the participants. The stakeholder system succeeded in aligning the objectives of different parties involved in the project in such a way that it allowed swift delivery of the project objectives. The original purpose of Railtrack and operators like Virgin was focussing on each organisation's own short term financial results: the organisations (Railtrack and the operators, like Virgin) focused mainly on profit. Over and over again, it was found to be beneficial to align the objectives of different parties involved in this project. This is a crucial factor in the ultimate realisation of the project to time and to budget.

Virgin has realised that it is better for all concerned to cooperate with others involved, especially other train operators. The same was the experience of Network Rail. In the second round everything was processed "through the contract". But with the improvement in relationships in the third round, communication and relationships shifted to a more informal and personal basis which turned out to be better for cooperation. The important lesson from the West Coast is that cooperation with other stakeholders turns out to be a sounder base than an 'egocentric' and contractual approach.

The external stakeholders of the WCML are important because they are representative of the inhabitants along the line – who are also the users of the railway and can give 'local intelligence' concerning measures to be taken. They play an important role in explaining to the public what is being done on the project and why things are done the way they are done (explaining and reasoning). 'West Coast 250' a grouping of stakeholders – facilitates the link with other external stakeholders; (see 8.3.1).

This third period has led to an intriguing combination of public guidance and private production. An effective network of parties was built up capable of dealing with the network characteristics and interdependencies of the physical rail network and future delivery. On the one hand there were clear formal divisions in tasks and responsibilities, but there also were adequate informal networks and methods of collaborative planning, building up sufficient knowledge and support.

Our analysis of the behaviour of stakeholders within LIPs shows that the natural dominant driver is – not surprisingly – serving their own interest. A search in the studied sub-cases for general or common interest is often in vain. While this behaviour is totally legitimate, a focus on self interest, might result in actions that whilst seeming logical at first might lead to disappointing system outputs and, in this way, rebound in the form of diminished individual benefits. A good example was observed in the transport contract of the HSL-South where the winning consortium (HiSpeed) and the project delivery organisation (within the Ministry of Transport) argued as to who was responsible for the late delivery of the rolling stock (trains). While this arguing is understandable from a contractual point of view, the result was that no shared solution was developed on how to get trains up and running as quickly as possible on the new track. The two parties ignored the reality that if there were no trains available, this would soon lead to massive financial and image damage for both of them. In addition, the HiSpeed consortium is, although comprising separate companies, for a large part state owned, putting financial discussions in a different light altogether.

The WCML is a primary example of how a higher order of co-operation was achieved between public and private organisations in getting the WCML project going again. The core of the A73-South co-operation at the 'Region' was that it aligned interests in such a way that the Ministry of Transport was ultimately left with no realistic choice but to support their proposal.

Regional cooperation at A73-South

The regional cooperation has already been described in chapter 3 and 8. It is notable that the regional partners were able ultimately to present a plan to the minister that she *couldn't* and *wouldn't* be able to refuse. This was the result of an intense process in the region with all relevant players involved. As mentioned in 8.3.2, the key players knew each other well, had respect for each other and had a mutual interest. The methods of cooperation adopted were unique and demanded that the organisations involved had to think further than their own interests. The result of the constructive process was a package with sufficient benefits for all.

Swiss referenda and NAD (NEAT-Aufsichts-Delegation)

Another example of a higher order of co-operation was found in the Swiss projects studied. The Swiss political system has an obligation to put forward important decisions for a public vote. This has not happened for any of the large national projects in The Netherlands and UK. In the public vote both the majority of the Cantons and the majority of the Swiss citizens have to support the project in order for it to be accepted. The public vote has ensured a broad public support for the NEAT projects. The public vote of 1992 secured the first decision to build both Lötschberg and Gotthard projects. The vote of 1998 had a positive outcome for the financing of the NEAT projects from a heavy-vehicle tax (65%), oil tax (25%) and value added tax (10%).

Following the decisions of the Federal Council and of Parliament, as well as the majority of the Swiss people and cantons, delivered by the referenda of 1992 and 1998, the NEAT has not been the subject of debates about 'necessity'. This is an advantage for the politicians and project organisation and gave them an important guarantee. This can be compared to, for instance, the Betuweroute, where decisions about need and necessity stretched towards the realisation phase and resulted in a longer period of uncertainty for all stakeholders. This was also the case at the A73-South. After the decision by parliament (by a one vote majority) the project had been postponed twice, for financial reasons. In addition, the discussion of the west and east bank alternative routes continued until the judgement of the Council of State[1] on the appeal. It seems that the referenda can be successful in decreasing complexity within the project.

While the use of public votes within Switzerland has helped in securing political support – stimulating co-operation – it has had one major downside: many stakeholders agreed in interviews that only one axis (they mentioned Gotthard) was needed in order to meet traffic needs. The proposal to build both was needed to make sure that a majority of the Cantons would support the NEAT. For instance, if only the Gotthard was to have been built, the Cantons in the western parts of the country wouldn't be satisfied, prejudicing the positive outcome of the referenda. It seems that political support turns out to have a high price.

Andrea Hämmerle (2004):

> *"The decision for both projects can be considered as the price of the democratic system. In Switzerland more than 50% of the people in a referendum have to vote in favour and if it involves an amendment to the constitution (eine Verfassungsänderung) 50% of the Cantons should also vote in favour, and this was the case with the NEAT proposal. To gain this double majority, both axes were needed."*

A higher order of co-operation was also found in the 'Delegation for the Supervision of the NEAT' (NAD) which is a permanent committee of Members of Parliament that regularly talks to the Federal Office of Transport (FOT). The FOT is the civil client of the NEAT. The regular talks between the FOT and the Members facilitates discussion, information gathering and sense making – reducing any ambiguity surrounding the NEAT. In contrast in The Netherlands there is no common platform where civil servants and Members of Parliament can discuss such issues, often resulting in more political turbulence. The track record of the NAD shows that a special 'Political Delegation' for supervision of a LIP can stimulate project implementation.

[1] The Council of State advises the Dutch government and parliament on legislation and governance and is the country's highest administrative court.

The Delegation for the Supervision of the NEAT (NEAT-Aufsichts-Delegation, NAD)
The NAD is the higher supervisory authority for the planning and construction of the New Railway Lines under the Alps.

The delegation is composed of two members from each of the following Parliamentary Standing Committees of both Chambers: the Finance Committee, the Control Committee and the Committee for Transportation and Telecommunications; Thus there are 12 members. The NAD has the same rights as the Control Committees and the Finance Committees.

Its main assignments are the following:

- Parliamentary control over the federal offices in charge of operations and higher financial surveillance, during and after the planning and construction phases.
- Monitoring all operations as to their compliance with legal provisions and interpretation thereof; follow-up of services, costs, deadlines and expenditures in all the planning and construction phases.
- Verification of organisational structures and of surveillance procedures; verification of how supervision authorities carry out their supervision and management assignments.

Text box 10.1: NAD as a form of higher order co-operation

We concluded from interviews that all involved project members consider the delegation to be one of the biggest strengths of the project. It works as a bridge between changing governments and public authorities. Even a changing cast of characters within the delegation or altered political orientation of the head did not have a major influence on these benefits, although it had an influence on the style of communication and the main focus of the work. The institution and the work of the delegation in general can be seen as a surety for transparency and long-term political support.

Andrea Hämmerle (2004):

> *"The project delivery organisation has to report on a half yearly basis. In these reports all problems need to be reported. Within the reporting period there may however also be problems that need to be communicated earlier. This happened in 2003 when problems arose and the NAD only received minimal interim information. Later, in the official half yearly report (no. 16) it was realised that this was an 'issue' resulting in a 700 mln CHF additional cost. This finding led to significant tension. The project delivery organisation defended itself by stating that, by doing everything within their power, they had hoped to cut back these additional costs within the duration of the reporting period. But the NAD and House of Representatives decided that in future when serious problems are notified to the project delivery organisation they should immediately be reported to the NAD even when the total impact is not yet clear. This is how we want to prevent surprises and the public debates resulting from them."*

Betuweroute: colleague model

Within the Betuweroute we observed another instance of what we have started to call a higher order of co-operation. But here the co-operation centres around the relationship between the civil principal and project delivery organisation.

In 1999 a new Betuweroute Project Director for the Ministry was appointed as civil principal. The new Betuweroute Project Manager within ProRail (POBR) had entered the project one year earlier. At this time the project had a very negative image because of cost increases during earlier phases and the intense political debates that this had caused. In addition there had been numerous discussions between POBR and the Ministry on budget and costs estimates: the POBR cost estimates were far higher than the budget that was available within the Ministry. The two new project directors observed that the project organisations within the Ministry and of ProRail had been working insufficiently closely. They observed a lack of shared vision, a lack of "a common project feeling" and little confidence between the two organisations. The result was a formalised style of communication, illustrated by many official letters to each other. Important mutual matters were hidden from each other for too long and all these matters could only be discussed at top level: between the Project Director Betuweroute (Ministry) and the Project Manager Betuweroute (ProRail), no matter the importance or degree of detail. There was very little contact on the lower management levels. The division of tasks and responsibilities between the organisations was carried to extremes.

To cope with these challenges, a belief arose that it was necessary to act together more, in 'a strategic partnership', where 'both worlds co-operate'. This was stressed by both project directors. They decided in the second half of 1999 to integrate their organisations as far as the outside world was concerned – the Betuweroute project organisation, with one management system, that was certified NEN-ISO 9001, 30 May 2000 (Progress Report 8). Both project organisations at the Ministry and ProRail remained as separate entities, but the intention was to work more 'as one'. The new way of working was called 'colleague model', in which they spoke more openly about important matters and progress. Another important change resulting from the colleague model was that co-workers of both the Ministry and ProRail had contact and worked together in a structure of vertical communication.

In November 1999 the Project Director of the Ministry of Transport and the project manager of ProRail formulated the project assignment ('opdracht') as can be found in table 10.1.

Before November 1999:	After November 1999:
• Execution of the Betuweroute • Preparation of Private Exploitation • Preparation of Decision Process of the North Link of the Betuweroute	• Execution of the Betuweroute • To realise the Betuweroute within the limits of budget and time • Signalling issues regarding: Execution of the Project Social support

Table 10.1: Project assignment before and after November 1999

In this sense the colleague model can be seen as a higher order of co-operation between the civil principal (the Ministry) and the project delivery organisation (POBR). So what have been the experiences with this colleague model? A manager of POBR told us:

> *"It looks like the goal of the working relationship was to work together. But the actual background was to get more grip on the project. The Ministry of Transport did not have good feeling about the project. They did not know if the project organisation functioned adequately."*

Yet, he also stressed:

> *"It (The Colleague Model) definitely improved the working methods within the project."*

This quote further illustrates our finding that a higher order of co-operation can stimulate the control of the project.

The colleague model worked out particularly well at the level of the top management. The good relationship between the Project Director of the Ministry and the Director Realisation of ProRail proved to be important at the time of sensitive negotiations of the Betuweroute budget. It increased mutual understanding of each other, why and how 'the other' works. The vehicle of one quality system facilitated this process. It was an initiative to bridge the gap between the political side of the project and the operational side of project execution. In this way it reduced the ambiguity and addressed the social complexity existing between the two involved parties. It might not be a perfect solution, but it has certainly showed its benefits in the management of complexity.

Our first key to success is in achieving a higher order of co-operation. This higher order can be in various parts of the stakeholder system (see figure 10.1, here the examples are placed in the stakeholder network active in LIPs). Achieving this co-operation is connected to the strategies of interaction which help to align and realign

interests in the project over time. But the strategies of control also form a necessary component here, since without control strategies the project would run the risk that co-operation would fall apart because insufficient progress was being made. So a higher order co-operation also requires that stakeholders reach agreements on the division of work, the scope of work to be delivered and schedules. A higher order of co-operation can only exist in a sustainable manner when the strategies of control and interaction are balanced.

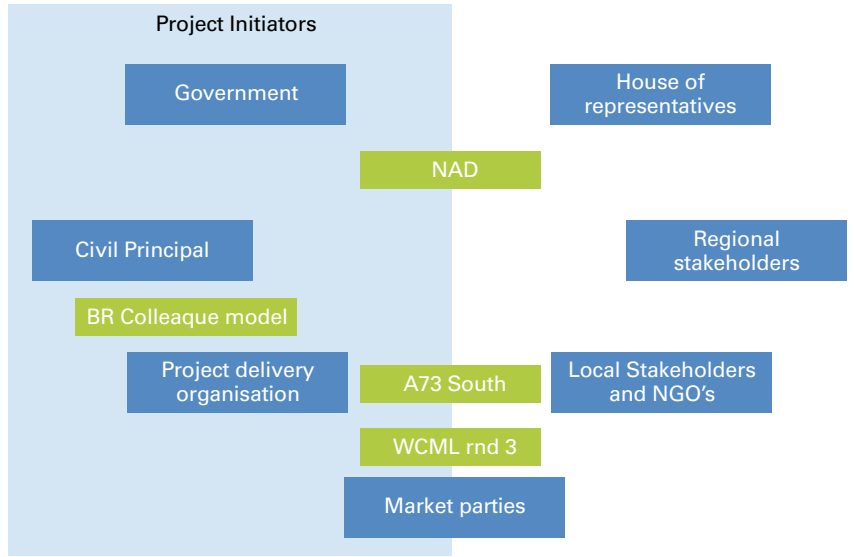


Figure 10.1: Examples of higher order co-operation in the stakeholder system of LIPs

Figure 10.1 further illustrates that the co-operative capacities are needed between various players within the stakeholder constellation commonly active in LIPs:

- Between the political level (Government and House) and civil principal;
- Between the civil principal and project delivery organisation;
- Between project delivery organisation and local stakeholders and NGO's
- Between project delivery organisation and market parties

But how to achieve this higher order of co-operation in such a dynamically complex stakeholder system? This is were our second key to success might offer project managers assistance.

10.3 X-FACTOR 2: PROJECT CHAMPIONS

In our analyses we observed that to initiate the extraordinary, the stakeholder network at LIPs needs a stakeholder that will 'go the extra mile' to make the project a success. As mentioned before, co-operation is not a natural behaviour of stakeholders as we saw in the dominant approaches of content focused and systems management. Who will see and take the challenge? Who will become the 'project champion' that stimulates the cooperative capacities of the involved stakeholders?

From our sub-cases we found the following condition to achieve project success:

> *In order to manage complexity in LIPs successfully, the project initiators need to 'go the extra mile' in the sense that they should feel responsible for delivering project outputs that fit the needs of the involved stakeholders and not only focussing on their constraints in terms of budget and schedule.*

In the previous section (10.2) we saw that the stakeholder system has the tendency to produce unwanted system outputs (dissatisfaction) when unaligned individual interests dominate the behaviour of players. In order to solve this and prevent deadlocked situations such as observed in many of our cases – especially illustrated in chapter 6 – we believe that this role could be best fulfilled by the project initiators: the civil principal and project delivery organisation. They should serve as the project champions.

In literature on project management the role of project champions is often mentioned. However these studies are viewing project champions as individuals providing the necessary and essential supports for projects to be executed. In our study we are referring to something else, not that support referred to in those studies. Instead we are presenting an additional view in which we position project champions on the player (and not individual) level. The individual level is however presented as X-factor 3, see section 10.4.

Earlier we illustrated the different perceptions and goals within LIPs (figure 10.2). Here it is of extreme importance that the higher order benefits, for society and stakeholders, form the basis of their management. And this is especially difficult because of the decomposition – into both horizontal and vertical structures – necessary to implement a project.

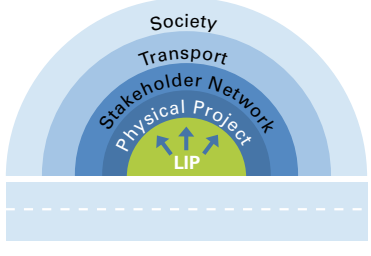


Figure 10.2: Benefits of LIPs in the stakeholder network

The civil principal and project delivery organisation are the stakeholders best suited to think beyond their project boundaries to manage all the interests represented in figure 11.2. They are at the core of the implementation process of LIPs and as initiators are the ones most able to take this role. They can reach out and connect with the other participating stakeholders (section 10.2) to create the sometimes unconventional management solutions which are needed to break deadlocks in LIPs (described in section 10.5).

Examples of this were found in all our six main cases, see table 10.2.

	Case	Sub-case	The extraordinary	Project Champion works from:
1	Betuweroute	Organising 1999	Colleague Model (10.2)	Principal/ PDO
2	Betuweroute and HSL-South	Risk reservation	Risk reservation for HSL-South and Betuweroute (10.5)	Principal
3	A73-South,	Political Agreement	1. The broadening of scope (10.2, 10.5) 2. The region that made the proposal, with cost savings and co-financing (10.2, 10.5).	Province, PDO in cooperation with cities
4	Gotthard and Lötschberg	History	Referendum (10.2) NAD (10.2)	Parliament, Principal (BAV)
5	Gotthard and Lötschberg	History	FinÖv (10.5)	Parliament, Principal (BAV)
6	West Coast Mainline	Round 3	Joint sense making (10.2)	Principal, PDO and operators

Table 10.2: Examples of project champions found in our cases

It is interesting to note that with A73-South the initiative was not only pushed forward by the project delivery organisation, but also by the regional governments, especially the Province, to expand the scope and develop a new project. In this case, the province also served as a civil principal, because of the co-financing arrangements. With West Coast Mainline the joint effort was initiated by the principal (SRA).

However, especially with the project delivery organisation, this set of responsibilities needs to be compared to their traditional role within LIPs as 'an implementation agency'. Often these project delivery organisations are judged on their capability to execute a project with a set scope within the constraints of budget and schedule. But as we saw earlier, this does not fit well with the characteristics of dynamic complexity found in LIPs. Changing preferences of stakeholders mean that the scope and constraints might need to change in order to better fit the changing interests of

stakeholders. Changes are inevitable in the execution of LIPs. We propose that in order to manage this complexity more successfully, the traditional judgement criteria for project delivery organisations need to be expanded. They should not just take project constraints as their basis but the realised benefits for society as a whole and those of the involved stakeholders in particular. Needless to say these benefits still need to be translated in terms of constraints so as to facilitate project execution.

It seems to be good practice to keep the decision on major changes outside the mandate of the project delivery organisation, but the project delivery organisation should definitely play an important role in the change process. Strategies of control remain necessary in project implementation by the project delivery organisation. But at the core should be the 'benefits to stakeholders', which are best served by applying a combination of the strategies of control and interaction, as part of our dynamic management approach.

10.4 X-FACTOR 3: COMPETENT PEOPLE MAKING THE DIFFERENCE

"Interactive Management is all about competences."
Jacques Hock (Adjunct Director Project Management Bureau Amsterdam, 2005).

In the previous section, we described project champions, because these are the players that should make the difference. And when success is determined by groups of people, the importance of the competences of crucial people in the process cannot be better illustrated. A successful manager of complexity facilitates the process, looks for opportunities, takes care of participation of stakeholders, and tries to make sufficient progress.

Bekkering et. al. (2001) describe the interactive manager 'in ten seconds':

> *"The interactive manager is someone who in interaction with a number of important organisations knows how to act in an unstructured environment. He distinguishes himself by sensitivity, brightness, willpower and position. Furthermore he masters basic social skills (on conversations, how to deal with conflicts, …) and has general knowledge of the theme and branch."*

Teisman (2005) mentions five core competences he often envisions in debates about executives and managers: speed, smartness, responsibility, consistency and vision.

Managers of LIPs should have the ability to (De Bruijn, Hertogh and Kastelein, 2004):

- develop high trust relationships
- be sensible for relationships
- understand deeper drivers of actors behaviour
- create progress
- attribute success to others
- switch between different approaches.

And finally managers need to have affinity with content and systems management. This last recommendation also demonstrates that in the skills of the project manager, the approaches of systems management and interactive management need to be combined.

Individuals making a difference at A73-South
At A73-South three persons catch the eye. First is the Deputy who suggested the broadening of scope, initiated the brainstorm sessions and was prepared to advocate a new role for the Province.

The second was the project director of Rijkswaterstaat, who was very aware of the need for interaction and was willing to cooperate despite his colleagues at the head office who sometimes had different opinions.

Mentioned many times in the interviews was the appreciation and respect for the Regional Fire Officer, who spent a lot of (extra) time on the issue in order to get sufficient knowledge to judge what the right solution was and to become a professional counterpart to the specialists of Rijkswaterstaat. Competences mentioned were: "enthusiastic, dedicated, well prepared, upright and modest".

These people had the ability to look beyond the interest of their own organisation.

Text box 10.2: Competencies at the A73-South

Competent individuals make all the difference in the management of complexity. At The WCML (see section 10.2) it is fascinating to see that there appears to be a clear formal distinction between the public domain (DfT, Office of Rail Regulation) and the private (Network Rail, Virgin and other operators) but that in fact the whole rail industry is operating as a network of partners. The degree of maturity does more depend on the quality of the network of managers than on the formal structures themselves.

The management of LIPs evolves, as we have illustrated in this thesis, around the management of complexity which means that within the stakeholder system 'no one is in charge' (see chapter 1). The management of detail and dynamic complexity places demands on all active participants in the stakeholder network of LIPs. It is necessary to meet these demands in order to produce beneficial output. This means that the capability to delivery this output is highly dependent on the whole range of competences of the various individuals both within the project delivery organisation and within other participants.

Of course there is much more to say about the influence of individuals within LIPs. Here we have demonstrated its importance and exposed the top of the iceberg. Our guess is that in future within this area there are major contributions to expect from further research.

10.5 X-FACTOR 4: CAPABILITY TO FIND UNIQUE MANAGEMENT SOLUTIONS

Within the LIPs studied we saw several examples of deadlock or crisis in which the projects concerned came close to being abandoned. In these times of crises there is a great sense of urgency, a motive to change things. In addition, because the problems faced are often unique and so specific, principals, project delivery organisations and other stakeholders need to come up with unconventional solutions to change things, to ensure project survival. We saw unique management solutions in several cases such as:

- Finöv fund at the Gotthard and Lötschberg
- Political agreement A73-South
- Risk reservation HSL-South and Betuweroute

Unique and unconventional management solutions can allow major breakthroughs in situations of deadlock or crisis.

Finöv fund at the Gotthard and Lötschberg

We now illustrate the Finöv fund example from the Swiss cases. As Peter Testoni, project director Ministry (BAV), said during our interview, 2004:

"The real critical moments were in '94/'95, when the finance minister objected to the existing financing system. This was resolved by the FinöV-fund in '98."

The intense discussions, especially between the Ministers of Transport and Finance in 1994/95 meant 'heavy weather' for NEAT. The Minister of Finance doubted the financing and profitability and Coopers Lybrand agreed in a report, that the NEAT was not profitable. The Minister also doubted the need for two axes (Gotthard as well as Lötschberg). This last discussion he lost but, because of his worries, a totally new financial model was developed and decided – the FinöV-fund. With hindsight, the discussions led to a better solution in the end, where both Ministers were satisfied with the outcome. But before establishing this solution, it was felt to be a further advantage that both Ministers left their jobs and the new Minister of Transport and Energy, Moritz Leuenberger could move forward without the burden of past discussions.

Important characteristics of the FinöV-fund are:

1 Secures 20 years of financing.
2 Less dependent on political priorities.
3 Finances a package: NEAT, High speed connection West and East Switzerland, noise protection measures and Bahn 2000.

The FinöV-fund is a financing programme that ensures financing for 20 years, without burdening the Treasury as was the case with the 1992 proposal. This new way of financing provides an important security for the financing of NEAT, one that is less dependent on political changes and financial priorities of the Federal Council. This solution provides an opportunity after 20 years for it to be continued and with these funds new investments can be paid for.

It is a perfect example of 'changing the scope' in order to make a feasible plan. The FinöV-fund enlarged the scope from NEAT to an overall package embracing High speed connection West and East Switzerland, noise protection measures and Bahn 2000. The solution fits the dynamic complexity within LIPs and stimulates project execution.

As we saw in chapter 5, things are unlikely to change in LIPs without outside pressure resulting from (mainly) dissatisfaction. We already concluded that the project delivery organisation has the tendency to aim to maintain the status quo. Combined, these factors mean that innovative solutions often do not come from within the project delivery organisation, but are forced by outside pressure from dissatisfied stakeholders.

Management innovation within LIPs does not normally come from within the project delivery organisation but is mostly caused by external pressure.

Political agreement A73-South

After the second postponement of the A73-South in 1998, the regional partners in the

province of Limburg successfully tried to find a solution (see section 8.3.2) together. Two extraordinary processes catch the eye in this sub-case:

1 Redefining the problem with the goal of solving the mobility problems faced by the region, led to the broadening of scope from a single project (the A73-South) to a package of four projects (later on a fifth was added: Haelen).
2 The Region's proposal for cost savings and local co-financing. This was seen by the Minister as a template for other regions, as a way to solve other regional problems. The region was also satisfied, because they could realise three (four) new projects, apart from their main goal the A73-South.

Risk reservation HSL-South and Betuweroute

After some serious budget overruns with the Betuweroute and HSL-South, the Ministry proposed to implement a special fund to cover the remaining risks of the project were they to occur. It was decided to make a reservation for both projects in one budget (so as to keep attractive potential claim information hidden from contractors). In addition it was decided that the budget could only be used after approval of the House of Representatives, so it was not immediately available to the principal and project delivery organisation.

The risk reservation can be regarded as an innovation in budgeting for public authorities: since normally it is not possible to reserve funds for something without a clear scope of work, such as a risk contingency as in this case. But the reservation proved to be beneficial because it gave more structure to how risks within these projects should be reported and as to who would decide on providing additional budget. The innovation was forced by the Ministry of Transport as the civil principal of the project, because they were dissatisfied at that time with the 'usual' process of ever growing budgets in the two projects that caused fierce discussions in the House of Representatives.

Capability to find unique management solutions

So innovation can be a good way to tackle situations of deadlock. Innovation is a strategy that is linked to interaction: it is a way to align interests of stakeholders in ways not seen before. Using innovation in such situations can be very beneficial but is also very much dependent on the individual competences of key personnel. For example with the A73-South where the dedicated fire brigade officer convinced the Minister of Transport to use a compressed air foam solution. Or the Deputy of the Province of Limburg who directly arranged a meeting with the Minister when contact via the Ministry proved to be fruitless. These, and many more examples, show that in order to turn around deadlocked situations in the stakeholder system within LIPs, key personnel must have a vision of change, broader than simply serving the interest of their own organisation.

The capacity to develop unique management solutions that fit the context of the project has several consequences for managerial learning within LIPs. While we observed in cases studied that complexity in both characteristics (detail complexity) and implementation process (dynamic complexity) is comparable for the studied projects, each require their own solutions. This means that a 'carbon copy' of one successful approach, from one project to another, is bound to fail. A project drawing lessons learnt from other projects, understanding the context in which these strategies were successful and using it to develop a unique management solution – fitted to the circumstance of the case in hand – however offers far better changes of success. An comparable example would be a cook producing a unique meal for a specific set of guests, based on a mixture of some well known ingredients and previous experiences. Similarly, successful management approaches for LIPs need to be tailored to the unique character of the project – its context, its history and the unique events associated with it.

10.6 X-FACTOR 5: USING WINDOWS OF OPPORTUNITY

Project managers have a limited ability to change the outcome of their projects: many of the factors that influence project results lie outside their control and many things cannot be changed overnight. However they can and do influence results by:

- Addressing the themes in which complexity occurs (see chapter 4)
- Combining the approaches of control and interaction (see chapter 9)
- Developing unique management solutions that fit the project context and history (see 10.5)
- Finding windows of opportunity

In this section we look at this fourth suggestion: windows of opportunity for change often mark the end of a round of decision making and the start of a new one. Changes originate often, as we demonstrated earlier, from dissatisfaction from one of the key stakeholders. The implementation of LIPs in a highly complex context, demands the utmost of people to keep the process going. This may lead to the conclusion that complexity can be viewed as disturbing. But, as we observed in the projects, complexity can also be the stimulus for new approaches.

As we stated in chapter 5, changing preferences are at the core of the management of complexity. Changes in preferences might be the start of a new balance in the stakeholder system. But how does a change in preference occur? We saw that various external and internal developments can trigger a change in preference of an involved player. External factors can be specific events or independent changes in context. Internal factors originate from the effects of past decisions. We also noted that the main driver for change in LIPs is dissatisfaction: without one stakeholder being

dissatisfied, the stakeholder system has a tendency to maintain the current situation and balance.

What can project delivery organisations do when faced with these processes of change? From our research we conclude that:

> *Project delivery organisations should use windows of opportunity to achieve change in LIPs so that the project better fits the interests of stakeholders or is managed in a better way.*

In our cases we saw some examples where dissatisfaction of stakeholders can be transformed into satisfaction. This was for example at the sub-cases of the 'Birds' (HSL-South), 'Political Agreement' (A73-South) and West Coast Mainline. When we have a close look at these cases we see that dissatisfaction can be overcome by using the strategies of interaction and control. Within the WCML it was the SRA at the start of round 3 that changed attitude from 'internal' to 'interaction'. In phase 2 neither Railtrack, nor the rail industry was able to remove process blockage. The way to address this situation proved to be an increased level of interaction, combined with new measures of control.

Another example comes from the Betuweroute. The bad image arising from the controversy and the cost overruns in the first half of the 1990's, created an immense pressure on the project organisation to find ways of management that would avoid political dissatisfaction and cost overruns. Mrs. Netelenbos, Minister of Transport from 1998-2002 told the responsible director at the Ministry that she did not want to hear "anything about the project that may attract political attention". Even though this statement was highly frustrating for at least some officers working on the project, it is also one of the reasons the project delivery organisation developed a 'best practice' management system that could serve as an example for other large projects (Westerveld, Flyvbjerg, 2007). Here we have an example how outside pressure contributed to the control of the project.

Another sub-case in the scope and costs development of the Betuweroute demonstrates where an internal, content focused approach changed towards a more dynamic approach. The trigger to change was an expectation of an extreme budget overrun. The civil principal (Ministry) and project delivery organisation (ProRail) changed their previously distant attitude into a more a cooperative one around the end of 1999 because a rise in costs was unacceptable and external reports gave negative views on the quality of project control.

The sub-cases where we saw a change in the approach from content focused to an approach using strategies of both interaction and control are summarised in table 10.3.

Sub-case:	Window of opportunity (that marks the change of round) because of:
Birds (HSL-South)	Legal threat by NGO (after more interactive attempts failed). The project delivery organisation judged they would loose the case in court.
Organising the Betuweroute ('tension arcs')	Shared sense of urgency because of unacceptable budget rise and bad reports coming from external enquires. Two new key managers at both sides wanted to change this situation.
Political Agreement (A73-South)	A totally new concept that convinced the Minister by including provincial roads, co-financing of the region and providing an example for other regions.
TTI at Betuweroute	Enormous rise in budget (from € 150 million to a maximum of € 345 million within a few months).
Frutigen at Lötschberg	Shared realisation of Canton, Community and BAV that Frutigen would be too heavily affected by the project.
West Coast Mainline	Enormous rise in cost (towards £13 bn.), bankruptcy of Railtrack and safety problems (accident at Hatfield).

Table 10.3: Motives to change an internal approach towards a dynamic management approach

Based on table 10.3 we can draw the following conclusion:

> *A deadlock or impasse situation can be removed by applying dynamic management when there is a clear sense of urgency.*

Sub-cases where this change was not made, were the Bos-alternative, Canton Uri, Betuweroute operations and the tunnel safety case (table 10.4). In each of these four cases the initiator maintained a (more or less) content focused approach and continued to minimise room for discussion with the stakeholders. That led to less ability to align the project with the preferences of the involved stakeholders, resulting in a failure to incorporate dynamic complexity into the organisation.

Sub-case:	Stick to the internal and content focused approach, because:
Bos-alternative (HSL-South)	Although the Ministry of Spatial Planning supported the alternative it was not considered seriously by the civil principal and project delivery organisation. The alternative did not fit with the ideas of the project initiators.
Canton Uri (Gotthard)	The solution of Canton Uri is too costly according to the client and project delivery organisation. An internal approach of these initiators didn't improve the process.
Operations at Betuweroute	No sense of urgency because the operational phase was still so far ahead that real negative consequences of failures in the process did not become visible.
Tunnel Safety (A73-South)	The Ministry was not very keen on interaction because there was a distant relationship and a need for cost savings

Table 10.4: Reasons for sticking to the internal and content focused approach

The table reflecting the causes for sticking to an internal approach shows us that:

A situation of deadlock will continue when there is no clear sense of urgency to change things for at least one of the main involved stakeholders.

Timing of interventions is crucial. Windows of opportunity open as the result of external change events or as the result of re-evaluation of past decisions – or a combination of both. The strategies of using 'short term predictability' by periodic evaluation and selection are useful to track this. They enable you to calculate when things can and need to be changed. Project delivery organisations should not be afraid to use external pressure in order to change things. Our sub-cases show that this external pressure creates the greatest sense of urgency. So while political turmoil is often regarded as undesirable by project managers – because it disturbs the flow of implementation, it is usually an effective and necessary factor facilitating re-alignment of the preferences of stakeholders in a new and improved manner.

10.7 SUMMARY AND CONCLUSIONS

In the successful management of complexity within LIPs, X-factors can make the difference. We observed the following 'extraordinary' solutions:

1 Stakeholders system – higher order of cooperation
2 Player level – project champions
3 Personal level – competent people making a difference
4 Capability of finding new management solutions
5 Using windows of opportunity

Combined with the balancing of control and interaction, these represent the keys to success in the management of complexity within LIPs.

The first three X-factors consider the players within LIPs on three separate levels: system, project delivery organisation and individual. The stakeholder system within LIPs has a tendency to produce unwanted results when the participating stakeholders only look to serve their own interests. To solve this a broader systems view should be encouraged as the basis for their actions. This view would allow them to see their actions and position related to that of other players and enable them to see the broader perspective. The project delivery organisation is the stakeholder that should be responsible for encouraging the adoption of a broad, system based, perspective by the participants. In this sense the project delivery organisation is much more than an 'implementation agency': it is the stakeholder that should make sure that the entire stakeholders' system produces optimal benefits in terms of output of the project. This translates to the individual behavioural level where we see that competent individuals can make the difference within LIPs by taking a system-wide view – which also facilitates the achievement of their own objectives.

X-factor 4 focuses on management solutions. To align interests and create progress, unique management solutions are needed. New management solutions can create a breakthrough for participants. The dominance of dynamic complexity within LIPs means that creating and dealing with change becomes a subject of vital importance. Project managers and others should look for windows of opportunity to stimulate progress and align interests. These windows often open as the result of external pressure from one of the main stakeholders. Change should not be regarded as a negative thing: it offers new and unforeseen potential benefits to all involved.

APPENDIX 1: INTERVIEWEES

A73-South

Rob Prins (†)	Project Director A73-South, RWS
René Scholtes	Contract Manager A73-South, RWS
Math Vestjens	Delegate Province of Zuid-Limburg
Ditmar Weertman	Project manager A73-South, RWS
Angelino Wollersheim	Regional fire officer
Geert Rutten	Civil servant, Roermond
Ad Jereskes	Civil servant, Roermond
Gerard IJff	Alderman Roermond
Toine Wuts	Stichting Milieufederatie Limburg

Betuweroute

Hans Versteegen	Head Major Project (Civil Principal Project Betuweroute), Ministry of Transport
Patrick Buck	Project Director Betuweroute, Project Organisation Betuweroute
Henk van Harmelen	Head of Planning & Risk Management, Project Organisation Betuweroute
Jaap Balkenende	Director Realisation, Project Organisation Betuweroute
Bert Klerk	CEO, ProRail
Cees de Vries	Deputy Project Director Betuweroute, ProRail
Carla Fenijn	Co-ordinator of local interest groups Betuweroute
Piet IJssels	Mayor of Gorinchem
Johan de Bondt	Delegate Province of Gelderland
Marijke van Haaren	Delegate Province of Gelderland
Marina Hart Nibbrig	Head of Communications, Project Organisation Betuweroute
Rob Mulder	Project Controler, Project Organisation Betuweroute
Wim Fritz	Project Controller, Project Organisation Betuweroute
Teun Tuytel	Divisional Manager Infrastructure and Maintenance, Port of Rotterdam
Theo van Bekkum	Director Project Control Betuweroute, ProRail
Thieu van de Wouw (†)	Mayor of Barendrecht
A. Koekhoven	Civil servant, Barendrecht
Jan Wabeke	Member committee of architecture ('welstandcommissie') Betuweroute, Gelders Landschap
R.J. Messemaeckers van de Graaff	Head of Quality Management, Project Organisation Betuweroute
Jan Jonker	Preparation Tunnels, Project Organisation Betuweroute
Reijer Baas	Director Stakeholder Management Alliance Sliedrecht-Gorinchem, Betuweroute

Gotthard Base Tunnel

Toni Eder	BAV, Head of Division Infrastructure
Peter Testoni (†)	Ex BAV, former Head of Division Infrastructure
Peter Suter	Ex BAV, former head of Section Alp Transit
Andrea Hämmerle	NAD, President
Nikolaus Hilty	BAFU, NEAT Coordinator
Stefan Trüb	Canton Uri, Mayor of Schattdorf
Peter Zbinden	Ex ATG, former CEO
Toni Büchler	ATG, Head of Commercial Division
Walter Jauch	Canton Uri, NEAT Coördinator
Martin Furter	Representative of eight national environmental protection organisations
Placi Berther	Community Sedrun, Mayor
Thomas Pfisterer	NAD, President

HSL-South

Jaap Geluk	Project Director, Ministry of Transport
Jan Bijkerk	Project Manager Bored Tunnel, Ministry of Transport
Yolanda Oudt	Head of Legal Affairs and Project Secretary, Ministry of Transport
Alexander van Altena	Director Rail, Ministry of Transport
Peter van Kleunen	Test manager (integrated system), Ministry of Transport
Jan Ochtman	Tender manager superstructure, Ministry of Transport
Hans Odijk	Head of Project Management, Ministry of Transport
Wim Korf	Project Director, Ministry of Transport
Theo Podt	Manager Project Control, Ministry of Transport
Wim Gideonse	Deputy Director Rail, Ministry of Transport
Peter Kee	Assistant to the Board of Directors, Ministry of Transport
Frans de Mol	Knowledge Management, Ministry of Transport

Lötschberg Base Tunnel

Toni Eder	BAV, Head of Division Infrastructure
Peter Testoni (†)	Ex BAV, former Head of Division Infrastructure
Peter Suter	Ex BAV, former Head of Section Alp Transit
Andrea Hämmerle	NAD, President
Nikolaus Hilty	BAFU, NEAT Coordinator
Karl Klossner	Mayor of Frutigen
Martin Furter	Representative of eight national environmental protection organisations
Jürg von Känel	Civil Servant, Bern
Peter Teuscher	BLS AT, CEO
Thomas Pfisterer	NAD, President

West Coast Main Line

Stuart Baker	DfT, Divisional Manager - Rail Projects (National)
Tony Francis	DfT, Project Sponsor - Rail Projects (National)
Matt Dillon	DfT, Project Sponsor - Rail Projects (National)
Tom McCarthy	Bechtel, Project Manager
Simon Maple	Network Rail, Investment Manager West Coast
Tony Sadler	Virgin West Coast, Operation Planning Manager
John Ellard	Shearman & Sterling, West Coast Legal Advisor
James Mackay	West Coast Advisor

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