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Organising the Early Design Phase in a Large Infrastructure Project

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Abstract:

Large physical infrastructure projects are complex, lengthy endeavours usually initiated on a political level and managed by public clients. Many important decisions are made in early design phases, when the knowledge of numerous technical specialists is integrated to balance cost, quality and scope over the whole project lifecycle. Since projects and their contexts are unique, there are no comprehensive standard models for how to organise decision making in these early phases. Instead collaboration and coordination processes result from project members' conscious efforts to merge existing organisational routines and tools with their own previous experiences and input from other projects. To enable a learning project organisation capable of managing complex coordination and cooperation issues, organisational structures and processes need to be carefully designed and open to successive adaptation.

The aim of this thesis is to investigate what aspects affect the development of organisational structures and routines of the little researched but influential phase of early design in major infrastructure projects. An in-depth, single case study was conducted to investigate everyday practices and interpretations in management of the West Link project, an urban major railway tunnel project. The approach was longitudinal and mainly based on non-participant observation. Four papers are presented in this thesis. The first focuses on how perceived needs for cooperation and coordination influence the design and continuous development of the project organisation. The second paper looks into formal and informal knowledge transfer, primarily from other projects, to the case study project. Paper three investigates the development and implementation of a cooperation bonus. The last paper is based on an earlier case study of a tunnel project in its construction phase and looks into communication and interactions between client, contractor and consultant parties. One conclusion drawn from these papers is that aspects influencing early design organisations often relate to both coordination and cooperation, influenced by constraints in available resources as well as in participant cognition. The project organisation continuously develops as changing circumstances are revealed in formal and informal communication, both internally and in relations beyond the individual project. However, focus on cooperation declines as relations are established and project activities commence, while issues of coordination remains as explicit concerns. Further it seems that factors concerning predominantly coordination tend to influence and explicitly add to formal structures, while effects of factors related to cooperation tend to be integrated into existing routines and procedures.

Keywords: Infrastructure project, coordination, cooperation, learning, organisation

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Gothenburg, March 2013

Therese Eriksson

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List of appended papers

Paper I - Organising design processes: collaboration, coordination and learning in the West Link Project

Eriksson, T. and Kadefors, A.

Previous versions of this paper have been presented at the Engineering Project Organizations Conference, July 10-12, 2012 in Rheden, The Netherlands and submitted to the European Academy of Management Conference, June 26-29, 2013, in Istanbul, Turkey.

Paper status: Work in progress. To be revised and complemented by data from a still on-going sub-phase in the case study project and interviews.

Paper II - Learning in the early design phase of an infrastructure development project

Eriksson, T.

Conditionally accepted to the 7th Nordic Conference on Construction Economics and Organization, June 12-14, 2013, in Trondheim, Norway.

Paper status: Working paper.

Paper III – Designing and implementing incentives for engineering consultants – bonuses for cooperation and innovation in the West Link project

Eriksson, T.

Paper accepted to European Academy of Management Conference PhD student workshop, June 24-25, 2013 in Istanbul, Turkey and abstract accepted at Engineering Project Organizations Conference, July 9-11, 2013 in Winter Park, USA.

Paper status: Working paper

Paper IV - Trust, control and knowledge integration in a rock tunnel project

Eriksson, T. and Kadefors, A.

In Proceedings of the Association of Researchers in Construction Management Annual Conference, 3-5 September, 2012, Edinburgh, UK

1. Introduction

Large physical infrastructure projects are complex, lengthy endeavours usually initiated on a political level, managed by public clients and paid for with tax money. Decision makers in rail and road projects are expected to create solutions today for needs of commuters and goods transports in a distant future. However, headlines of major infrastructure projects failing to meet deadlines or running over budget during construction are common. These issues make development of infrastructure a frequently debated topic, often raising questions about project relevance and the origin of delays and budget overruns, especially regarding high-profile major projects.

Causes of increases in estimated costs may often be derived from early project processes of planning and design (Lundman, 2011; Sturts and Griffis, 2005). A study of selected European major infrastructure projects being built around the turn of the millennium found that underestimations of costs mostly occurred during the planning stages before the project scope was settled (Hertogh et al., 2008). Considerable delays during planning of the projects were caused by changes in legislation, changes in regulations concerning e.g. environmental impacts, or by local opposition. Choices made during early phases have an impact on the subsequent phases, enabling or hampering innovative or cost saving solutions for further planning, construction, operation and maintenance. A minor misjudgement while planning could have a negative effect on aspects of safety, flexibility of production techniques, environmental impacts, meeting budgets and deadlines as well as on operational value and cost.

Managing large infrastructure projects is complex and new challenges have come up in recent years. Many infrastructure clients are government agencies subject to public sector reforms, involving a shift from hierarchical relations to contracts as the preferred governance principle (Pollitt and Bouckaert, 2011). As private actors are gaining increased responsibility in planning processes of urban projects, the relationship between public and private parties becomes more important (van der Veen and Korthals Altes, 2011). Infrastructure project organisations are involving a greater number of participating firms which all contribute with their own piece of specialized technical knowledge and competence. Today, consultant responsibilities in early design phases include development of solutions and previously traditional client tasks such as investigations to determine design parameters and requirements. A central task of project management is to integrate all these competences in an efficient way, creating challenges for contractual as well as relational capabilities (Hartman et al., 2010). These changing demands on management mean that many established practices need to be reconsidered and integrated with new tools and models.

Literature on major infrastructure projects tends to focus on later phases of detailed design and primarily construction, often stressing needs for planning and flexibility in management and initiatives of e.g. partnering, incentives and risk sharing (Bemelmans et al., 2012; Koppenjan et al., 2011; Rose and Manley, 2010; Kadefors, 2004). Not much research has dealt with the organisation of early design phases, but several authors have called for more studies of this phase (Giezen, 2012; Lundman, 2011; Hertogh et al., 2008). Further, current literature has mainly examined decisions affecting the project scope and costs (Flyvbjerg et al., 2002), but these decisions are influenced by organisational routines, structures and leadership. This

research project focuses on these latter aspects and investigates how project members organise and communicate in large infrastructure projects.

To gain insights into the reality of managing these challenges a case study of the West Link project has been the main empirical source. It is a major urban railway tunnel project in Gothenburg, the second largest city in Sweden. The study of the West Link project started in March 2012 as consultants were being contracted. The early design phase is supposed to finish in 2015, with legal consent to start detailed design for later construction. The primary data collection method is non-participant observation.

1.1 Purpose and research questions

That large infrastructure projects engage many private actors conducting, for them, partially new tasks poses a new challenge for public clients. Also, when making decisions they further need to mitigate negative consequences for subsequent phases many years into the future. In each major project organisational structures, routines and tools designed to support in planning, decision making and knowledge integration are implemented. Some of these aspects are predetermined by existing structures in the client organisation while others will emerge during the project, and several will be changed as the project progresses. Such decisions should be carefully considered and adjusted to the changing context of the project. An ineffective and inefficient project organisation would not be able to produce deliverables of the right quality, on the right time at the right price. Competent individuals could be unable to use their skills and spread their knowledge to others if organisational design and routines prevent it.

There are calls for more research into everyday organisational life and the actuality of project based working and management (Blomquist et al., 2010; van Marrewijk et al., 2008), for example that greater attention should be given to spontaneous governing as complement to research on ex ante governance principles (Sanderson, 2012). The purpose of this thesis is to examine how organisational structures and processes in early design phases in large and complex infrastructure projects emerge and why they look the way they do. Following this purpose two research questions are posed:

RQ1: *What aspects influence choices of organisational structure and operational routines in early design phases of large and complex infrastructure projects?*

Project participants' reasoning regarding how to organise design processes in the start-up stage in the case study project are investigated. Findings will be discussed in relation to the influencing factors identified in the literature review in Chapter 2, specifically focusing on issues of cooperation, coordination and knowledge transfer. A cognitive approach is applied, taking account also of limitation and biases in decision-makers' perceptions of the task at hand.

RQ2: *How are design organisations in large infrastructure projects developed in response to changing circumstance*s?

Changes made to the design organisation are investigated, also in relation to the literature review. One aspect of answering this research question is to identify what circumstances lead to change: if it originates in external circumstances, such as changing technical requirements or new information about alternative organisational solutions developed elsewhere, or in internal circumstances such as increasing task awareness. The other aspect is to see what kinds of organisational changes these new circumstances induce. For example do they change the

formal organisational structure, are routines added/removed/revised or are changes more informal?

1.2 The research context

The process of developing infrastructure is similar but not identical in most European countries (see e.g. Sözüer and Spang, 2012; Winch, 2010). As a project changes phase, so are project member constellations often changed, especially in government projects subject to public procurement legislation. New capabilities are needed as the next step of infrastructure development starts. In planning and early design, relevant competences provided by consultants are mainly engineering, design, environmental and project management capabilities.

In early design phases, much is unknown, many properties of the future infrastructure may still not be determined and knowledge about e.g. soil conditions in the area where a tunnel is planned is usually limited. The early design phase investigated in this research project is named the "Railway Plan phase" in the Swedish system and has great legal importance for the project (see Figure 1). The aim of the phase is to gain governmental approval to commence construction. This requires the production of three extensive documents: the Railway Plan describing the basics of the chosen solution, the Design Development document that clarifies selected issues of the Railway Plan through drawings, and an Environmental Impact Assessment. Prior to this phase are three phases that gradually limit what the project shall produce and an approximation of the future infrastructure's location. After the Railway Plan approval, detailed designs for construction are produced under the responsibility of the client, or by a main contractor in a design-and-build contract.

It is common that consultancy firms have competences to be involved in all phases from the Conceptual study up until the Detailed design. In practice it happens that individuals are involved in several phases because their company has won several tenders or because they have changed employer. Although a number of individuals and firms may participate in several phases of the same project, which could stimulate a common way to organise in all phases, the same aspects may not be of equal importance in all phases.

Figure 1 The Swedish process for developing infrastructure; the studied Railway plan phase is highlighted

The client organisation in Sweden for infrastructure projects is very often the Swedish Transport Administration (STA). In Sweden infrastructure projects with total budgets that exceed 400 MEUR and construction times running for at least 4 years typically belong to the Major Projects division of the STA. The life span of an entire project from inception until start of operations is however much longer, counting decades of conducting pre-studies, planning, designing and constructing.

Usually there are up to 15 on-going projects falling within the category of large infrastructure projects in different phases of the Swedish development process. In 2012, four large projects were in the early design phase, the Railway Plan phase. The 2 BEUR railway tunnel project, the West Link Project, which is the focus of this thesis, is one of these. This tunnel project is part of a program named the West Swedish Package and its aim is to develop regional commute around the second largest city in Sweden.

The STA was created in 2010 as a result of a merger between the Swedish Railway Administration and the Swedish Road Administration. This reorganisation together with earlier developments within the merged authorities have brought about a variety of initiatives and tools within the STA affecting projects and their organisations.

1.3 Outline of thesis

In Chapter 2 the theoretical framework of the thesis is presented. Areas of infrastructure project management, coordination and cooperation research as well as knowledge transfer and learning are covered.

The qualitative approach and methods used in this research are presented in Chapter 3. This is followed by a more thorough description of the main case study of the West Link Project.

The findings from the literature review and the case study are discussed in Chapter 5 and conclusions related to the research questions are put forward in Chapter 6. Finally, conclusions are outlined, followed by suggestions for future investigations within this research project.

2. Theoretical framework

The theoretical framework starts with an overview of literature on large and complex projects to be followed by research concerning coordination, cooperation and knowledge transfer in project contexts.

2.1 Research on large and complex projects

Large and complex projects, sometimes referred to as mega-projects, are usually evaluated in terms of time or money. Other measures that can be used are related to quality, goal fulfilment, number of disputes and support of the project (Giezen, 2012). Much research has focused on cost increases, and Flyvbjerg et al. (2002) found that nine out of ten infrastructure projects underestimate costs, but are not more prone to cost underestimation than other types of large projects. Although it is debated if larger projects imply a higher percentage overrun, or cost estimation error, than smaller ones (Jørgensen et al. 2012), a larger amount of money is involved in major projects.

This stream of research has blamed vested interests and deceptive behaviour as primary causes of cost and time overruns and failures to achieve other project goals (Flyvbjerg, 2008; Flyvbjerg et al., 2002). Such strategic misrepresentation implies that underestimations of costs, completion times and risks together with overestimated benefits are caused by organisational and political pressures (Flyvbjerg, 2008). From this point of view decision makers see it necessary to behave in this way in order to secure needed approvals and funding. Similar but unintentional behaviours that cause the same kind of errors are often related to features of overconfidence in oneself, attribution errors (typically all positive outcomes happened because of oneself and all failures were caused by external factors) and the like (Gulati et al., 2012; Lovallo and Kahneman, 2003).

Planning fallacy, i.e. optimism bias and strategic misrepresentation, can according to research be present in both planning and execution of an infrastructure project (Kutsch et al., 2011). Some recommended ways to avoid planning fallacy are to include new people in the team, and recognizing and working with false optimism behaviours (Kutsch et al., 2011) or adopting formal decision models like reference class forecasting (Flyvbjerg, 2008).

Research taking another point of departure, as identified by Sanderson (2012), considers projects to be managed to the best of involved professionals' abilities in a context of complex operations, uncertainties, influences and ambiguities (van Marrewijk et al., 2008). In this perspective underperformance can be explained by improper governance methods. It means that incoherent, inappropriate or underdeveloped governance arrangements cannot handle risk and uncertainties in projects (Sanderson, 2012). Researchers have produced numerous conceptual frameworks suggesting new governance routines to improve current practices: governance of transactions during the entire project life cycle (Winch, 2001), governance structures of collaborative contracts including both formal and informal mechanisms (Chen et al., 2012) and governance regimes adapted to the particular project and its context (Miller and Hobbs, 2005) to mention a few.

A third perspective is that performance problems and failure to meet project goals in mega-projects can be explained by competing project cultures and rationalities that affect day-to-day practices (Sanderson, 2012). For example, optimism bias and strategic misrepresentation were not enough to explain design errors in case studies of detailed design of infrastructure projects (Love et al., 2012). Errors were instead explained by latent conditions revealing themselves.

Latent conditions can hide in circumstances, tasks, practices, organisation, systems, the industry or tools, used in or affecting project operations (Love et al., 2012).

Although there are great differences in the three general approaches outlined above, most of that research does however suggest that actors can and should prepare for the future (Sanderson, 2012). One proposed strategy to manage uncertainty is to keep tight control of time and costs by keeping a project simple, planned and controlled through e.g. using existing techniques and avoiding underground constructions (Giezen, 2012). Such methods however have drawbacks in the sense of limiting further development in the projects' proximity (Giezen, 2012), which is less desirable in urban, expanding areas.

Two extreme management styles are often debated in regard to large projects (Koppenjan et al., 2011). One is concerned with planning ahead and controlling as discussed above, while the other copes with project complexity through flexibility. Although one of these approaches might be dominating, projects should and are in reality being managed through a mix of both to enable project managers to cope with different kinds of issues (Koppenjan et al., 2011). Research promoting flexible approaches has led to the recommendation to use early information and parallel design processes, thereby necessitating design rework (Chua and Hossain, 2011). This particular model does however make the assumption that designing companies have enough resources to perform redesign activities concurrently with scheduled on-going design. This is an assumption that might not be true in reality.

According to the literature review, project management needs to master the arts of both planning ahead and being flexible enough to respond to changes and new information. Often, it is useful to bring in previous experiences and external expert knowledge. However, where relevant experiences and knowledge for supposedly unique endeavours such as large infrastructure projects are to be found is not evident. In order to handle challenging circumstances project management needs to manage external relations as well as ensure cooperation and coordination between project members from different organisations.

2.2 Cooperation in infrastructure projects

Cooperation is the behavioural outcome of inter-organisational relations and is defined by Gulati et al. (2012, p. 533) as the "joint pursuit of agreed-on goal(s) in a manner corresponding to a shared understanding about contributions and payoffs". In this thesis cooperation and collaboration is used interchangeably. In the construction industry there has been a trend to strive for closer and more trust based cooperation in projects during the last decades under labels such as alliances in Australia, partnering in the UK and increased cooperation in Sweden (Bresnen and Marshall, 2000 a, b; Kadefors, 2004; Rigby et al., 2009). Such initiatives are hereafter referred to as partnering. Partnering often includes a range of activities but not necessarily all of: setting joint goals, offering financial and non-financial incentives, workshops, teambuilding, sharing risks and evaluating performances (Rose and Manley, 2010; Pryke and Pearson, 2006; Nyström, 2005; Bresnen and Marshall, 2000 a, b). Most often such initiatives only involve contractors but in the Swedish industry at least detailed design consultants have been included during the last years (Cordi et al., 2011).

In partnering projects, members often refer to the importance of trusting one another, both as competent experts and as honest business partners. Collaboration does not require trust, but trust encourages constructive interaction without fearing potential ulterior motives (Kadefors, 2004). Trust includes a willingness to be vulnerable to another party while expecting the other

to perform according to ones expectations, even without the ability to monitor or control the other (Mayer et al., 1995). Democracy and consensus tend to be associated with cooperation, and studies of decision-making in groups have found that members have a habit of striving for harmony and avoiding conflict (De Dreu and Van de Vliert, 1997).

Trust is further strongly connected to motivation. There are different types of motivation with different bases. Extrinsic motivation like incentives is an external source of motivation to perform an activity. Intrinsic motivation is to carry out an activity because of the satisfaction of performing the task in itself. Conditions that support autonomy and competence facilitate intrinsic motivation (Ryan and Deci, 2000). Examples include verbal reward or feedback (Frey and Jegen, 2001), project members participating in development of work breakdown structures and autonomy with connected performance based rewards (Dwivedula and Bredillet, 2010).

The use of performance incentives, financial and non-financial, are considered crucial in European construction projects because incentives are believed to motivate a party to achieve set targets or to behave in a certain manner (Hughes et al., 2012; Pryke and Pearson, 2006). Bayliss et al. (2004) found that incentives, together with recurring workshops, were the most influential factors in maintaining the partnering spirit. Holt et al. (2000) encourage using reward and incentive systems to promote individual and organisational learning in projects. However, Rose and Manley (2010) caution that financial incentives and associated delivery initiatives should be adapted to the specific project context. One risk is that incentives do not reflect all organisational goals, resulting in that people focus only on the areas rewarded (Akerlof and Kranton, 2005; Milgrom and Roberts, 1995). Like partnering, incentives have traditionally only been offered to main contractors during construction but it has been recommended to distribute rewards across all key organisations that contribute to team performance, including sub-contractors and consultants (Rose and Manley, 2010).

Initiatives such as partnering and incentives have the possibility to affect both intrinsic and extrinsic motivation, thereby improving the cooperative atmosphere in a project. Incentives may also have important roles in signalling trust and cooperation and creating new organizational processes that enable relationship development (Kadefors and Badenfelt, 2009). The same initiatives could also be factors to improve issues related to coordination since cooperation and coordination are in many cases interrelated (Gulati et al., 2012).

2.3 Coordinating in project settings

Coordination is about technical and administrative concerns and focuses primarily on interdependencies, inter-organisational interfaces, plans and schedules (Gulati et al., 2012; Söderlund, 2011). According to Söderlund (2011, p.48), the key message in literature on project management is that “Project organization is a matter of coordination that deals with task interdependence and task uncertainty”. Coordination in inter-organisational contexts is defined by Gulati et al. (2012, p. 537) as “the deliberate and orderly alignment or adjustment of partners’ actions to achieve jointly determined goals”. Actions include specifying and carrying out information-sharing, decision-making and feedback activities to bring together the involved partners and utilize their resources efficiently.

However, coordination in complex settings is affected by bounded rationality and other cognitive limitations. It has been claimed that individuals’ lay theories of organisation suffer from a cognitive “coordination neglect”, a tendency to underestimate the need for communication and other systems to integrate tasks (Heath and Staudenmayer, 2000).

Organisations do not fully realize that coordination needs increase considerably when interdependent tasks are divided between more people. The result is a partition focus: to attend more to how to partition tasks than on how to integrate them (Heath and Staudenmayer, 2000). Further, smaller teams are more efficient than larger since the number of interpersonal links increases exponentially with the increase in members (Hoegl, 2005). Thus, increasing the size of a team to incorporate more specialist competences creates corresponding coordination needs that limit actual team performance. In estimating how much resources are needed for coordinating a larger team, people are prone to an optimism bias called the team scaling fallacy (Staats et al., 2012).

Failure to reach coordination related goals can according to research be caused by a failure to plan, by failing to adjust to each other's practices and structures or by adopting rigid roles, procedures and interfaces that prevent ad hoc responses (Gulati et al., 2012). Another coordination risk is the risk of unforeseen coordination needs and costs, arising as a result of shortcomings in initial setup, endogenous developments in the cooperation and shifts in the external environment (Gulati et al., 2012).

Issues of coordination exist in all major projects. Even though specific needs will not be the same in all projects there should be general ideas and experiences that could provide useful input to a project. It is however not evident how such external knowledge is to be collected, evaluated and integrated into project structures and routines.

2.4 Knowledge transfer and learning in projects

The construction industry is often criticized for being slow learners or not learning at all (Hertogh et al., 2008; Drejer and Vinding, 2006; Flyvbjerg et al., 2002). Researchers have mainly investigated management of knowledge of a technical character and not how knowledge about managing and organising projects is managed (Hertogh et al., 2008). Further, most research looking into knowledge management in construction concerns listing what practices are used and not explaining how knowledge management is used in day-to-day practice (Styhre, 2009). The literature review by Styhre (2009) includes mainly research on construction phases, indicating a lack of research on knowledge management in earlier phases, including early design.

Knowledge transfer and learning can take place both within and between projects. To learn or transfer knowledge from other projects it is important to avoid repeating mistakes already made and become familiar with current industry best practice. However, project-based organisations are decentralized, have short-term emphasis on project performance and distributed work practices. These features impact on shaping and embedding of new management practice (Bresnen et al., 2003). Organisational routines are one way for collective know-how from earlier projects to become embedded into everyday work in current projects (Julian, 2008). Routines provide a formal mechanism for lessons learned practices and can also improve project methodologies and templates (Julian, 2008). There is however a tendency to reinterpret and make sense of new practices so that they conform to local existing and preferred norms and values (Bresnen et al., 2003), which implies that in reality new management practices may have limited impact. On the other hand, before adopting a best practice or successful experience from another project the context of that project and its differences from the current project need to be understood (Hertogh et al., 2008).

However, no improvements (such as learning) in cost estimation in projects were noticed during a period of 70 years and Flyvbjerg et al. (2002) claim that it cannot be explained by error, but by intentional actions. In their study of major European infrastructure projects, Hertogh et al. (2008) found that there was little interest in learning from other more progressed projects or to pass on knowledge to projects at earlier stages of development. One explanation was that project teams might enjoy the challenge of tackling (for them) new problems rather than investigating solutions in other projects. Findings showed that experience sharing did not even occur between similar concurrent projects within the same country (Hertogh et al., 2008).

Social processes play an important role in the diffusion of knowledge and learning in the construction industry (Bresnen et al., 2003); organisational learning in this context relies to a large part on personal contacts, communities of practice and learning by doing (Styhre et al., 2004). A project case study found that personal networks for assessing knowledge, discussion forums and engineers moving between projects were perceived as the main mode of cross-project learning (Bresnen et al., 2003). However, more important for learning was shared meaning and understanding of issues that were considered central.

The ability to learn within projects is important and not as thoroughly researched as learning between projects. Recommendations in research for improved joint learning in projects, and also other positive features as personal growth and use of intellectual resources, are often socially oriented. For example, project members are recommended to pursue more socially oriented learning and knowledge management activities (Sense, 2008). This, for example, includes new arenas drawing upon social interactions to bring various professional groups together (Styhre et al., 2004).

Transferring knowledge within and between major projects is needed to be up to date about best practices, to avoid unnecessary mistakes and to help to avoid time and cost overruns. Apart from formal documentation and routines, additional socially oriented practices may be facilitated and developed. This should be considered when setting routines for activities and decision making processes to coordinate consultants in early design organisations of large infrastructure projects.

2.5 Summary of factors influencing organisation and routines in large projects

From the literature review it may be concluded that several factors can affect decisions regarding management in large projects. There are aspects, or groups of factors, related to coordination, cooperation, organisational frameworks and cognition.

Factors relating to **coordination** are *task complexity*, *type of interdependence between subtasks, number of participants, uncertainty, planning needs* and *flexibility needs*. Organisational changes may depend on changes in the task (exogenous) or available resources (endogenous).

Cooperation-related factors include needs to *build relations* between participants and to *motivate* them. Changes depend on development or destruction of trust as new information is revealed or introducing incentives in the relationship.

Organisational framework factors are *culture*, existing *roles* and *routines*. Change implies that a project-specific way of organising takes over instead of general industry based culture in projects.

Factors relating to **cognitive aspects** are *bounded rationality*, *partition focus*, *team scaling fallacy, coordination neglect*, *attribution biases* and that *feedback is interpreted* (possibly in another way than intended by the transmitter). These kinds of factors often reveal themselves as the understanding of tasks increases.

Learning or adoption of transmitted knowledge concerning organising has taken place explicitly when changes are made in structures or routines. Knowledge may cause changes in perceptions of decision makers as task awareness increases and through external impressions. Further, although previous research has often found shortcomings in knowledge exchange between projects or between projects and the central organisations, it is not totally absent. Circumstances influencing the impact of knowledge transfer are decentralisation, tendencies to local adaptations and degree of project focus.

The empirical results will be discussed in terms of these aspects found in the literature. Methods used in the case study are presented in the next chapter.

3. Research method

Recently, several authors have pointed at a need for deep case studies of project practices (Blomquist et al., 2010). Engwall (2012) argues that there is a need to understand how project management principles and techniques are used in different settings, and Sanderson (2012) calls for studies of everyday spontaneous governing, as well as choices of governance method, in order to understand why projects develop the way they do. Van Marrewijk et al. (2008) argue that megaprojects should be investigated with an internally-focused, contextually-grounded view of actual practice instead of using an outsider's preordained view. These researchers all promote to get into project contexts and identify actual practices, as compared to solely focusing on advertised routines and procedures. This research project has been designed in line with these suggestions. In practice theory it is considered that "activities depend on shared skills or understandings" and that the field of practice is the place to investigate such phenomena as agency, knowledge, language and power (Schatzki et al., 2001 p.3).

The research questions in this thesis are of an explorative character with a dominating viewpoint of understanding how and why things are done the way they are. It was therefore considered suitable to take a qualitative approach (Edmondson and McManus, 2007) and conduct a case study. That the focus is on contemporary events in a project without any means to control behavioural events also supports the choice of case studies (Yin, 2009). A researcher can use case studies to "retain holistic and meaningful characteristics of real life events" (Yin, 2009 p.4), which is important to achieve understanding and in depth knowledge. Eisenhardt (1989) describe case studies as a strategy focusing on understanding the dynamics present within single settings. Further, cases can use an embedded design by using multiple levels of analysis, focusing on e.g. individual, firm and industry level. Individual, team and project level are of interest in this study since practices and opinions are investigated. Case studies are especially suitable for illuminating specific issues and clarify the deeper causes behind problems through theoretical sampling or information-oriented selection (Eisenhardt and Graeber, 2007; Flyvbjerg, 2006).

Qualitative and ethnographical methods are considered suitable in the study of organisations and one of the goals is to make the implicit explicit (Schwartzman, 1993). Therefore the case study was designed with an ethnographical approach. An important research context has been meetings. Meetings are responsible for both order and disorder in social systems and should be studied to learn about the setting (Schwarzman, 1993). Further, stories that emerge in everyday life reveal what individuals ask themselves and there are benefits in using participant observation to see how stories appear in natural situations such as meetings (Schwarzman, 1993).

3.1 Early research activities

Before the main case study was initiated, a case study with a partly different focus was conducted, as well as a pre-study (see Figure 2). The research project started in the fall of 2010 with the original aim to investigate cost increases during construction of rock tunnelling projects. This area was identified as an important field of research, in a call for research proposals issued by the former Swedish Rail Administration. However, the subject was changed as a result of discussions with the STA after the merger of the Rail and Road authorities. Instead, the focus turned to major projects and earlier phases of planning and

design, further making any kind of infrastructure project interesting, not just tunnels. Before this change of purpose, a project case study was carried out to fulfil the original aim. After the change a pre-study helped to confirm the research interest identified in discussions with the STA.

The first case study, of the 1.8 km Kattleberg railway tunnel, was conducted from late October 2010 until February 2012. The project was part of a major project to construct a combined road and rail route between Göteborg and Trollhättan. The exploratory purpose of the study was to identify communication practices during tunnel construction. The study forms the empirical basis of paper IV in this thesis. Members in the client on-site project management group, both client employees and consultants, were interviewed and observed on four separate full-day occasions during October-December 2010. One representative from the main contractor and one from the rock expert subcontractor were interviewed in August 2011 after drill and blast activities had been finished. Interviews with two design consultants, two engineers whom had had responsibility of the consultant assignment during detailed design and as construction support, were conducted in February 2012. These last interviews took place concurrently with the interview-based pre-study described in the following paragraph. All interviews were about 1-2 hours long and semi-structured with content adjustments according to the interviewees' roles in the project. Semi-structured interviews were chosen to allow interviewees the opportunity to elaborate on topics of interest and those they perceived relevant to their roles (Bryman and Bell, 2011). Field notes from the observations and document considered relevant for the study supplied by interviewees were used to confirm and complement interview results.

The pre-study building up to the selection of the West Link project as a main case study comprised of interviews with two consultants and four STA representatives between September 2011 and March 2012. The purpose of the pre-study was to confirm the new focus of the research project and to plan research activities. Both consultants had long experience and held senior positions in the respective companies. STA representatives included individuals experienced with large projects and a person responsible for BESK, an initiative to improve client-consultant relationships. Semi-structured interviews with these individuals focused on the perceived relevance of investigating phases preceding the construction phase in major infrastructure projects and what topics would in that case be interesting. The interviews lasted between 1.5 and 2 hours and took place in the offices of the interviewees. All interviews were recorded and notes using pen and paper were written during the interviews. Later the transcribed notes were analysed to identify themes in the interviewees' answers of what was considered interesting from a practitioners' viewpoint.

The theme of how to organise the collaboration between the client and the engineering consultants arose repeatedly in these interviews. The issues of coordinating diverse technical expertise fields were brought up by one STA representative and confirmed by several others interviewees.

3.2 Case study of the West Link project

As mentioned in the introduction, only four major projects were in their early design phase during 2012. Of these, two were in a geographical area making it possible to conduct continuous data collection through frequent visits. Since the West Link project was of much larger size it was considered probable to reveal a multitude of potential issues and complexities in the early design. Therefore it was chosen as the first case study according to the new aim in

this research project. Additionally, the other three projects were further along in the Railway Plan phase and the timing to join the West Link Project coincided with the arrival of the consultants in the project.

The case study started already during the research project's pre-study (see Figure 2) through attending a presentation for potential bidders on the tender calls that the West Link project planned to issue continuously during the upcoming half a year. The actual start of the case study took place four months later, in March 2012, after confirming access to the project with the STA Project Director and the newly appointed Design Manager. At this point the consultants were being contracted or in the process of defining their assignments. Similarly, the client project organisation was also being formed as employees changed projects or was successively appointed.

The main form of data collection has been through non-participatory observations of primarily meetings and occasional workshops. Access was granted to the client's top management and design management meetings as well as to relationship management meetings with consultants. After seeking permission from consultants, selected assignment meetings between client and different consultants were added to the data collection as well as some internal consultant meetings. In general, top and middle management of the actors' project organisations participated in the observed meetings.

Field notes were in most cases written using a tablet during meetings and revised later to complement incomplete sections as thoroughly as possible. These notes, also including coffee break comments, were the basis to track decisions and changes in management procedures. To complement and also confirm observations reported in the field notes additional project documents were studied. This included reports from earlier project phases, information posted on a web portal for all project participants, preparatory documents for meetings and meeting minutes.

Figure 2 illustrates the three studies and their relationship to the appended papers. The West Link project has been the basis for work-in-progress Papers I, II and III, which are depicted in the top part of the figure. The pre study has been used in Paper I and III. As mentioned previously the Kattleberg tunnel study formed the empirical basis in paper IV.

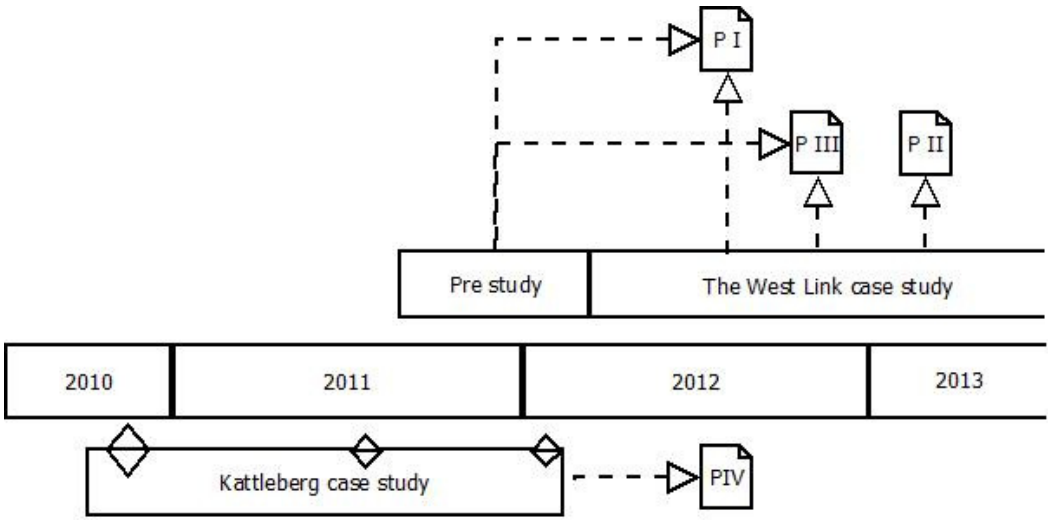

Figure 2 Studies in the research project and their input to the appended papers

3.3 Research limitations

One limitation of the case study is that the project's relationships with external stakeholders have not been considered, despite that this generally is seen as an important key to project success (Achterkamp and Vos, 2008), especially during planning phases leading up to legal consents (Hertogh et al., 2008). It was however excluded during the initial part of the case study since priority was to get an in-depth understanding of the complex project organisation.

Another limitation is that it is a single case study which could be argued to limit generalisation. Further, choices when selecting projects for case studies will influence the limits of generalisations of new findings (Eisenhardt, 1989). There are however plans to include additional projects as case studies in order to make comparisons later in the research process.

The outcomes are further limited to large infrastructure projects and a north European context. In the Nordic countries there is a rather informal, less hierarchical business culture (Selnes et al., 1996), which may limit the generalisability of some results.

4. The West Link Project

The empirical descriptions are mainly found in the appended papers. In this section, some aspects not covered by the papers are outlined.

4.1 Project description

The West Link Project will provide a double track railway that stretches for 8 km, whereof 6 km is in a tunnel, through the second largest city in Sweden (see Figure 3). It is part of a substantial regional investment in infrastructure development in Western Sweden to create more train capacity for commuting as well as for goods transports. In 2001 a conceptual study was initiated and by 2007 a so-called Railway Study presented the alternative of an underground tunnel including expansion of the Central Railway Station, from a cul-de-sac station to a run-through station, and the creation of two new city stations as the preferred solution. In 2010 the proposal received funding and the governmental client established a project to perform the next phase in the process, the Railway Plan phase. This phase consists of settling in detail what corridor the new railway line will follow, and of producing related Design development and Railway Plan documents.

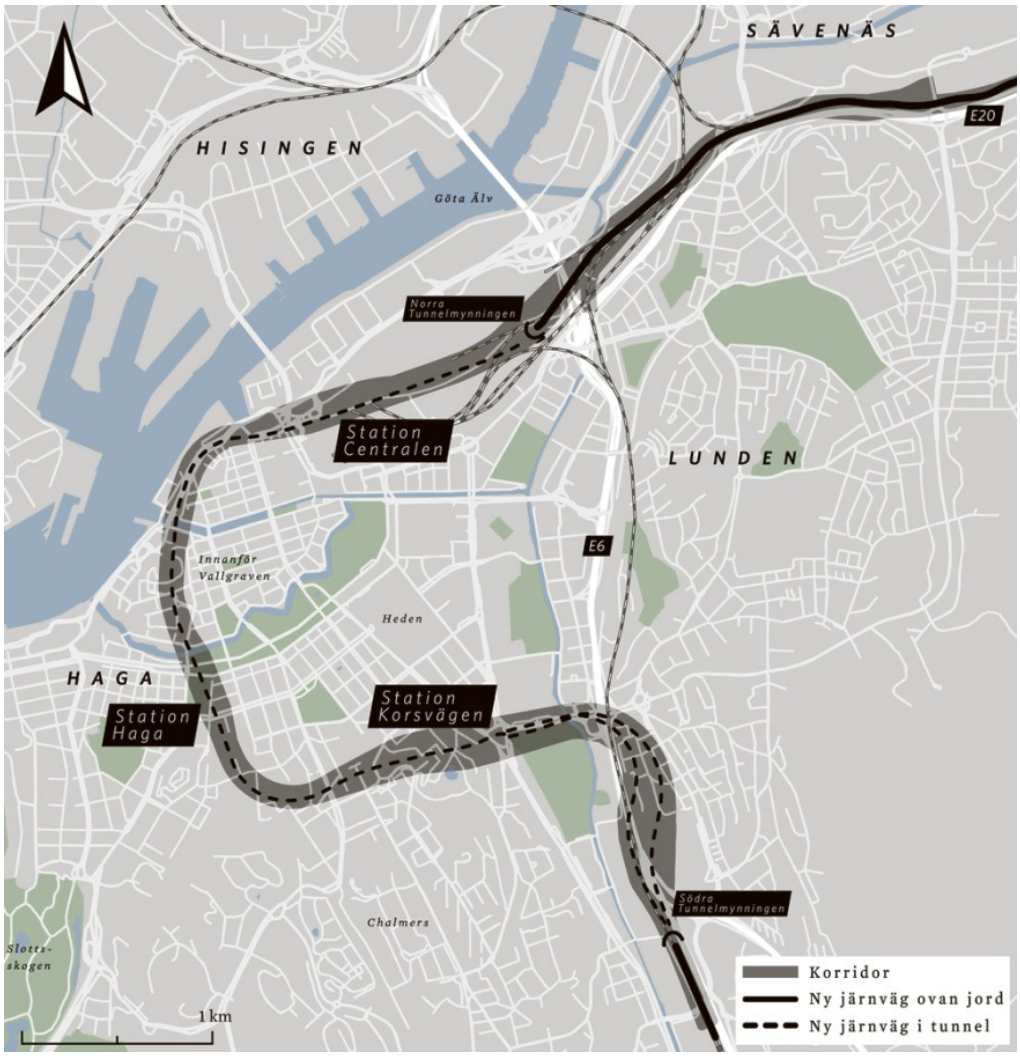

Figure 3 The West Link, Gothenburg (Source: The West Link project)

In 2011 preparations for the Railway Plan phase started, equipped with a budget of about 100 million Euros. Engineering consultants were continuously contracted during the spring of 2012. During 2012 main tasks have been to create a time plan for deliveries, make an inventory of existing conditions of the Gothenburg soil and structures, and develop requirements for the future infrastructure.

4.2 Project work

First of all, it should be mentioned that the project did not experience any major drawbacks during the time of study in its project work. The most obvious issues were negative media attention in a series of op-ed articles in regional newspapers, but most of its content was considered the responsibility of politicians and did not affect the design organisation. Consequences were that top management reached out to client and consultant project members informing that nothing was changing because of these articles, it did however induce some coffee break discussions. However, although there were no major problems encountered in the project, there were nonetheless changes in the project design organisation.

Other aspects not explicitly mentioned in the appended papers are the government client initiatives and IT systems affecting project work. Such tools and systems that were mentioned together with routines and organisational developments, by different project participants on various occasions, are presented below in Table 1.

Table 1 STA initiatives and systems affecting the West Link project

Initiative	Explanation/Includes
Pure Client Role	Outsourcing of specifications, increased usage of Design&Build contracts in construction, less steering of contracted partners
Increased Cooperation	Avoid disputes and claims between partners, joint goals, risk sharing, incentives for contracted partners
BESK	Dividing design processes into sub-processes of planning, sketching, designing and delivering
PPI	ICT portal for storage of administrative documents such as meeting minutes and for sharing project news
IDA	ICT system for document delivery of e.g. models, maps and drawings
PrimaVera	ICT system for time and economic reports
Exonaut	Risk Management system used in the client project organisation

A basic principle in the project was that information and decisions would be dispersed in a cascade model. Decisions were made in the top management group. Members then sorted out and informed about what was relevant for their groups (this could be consultant assignments or a project group like finance), if there were subgroups the individuals responsible for them once again should sort out the information and spread the news. However, project members seemed to need reassurance that communicated decisions actually were decided. Very often members also wanted to know “everything”. The top management group strived to counteract such behaviour since they considered the project too complex for everyone to know everything, instead members should focus on contributing to their part of the puzzle.

During the planning stage consultants define their general assignment descriptions and goals supplemented by detailed plans for specific activities to reach these goals. These detailed plans include deadlines, personnel, budgets and estimated times. If any changes were to be made, a formalized procedure was required. Early on, there were requests for adding more people in

the consultancy assignments or changing roles of people involved. Following planning and after starting project activities in the sketch phase there were some warnings for possible causes of failing deadlines communicated, for example if not gaining access to confidential documents in time this would affect project work. After one year, there were requests to replace project participants due to them changing employers.

Creating joint values and goals was done in the group that also created the bonus system discussed in Paper III. Three value statements concerned how the project culture should be described: comprehensive, perceptive and creative. Another three how project participants should act: swiftness, reliability and openness. (In Swedish the former three are: helhetssyn, lyhördhet and nyskapande. The latter three are: snabbhet, tillförlitlighet and öppenhet.) After finalising tasks such as developing the bonus system and settling value statements the need for this group was re-evaluated, and due to the limited responsibilities remaining the group was dissolved in 2013. Since this event is recent it has not yet been included in the appended papers.

5. Summary of appended papers

This document is a compilation thesis including a total of four papers, all of which can be found as appendices to the thesis. Paper I and IV are written by Eriksson and Kadefors while Paper II and III are authored by Eriksson.

Paper I - Organising design processes: collaboration, coordination and learning in the West Link Project

It is a challenge to integrate knowledge of numerous kinds of specialists in early design phases of large infrastructure projects. According to literature this requires project competence in coordination and collaboration, two interdependent concepts that have substantial influence on sense-making and decision-making. Design organisations in major projects are unique but influenced by institutionalized and client specific routines and systems. It is a context where significant learning and adaptation of design organisation and management processes take place. Organisational capability to adapt to changing circumstances is considered crucial to success in complex projects. Decision makers have to integrate a variety of inputs with possibly contradictory requirements all while experiencing cognitive limitations and biases. This paper focuses on how issues of collaboration and cooperation influenced the emergence and development of the organisational structures and processes in the West Link project case study.

The case study shows that collaboration-related initiatives were early on integrated with specific project activities and dominated the agenda during early project stages. But those activities were subject to trade-offs between ideals (equality and participation) and reality (schedules and resource constraints). In line with the literature, initial coordination efforts focused more on partitioning tasks than on designing integration mechanisms, which resulted in successive development of coordination mechanisms and roles. During the early phases, organisational changes have primarily occurred due to increasing awareness of task complexity and ideas of how this should be handled, not because of changing technical or environmental circumstances. This process of sense- and decision-making in connection to organisational changes increase understanding of joint tasks and build consensus. A reason for the client to leave development of the design organisation undefined is that involving as many (contracted) actors as possible is a way to gain project commitment and motivated members. It is further noted that managers' subjective interpretations in relation to issues of collaboration, coordination needs and motivation of others affect the management of design processes in large infrastructure projects.

Paper II – Learning in the early design phase of an infrastructure development project

There are few opportunities for project participants to gain first-hand knowledge of long-lasting large infrastructure projects, indicating benefits of learning from other projects. Such input may be both tacit and explicit and of both technical and organisational character. Knowledge and experiences can be transferred in personalized or codified forms, and project research tends to emphasize the importance and potential of social processes to diffuse knowledge in projects, underlining positive outcomes of bringing together individuals from various specialist fields. Ideally, networks should supply rich but non-redundant information exchange between projects. This paper investigates from what sources the West Link project

retrieved knowledge, what kind of information was transferred and if the knowledge was technically or organisationally oriented.

Main knowledge sources were found to be a small number of similar projects and earlier phases of the same project, and to some extent the public client through mandatory systems and initiatives. Technical and organisational knowledge was retrieved and acted upon both in codified and personalized form, although knowledge relating to organisational aspects tended to more often be transmitted and further integrated into the project organisation in a personalised flow. It is suggested that project organisations might experience more redundant links in knowledge transfer than permanent organisations, but this could also give rise to more opportunities to knowledge integration for the involved actors.

Paper III – Designing and implementing incentives for engineering consultants – bonuses for cooperation and innovation in the West Link project

In the construction industry, partnering schemes combined with financial incentives are common to promote collaboration or innovation in projects. A literature review reveals that there has been a tendency in construction to expect high quality output of consultant work also when only a basic service is formally required and paid for. However, from being a traditional contractor privilege financial incentives are increasingly being introduced also for consultants. Incentives are usually supposed to improve collaboration and motivation among partners through extrinsic rewards but may also have effects on project processes, as well as a symbolic role in signalling trust and innovation. This paper describes and analyses the development and implementation of bonuses for consultants in the West Link project.

The West Link project had bonuses for cooperation and innovation, where the latter was in effect a cost saving bonus. When defining the cooperation bonus and creating processes related to both bonuses, selected consultants were included. As nominations came in, it turned out that it was mostly these consultants who applied for the first rounds of bonuses. Further, all early nominations for innovation were organisationally related and not technical. The reason is probably that consultants had not started with assignment tasks and were still planning and defining these. A preliminary conclusion is that even though the aim of a bonus is to reach out with joint values and goals to all project members, one potential risk is that bonus awareness gets stuck on top management level in the consultant firms.

Paper IV – Trust, control and knowledge integration in a rock tunnel project

Tunnel excavation has historically been plagued by many uncertainties and frequent disputes between parties, with expensive standstills as one result. In Sweden, as well as in other countries, attempts to avoid disputes through less hostile relationships between actors involved in construction have been made. Formal and informal relationships support each other, either through supplementing or enforcing the other. This paper is based on the case study of the Kattleberg tunnel that mapped the most extensive formal and informal forms of communication between client, main contractor, rock specialist sub-contractor and the detailed design consultant that was supplying construction support in the construction phase.

It was found that formal communication was everyday practice and of central importance to bring the project on in its development, more so than project members had been used to in previous project. A new change order template was used post hoc to formalise the frequent use

of informal decisions, which was considered important by especially the client project organisation in order to keep track of approved changes, in relation to contractors, by construction managers working different shifts. Still, client employees watched their tongues at the tunnel front, to avoid that advice would be interpreted as instructions and thereby be grounds for claims. Further, consultant, client and contractor rock expertise resided at the far ends of the formal and lengthy communication path, with effects such as that the rock subcontractor sometimes did not receive information on why the company's improvement suggestions were turned down. The good collaboration in the project was attributed to the fact that individuals in the client organisation had worked together in preceding projects and learned how to coordinate tasks among themselves efficiently, which made it easier for them to work with the contractor employees. Further, the main contractor was and had been involved in other projects within the same program, and thereby also familiar with new routines introduced in the program. Formal and informal systems complement each other in that unofficial meetings were used to complemented formal meetings. Further, initiatives such as co-location give opportunities for formally weak actors to gain stronger informal positions.

6. Discussion

There is much research on factors affecting the scope and technical solutions in major infrastructure projects, but to what extent they also affect managerial aspects of organising and routines is less discussed. What is typical of and differentiates large infrastructure projects from most other kinds of projects are that they are temporary but long-lasting, involve a great number of organisations and are commonly lead by public organisations working in a stricter regulatory context than private parties. The discussion below is divided according to the two research questions presented in the introduction.

RQ1: What aspects influence choices of organisational structure and operational routines in early design phases of large and complex infrastructure projects?

In the literature review, a number of aspects affecting the development and design of organisational structures and processes were defined. Below, examples of these aspects found in the empirical studies are discussed. First, factors related to coordination are reflected upon.

Factors of *coordination* were influential in determining the organisation, especially at the outset of the project when the consultant assignments were created. The West Link project was known from the start to be large, very complex and involve uncertainties. Attention was strongly focused on how to partition tasks into consultancy assignments, based on an analysis of technical needs combined with market characteristics and available client resources. The result was a large number of interdependent consultancy assignments, creating extensive needs for coordination and development of collaborative inter-organisational relationships. Paper I and III show a planning focus, expressed in predetermined meeting series, guidelines and defined inter-disciplinary groups. However, while the client project organisation prepared for planning and control, there was also an awareness of the need for flexibility in relations to consultants.

Also important initially were goals relating to *cooperation*. For this purpose, formalised meetings were organised, a relationship management consultant was contracted and co-location was planned (see Paper I and III). Further, a cooperation bonus was introduced, giving rise to further processes (Paper III).

Another type of influencing aspect was *organisational frameworks* through existing routines and mandatory requirements from the client organization. Many existing routines were implemented in the project, such as ICT systems and monthly reports. Other routines and roles were new also to the client and did not follow traditional industry norms, which can be seen as conscious attempts by the client organisation to break traditional routines. One example is that consultants were required to plan their work more extensively according to new sub stages (Paper I). Another was the role of the coordination assignments, as discussed in Paper I, II and III. An example of a new routine was the Increased Cooperation model, including planned co-location (Paper I, III).

As discussed in Paper I, the attention towards how to partition tasks rather than how to integrate them may partly reflect a general *cognitive* bias in relation to coordination decisions. Implicit common sense understandings may also affect the design of cooperation activities and bonuses (Paper I and III).

Initially, activities of cooperation and coordination were not intended to be integrated in the West Link project. Instead intentions were to keep Increased Cooperation activities separate as traditionally done in the Swedish construction industry (this was the case in the tunnel project studied in Paper IV). However, as discussed in Paper I the intervention of organisation management consultants resulted in merging the intended cooperation group with another of more coordinating character before contracting consultants. This illustrates that the same organizational processes may fulfil purposes of both cooperation and coordination. Co-location as well can be seen as supporting both coordination and cooperation, as was the case in the smaller case study in Paper IV.

In conclusion, the following aspects had an influence on organisation: coordination, cooperation, beliefs and cognition of individuals and (mainly client) organisational frameworks. However, regardless of how thoroughly an organisation is structured and routines are planned in this kind of complex projects these will undoubtedly be changed for one reason or another. This aspect is dealt with in research question 2.

RQ2: *How are design organisations in large infrastructure projects developed in response to changing circumstance*s?

Most of the developments discussed in this thesis took place in the client project organisation but also changes in consultant organisation have been identified. Some developments have affected both sides in the sense that they led to changes in several organisations. Changes to project organisation and routines were caused by a number of reasons. During the period covered by the case study, causes were usually internal to the project, as awareness about tasks and circumstances increased. Often, emerging needs shed light on new roles and routines that were needed. In Paper I and III the constant learning and knowledge transfer in coordinating and cooperative activities within the project are examined. But, as discussed in Paper II, knowledge transfer from outside the project also took place and affected awareness of several issues. Although most of these learning effects were related to technical issues, the input also lead to some changes in organisational structures and routines.

As illustrated in Paper I and III, coordination related changes to organisational structures took place on a few occasions. The structure was changed when the contracts of consultant firms that were awarded several assignments were merged. This further led to changes in the client project organisations in order to align the organisations. A parallel process was that some roles in the client project organisation were not added to the organisation until all consultants had been procured and resources in a parallel infrastructure development program became available (mentioned in Paper II). The latter changes were obviously needed or planned from the start, while the changes in the alignment process emerged due to changing circumstances.

Coordination related changes to routines were for example changing meeting agendas (as missing or overlapping topics were identified) and changing meeting frequencies as awareness of tasks increased and purposes for meeting series were pinpointed (Paper I, III). Another addition to routines, addressed in Paper II, was when a Q&A template from the Stockholm bypass project was imported through consultants active in both projects. A further issue related to coordination regarded the coordination assignments (Paper I). This new role was initially difficult to understand for those involved, and it was not clearly defined from the start whether it was supposed to be a passive reviewing or an active decision-making task.

One group in particular was subject to cooperation related changes: the group that was assigned extra responsibility related to the Increased Cooperation initiative. This group was restructured on several occasions, partly influenced by the continuous contract award process (Paper I, III). Initially, cooperation goals dominated the group's activities and discussions. After a number of early cooperation-oriented one-off tasks were finished, the purpose of the group was re-evaluated in relation to how other meeting series had evolved. This ultimately led to the group being dissolved and the remaining continuous Increased Cooperation activities being distributed among other groups.

The co-location initiative was another cooperation-related initiative that was not implemented as originally planned. In general changes related to cooperation seldom showed in organisation charts, but were instead integrated in procedures and routines. Taking the bonus in Paper III as an example: it was (supposed to be) integrated into meeting agendas and the normal hierarchical route was followed in its nomination process, no new roles or fora were created. If looking at coordination induced changes as the merging of assignments described in Paper I, these resulted in changes to organisational charts for both the client and the consultants, in turn affecting meeting series and administrative routines. This might indicate that cooperation elements in projects tend to be integrated with coordination tasks to gain legitimacy (Paper III) as compared to construction phases where they are more often separate from other operations as illustrated in Paper IV. One possible explanation is that relationship-building-activities are perceived as less important since client-consultant relationships are traditionally not as adversarial as client-contractor relationships.

Considering learning from other projects, it may be noted that familiarity of individuals and of work processes were thought important to establish good cooperation during construction in the project described in Paper IV. In the literature it is emphasised that coordination and cooperation are interrelated, indicating that familiarity could also improve coordination apart from shortening learning curves in projects. However, as discussed in Paper II and also visible in Paper IV, such learning effects may more easily occur between temporally and geographically related projects of a more normal size, but opportunities are limited in a large project such as the West Link project. For example, the time between the Railway Study phase and the start of Railway Plan phase led to some loss of tacit knowledge and experience transfer.

Finally, literature on knowledge in projects often promotes social fora to bring in experiences from other projects or to connect project members from various disciplines. In the West Link project, this was formalised by inviting speakers from other projects. In Paper II it is described how such presentations had an informal impact through storytelling but did not lead to new roles or routines in the design organisation.

7. Conclusions

This thesis investigates how organisational structures and processes in early design phases in large and complex infrastructure projects emerge and why they look the way they do. Although specifics differ, large infrastructure project are often governed by public agencies in similar development processes and many of the findings should therefore be relevant also to other large projects. The research contributes to the practice-based stream of research within project management.

In the early design phase the central task of project management is to integrate numerous technical specialists in an efficient way, creating challenges for both contractual and relational capabilities. Complexity and coordination needs are high, and projects as well as project organisations are unique. Thus, the thesis has focussed on coordination, collaboration and knowledge transfer and identified a number of related factors that affect how organizations emerge and develop over time.

Recent literature emphasise that issues of cooperation and coordination are interrelated in their effect on organisation of inter-organisational relationships. This study confirms this observation and describes how the project organisation approaches this combined organising problem. Learning within both domains (cooperation and coordination) takes place continuously through intentional, formal and informal, emergent efforts.

Further, previous research has suggested that management styles should combine a traditional planning and control strategy with a more flexible approach, leaving room for changes in project scope and activities in response to new circumstances. In this project it was found that organizational changes were mainly caused by circumstances internal to the project, primarily due to increased awareness of tasks and possibilities. Thus, a related balancing challenge in the organisation may be identified: to what extent is it possible and advisable to pre-plan the organization of a complex project?

Another aspect discussed is conditions for learning within and between projects. Although relationships with external actors may influence a project organisation, these influences were found to be limited in comparison to internal factors. In line with previous research, organisational knowledge tends to be shared in a personalised manner, which is true also when integrating such insights further into the project.

8. Future research

There are clearly many issues left to explore in regards to organising early design phases of large and complex infrastructure projects. Possible directions for continued research are discussed below.

First, issues of coordination and cooperation should be studied more in detail to reveal further implications regarding how these affect project organisations and results. To this end, formal interviews will be conducted with central client and consultant representatives to capture their views on the process this far. Another aspect to consider is how cost and schedule goals in an early design phase are dealt with in relation to total project goals.

Causes of possible increases in estimated costs as outlined by several previous studies of major infrastructure projects are still too early to discuss in this case study. It is however clear that the scope still is not settled. Based on the negative media attention there might be local opposition during the public consultation later in 2013, giving the opportunity to observe in real time what effects such developments have on the project.

Further, if looking outside the project boundaries there are a number of stakeholders that have an impact on the project work. In the next phase it would be interesting to examine also how relationships to the city of Gothenburg and other external stakeholders are handled. This is also more relevant as the project moves on to the public permissibility process.

There are many reasons for continued in-depth studies of the West Link project, but it is also valuable to conduct additional case studies to compare alternative structures, routines and issues in other projects.

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