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Dealing with Competing Project Management Values under Uncertainty: the Case of RandstadRail

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Due to the uncertainty involved in many complex infrastructure engineering projects, it is not always possible for managers to establish detailed terms of reference at the departure. Although the flexibility of 'open' terms of reference is often indispensible, it makes the arrival at a successful outcome much of a gamble. Complex infrastructure construction projects often include the tension that the values and interests of clients and functional managers diverge or even contradict each other. This is especially evident when managing the project management values of time, cost, scope and quality in relation to each other while the results of trade-offs and decisions can not be predicted. Client's administrators defend objectifiable, instrumental values, while functional managers have an interest in relaxing them in order to realise the project. If these two contradictory sets of interests are not recalibrated, either the values are not met, or trade-offs may be made in an uncontrolled way, which can lead to suboptimisations or even project failure. Using RandstadRail as an example, this paper will show the problems that may occur in such situations and how unmanageability arises. A few lessons are derived to provide entrance to better manageable practice.

Keywords: project management; competing values; principal-agent relations; uncertainty

1. Introduction

1.1 Tension in Project Management

Large infrastructure construction projects often have two problematic characteristics:

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1) They have notoriously bad track records in terms of controlling implementation time and cost (Flyvbjerg et al. 2003);

2) They are so complex that project managers and especially administrators have difficulties in overseeing every aspect of design and implementation (Morris et al. 1987).

These two tendencies work in contradictory directions and may therefore create a tension in project management, in that incompatible forces emerge when managing such projects:

1) To be able to meet time and cost schedules, it is essential to reduce uncertainties as much as possible. This requires a stable project scope and clear quality requirements, defined in detailed terms of reference.

2) Complex projects inevitably involve a high degree of uncertainty and this makes it difficult to define the scope, quality and safety requirements early on. In fact, they remain subject to change throughout the preparation and implementation of the project. This requires flexible schedules and budgets to prevent them from losing their validity over time.

Both situations can put a heavy strain on the project management, particularly on its trade-offs of the main project management values time, cost, scope and quality (Turner 1993). In the former situation there is no flexibility to react to emerging developments, threatening manageability in the implementation. In the latter situation there is opportunity to react to emerging developments, but it is unknown to what extent they will occur and, as a consequence, manageability can be threatened as well.

In many projects, it results in a clash of actors within the project organisation. The client, headed by administrators, wants to complete the project in accordance with the performance benchmarks formulated (in terms of time, costs, scope and quality) which become his main project management values, whereas the contractor, although being judged by these benchmarks, also directly experiences the limits of control over the implementation of the project and the technical system that must be delivered. In public projects, the client's position often involves political responsibility, with as a consequence possible political interventions that may intervene in the balance between the values.

A few examples illustrate specific tensions in value trade-offs that may occur in the management of complex engineering projects:

1. Scope versus time/costs: a desired scope extension will likely have a negative impact on the implementation time and/or costs needed for the realisation of the project.
2. Time/costs versus quality/safety: suppression of time and/or cost overruns can have a negative impact on the quality/safety of the final system; for instance because the works will have to be done under higher pressure.
3. Cut downs usually imply a reduction of functionality (or otherwise quality).

1.2 Examples

Value trade-offs can have far-reaching impact in many complex projects. Just to give a few examples from the real world of infrastructure development:

- During the 1990s the Dutch Ministry for Transport developed the first highspeed railway link in the Netherlands, between Amsterdam and the border with Belgium. Parallel to this project, European railway management institutions have been developing a new, uniform traffic management system, ERTMS-2, to replace the numerous existing national systems; in order for the highspeed trains – which cross borders frequently – to operate smoothly. The new system was expected to be operational by the time the link was to be opened. But many

setbacks in the engineering development pushed the deliverance of the system back. By the time the specifications of the system were established, the manufacturer of the rolling stock had not enough time left to deliver trains by the agreed date. Managers could have decided to install the old traffic management system for the time ERTMS-2 was not yet available. But the additional costs required for a redundant traffic management system that would only be operational for a few years at most, were not considered efficient expenditure. Here, a political decision on the client side appeared to include large uncertainties and vital interfaces with the other operations in the project. It is an example of one decision on project management values that can determine the functioning of the whole system, but was hardly regarded as such when it was to be made by the ones who made it.

- The new A73 highway in the Southeast of the Netherlands included tunnels near the city of Roermond. To cut back costs, the minister of Transport decided to cancel the emergency lane and install an innovative and more extensive safety system instead. Throughout implementation, the system became more and more expensive. The minister therefore changed the plans again and opted for a different, cheaper system and in the meantime urged for speedy implementation. But apparently the minister had not realized that the system had important interfaces with many of the 52 other systems in the tunnel, that had to be changed as a result. In the end, as a result of reconsiderations of costs, the tunnels were completed with a large delay and functioned with flaws.[6]
- The RandstadRail lightrail project in the Rotterdam-The Hague conurbation in the Netherlands links up the Rotterdam metro with The Hague street tram, by conversion of conventional railway lines to a new light rail system. The project was characterised by numerous changes to the system design, while the planned conversion period was not extended as the system had to open on time. High time pressure evoked practical unmanageability. This project will be discussed more extensively in this article.

The examples above show a few common features:

1. A clash of desired speed and/or efficiency and the practical (im-)possibilities of the technical system to be realized. This concerns the trade-off of *project management values.*
2. Actors, especially on the client side, who cannot oversee all the impacts of their decisions on the end-result. This indicates a *principal-agent problem*.
3. Trade-offs related to the technical system and with strong links to speed and efficiency, with an influence that stretches much further than initially acknowledged by the decision-makers. In other words: practice has differed from the decision-makers' expectations. This is a likely indicator of *decision-making in a situation of uncertainty*.

The above examples give the impression that the tension is, if not common, at least occurring with some regularity in complex infrastructure engineering projects. We will first elaborate the tension in managing with project management values as related to the principal-agent problem and decision-making under uncertainty (section 2). We will then study the phenomenon in more detail with an exemplary case: RandstadRail. This case will be outlined in section 3, focusing on the aspects most relevant to this article. The case will then be analysed in terms of its treatment of the management tension (section 4). This analysis will serve as input for a reflection on how to deal with the management tension in order to prevent fallibility (section 5). Although this analysis may include features that are very specific for this case, they may derive from generic project management related tensions or may provide insights in the consequences of possible directions of solution. The conclusion (section 6) will briefly outline the principal findings.

[6] *De Limburger*, November 3, 2007.

2. The Management Tension

2.1 Agency Theory and Transaction Costs

The uncertainty of infrastructure projects has many sources in both the technical and organisational systems of these projects. Different actors involved in the project often have different ideas on desirable trade-off outcomes, based on their backgrounds and interests. We can roughly distinguish the project client and its administrators (*in casu* the political representatives) on the one hand and the functional management (project managers and engineers; often contractor related) on the other (Cleland and King 1983). It is in the interdependence of these two groups of actors that the main watershed exists: the client has the decision-making authority concerning the project management values time, cost, scope and quality, but lacks the knowledge of the impact of these values on actual implementation. The functional management and engineers, meanwhile, have this knowledge, but do not have the authority to make decisions on the project management values. In other words: the client *sets* the prerequisites of the values and the functional management has to *meet* the prerequisites of the values; the characteristics of a classic principal-agent problem (Jensen and Meckling 1976).

This watershed between principal and agent in the attendance of values results in a situation in which the project client has to ensure that the functional management respects the schedules, while the functional management has to convince the client of possible inconsistencies, lapses and impossibilities in the pursuit of the project management values when they are actually being implemented. This is a tense situation. The project client wants to maximize the scope with the highest quality for the least money and within the shortest possible time. The functional management, on the other hand, has an interest in expending the minimum effort for the highest possible budget and over the longest period of time. The client, lacking specialist engineering knowledge, cannot be sure that the functional managers are taking their decisions in accordance with the client's interests, which is indicated as 'moral hazard'.

Open terms of reference in combination with a principal-agent relationship in the project would normally require large client effort to monitor functional managers, resulting in high transaction costs (Williamson 1979 and Williamson 1981). This combination of circumstances may therefore incentivise the client to organise the project in such a way that costs can be cut. This is often done with contract arrangements. It often comes down to a trade-off between the client's acceptance of responsibility for risks and uncertainties to limit the costs of transactions from agent to principal and the principal's outsourcing of responsibilities for risk and uncertainties to the agent, who will raise the transaction costs for it.

2.2 Decision-Making and Uncertainty

As mentioned, the principal-agent relationship between the main actors entails that the client has to make decisions with limited knowledge of conditions and consequences. Theories on decision-making under risk have been dominated by utility and prospect theory:

- Utility theory includes the gain, probability of occurrence, risk aversion, and the differently valued utility of the same gain to different actors as relevant issues in decision-making in a case of risk.
- Prospect theory adds heuristics to this. This includes human behaviour as a relevant element of decision-making. This explains that decision-makers may base their decision on certain dominant values (Kahneman and Tversky 1979).

A natural response to uncertainty and risk is to elaborate the terms of reference in fuller detail. This minimises the chance that adjustments have to be made at a later stage that may increase the

transaction costs between agent and principal. However, we started in section 1 with the notion that the more complex a project is, the more difficult it is to avoid later scope changes, because it is more difficult to foresee all impacts of events in the implementation of the project. So, the higher the uncertainty in a project, the less likely that a 'nailed-down design' is actually possible. Attempts to do so anyway could have an adverse effect as they disable optimisations (to scope, quality or for efficiency reasons). Moreover, in a nailed-down project, the risk responsibilities may be laid down as well, but that means there is little flexibility to react to unforeseen events as none of the two main actors will be willing to go beyond their formal responsibility. This creates a tension between client and functional management in the management of the project.

To curb the negative effects of risks, project managers often implement an extensive risk management programme. Such a programme is not always a guarantee of success, because it requires interpretation of information resulting form the programme by the client. He is, in respect to engineering risks, often the less competent actor and may frame trade-offs on the basis of his main value priorities (often time and cost), possibly ignoring the impact of implicit engineering risks as a consequence.

2.3 Towards an analysis of RandstadRail

All complex infrastructure engineering projects are confronted with the above project management difficulties and so, many of them have comparable manageability features. The RandstadRail project that has recently been implemented in the Netherlands is an interesting case to study, because it started with very open terms of reference; as many complex project inevitably have to (or should). The following phenomena will be analysed in this case:

- Tension in the attendance of project management values;
- The way the principal curbed transaction costs;
- The principal-agent relationship between client and functional management;
- The effect of this policy on the decision-making under uncertainty.

3. The RandstadRail Project

The RandstadRail project is an example of a complex project with a high degree of uncertainty (TU Delft 2008). The owner of this project was confronted with serious disruption during the first month of operation. This case shows how the management tension occurs and why the project organization was unable to deal with it properly. We will describe a few of the complexities that contributed to the management tension. After that, we will analyse the conditions that led to unmanageability (section 4). We will start with a general introduction to the project.

RandstadRail is a lightrail system in the Rotterdam-The Hague conurbation in the western Netherlands. The project was conceived to provide rapid and frequent public transportation between and into the two cities, using the Rotterdam subway and the Hague street tram networks. The two networks would be linked via an old suburban 'heavy rail' connection between both cities, to be transferred from Dutch Railways. Additionally, the suburban rail to and in a satellite town of The Hague, Zoetermeer, was also to be linked, also via a heavy rail connection to be transferred from Dutch Railways. The system is owned by the regional authorities of The Hague (Haaglanden) and Rotterdam. The required works on the Rotterdam section were limited, except for a new tunnel that is still under construction. Most of the works were to be done in the Haaglanden part.

The conversion of the system took place between 2003 and 2006. The actual construction work was planned for a three-month period in the summer of 2006 in which service on the heavy rail lines was halted. In the period previous to that, the configuration of the system was worked out, the works were planned and the tenders for the construction work, for the delivery of rolling stock, and for operation and maintenance took place.

Due to a number of problems, the delivery of the various lines of the system was delayed by between two weeks and two months, depending on the section of the system. Moreover, within the first month of operation, RandstadRail was being plagued by numerous disturbances in the switch and signalling systems and four derailments, with seventeen people injured in the last derailment. After that, the Transportation Inspectorate shut the system down and it was not reopened for almost a year. Currently, the system provides a high service level and since its second opening it has functioned reasonably well.

3.1 Technical Uncertainty

The main feature of the RandstadRail project is that it links up three different modalities: metro, street tram and heavy rail. The three modalities share the same standard gauge, but apart from that the systems are quite different. Rail systems have numerous very crucial interfaces, such as between wheel and rail (including specifications for bends and gradients), between switches and signalling system, between overhead wiring and rolling stock and so on. Metro and heavy rail use electric signalling systems for example, while the trams in The Hague do not use any type of automated signalling. The specifications of rail and wheel geometry are also substantially different. Since railways have been built on a large scale, this technology is predominantly well tried and tested. Basing the design on three different systems, however, was quite new. Furthermore, the specifications of the new modality – lightrail – did not fully correspond to any of the three existing systems. Lightrail was also a new modality for the Netherlands, meaning that there were no precedents in the Dutch context and a legal framework or safety regulations for such a system were both lacking. Requirements for the system tests and the safety proofing were drawn up *ad hoc* and mostly tailored to this 'first-application-in-the Netherlands' case. Analogies could only be derived from high-profile heavy rail regulations or the lower-profile urban rail regulations. Managers could broadly choose the values against which they would be judged. As a consequence, some managers used the more convenient lower margins. As lightrail was a new mode of transport for both the Transportation Inspectorate and the independent safety assessor, they actually went through an exploratory and advisory process, rather than a real inspection process.

3.2 Organisational Uncertainty

As mentioned, the Dutch Ministry of Transport (the subsidy provider) delegated the ownership of RandstadRail to the regional authorities of the agglomerations of Rotterdam and The Hague, respectively. These authorities are cooperative bodies involving the municipalities of each urban region. As such, they are primarily consultative bodies, without an extended workforce or financial resources. The contributors to The Hague regional authority therefore decided to outsource the implementation of their part of the project, including the Ministry's subsidy, to the Municipality of The Hague – its largest contributor, with a relatively large engineering department and considerable financial backing. The Municipality took on both project management and financial responsibility. This meant the Municipality implemented the project *turnkey* – that is to say, on its own account and at its own risk. The subsidy was a lump sum, so setbacks or surpluses would apply to the Municipality rather than the regional authority. As the Ministry's €413 million subsidy for Haaglanden's portion of the system was considered generous, the Municipality accepted this arrangement voluntarily.

In spite of this arrangement, *de facto* decision-making took place within the regional authority, where the alderman of The Hague was the responsible regional administrator of transportation. To this end, the authority raised a committee of the aldermen of Transportation of all the municipalities with a direct interest in the scheme, chaired by the alderman of The Hague, to advise him on his decisions. This double role in the organisations of both the municipality and the regional authorities led to the somewhat awkward situation that the responsible administrator of the turnkey contractor was also his own client. In this position, he united both the decision-making and implementation competences, despite the existence of diverging values and interests between these two roles.

Interestingly, the project was financially reasonably successful. Favourable contracting results and ample central government funding provided opportunities for optimisations. In a later phase of preparation, foreseen but not exhausted funds (approximately 12 million Euros) were even transferred to another project. Due to the setbacks during construction, however, these remainders were necessary after all to complete the project in positive figures. As a result, the municipality had to produce the required 12 million Euros to cover these setbacks. That, in combination with the derailments, made the responsible alderman file his resignation.

3.3 Complexity on the Interface of the Technical and Organisational Systems

The RandstadRail scheme had been under consideration for quite some time when central government finally decided to make the funding available; there was, in other words, a 'policy window' that had to be exploited (Kingdon 1984). Although the system had not yet been elaborated to any great degree of detail at that time, the regional and local authorities wanted to use this momentum to secure central government funding. To ensure the funding, the authorities had to present terms of reference that would determine the scope of the system and the time and cost schedules necessary to achieve this. As a consequence, the project was initiated with a very open design, not elaborated in great detail and with schedules based on approximate system designs. Many technical and organisational details of the terms of reference remained undefined until later phases in the process, in which one decision would have an impact on other, while the optimal sequence was unknown. The sequence would basically emerge rather than being planned. All these circumstances created serious uncertainties.

3.4 Uncertainty in the Process

As a result of the immature level of elaboration and emergent developments, many changes had to be made throughout the process, putting much strain on the balance of project management values. There were several reasons for this. First, at the time that the first terms of reference had been drawn up, the actors involved had not yet agreed on whether or not to include a signalling system, and for that reason it had not been included yet. Connectivity to the Rotterdam subway and the frequency of trains stipulated in the terms of reference ultimately appeared to require such a system though.

Secondly, functional requirements for the service were set that could not be achieved with lightrail trains. This had not been known earlier because when the terms of reference were drawn up, an exploration of the available vehicles and their specifications had not yet been carried out because it would have required the involvement of the future operator. The fact that central government required an open tender for the operation and maintenance contract (on the basis of privatisation developments) a tender procedure had to take place first, although some design works had already been based on specifications from The Hague's local tram and bus operator. After long-lasting negotiations, central government accepted a private tender to this company after all. This was one of several examples where the sequence of the availability of specifications and other activities, such as procurement and technical elaboration, created problems. Some

specifications would only become available after tendering, while other tenders required those specifications.

Thirdly, negotiations with external actors continued to take place during the preparation process. The negotiations with central government concerning the operation and maintenance contract have already been mentioned. The project management also continued to negotiate with ProRail, the manager of all Dutch heavy rail infrastructure, on subjects such as the acquisition of traction power and the availability of a shunting yard for storing rolling stock. These negotiations proceeded with difficulty. In the end, the project organisation had to accept the construction of its own power supply system and pay for a connection to a joint shunting yard, neither of which had been included in the initial plans. Fourthly, the condition of the line to Zoetermeer, was worse than expected. It needed replacing before the lightrail operation could begin. One of the reasons for this was that the project management had made incorrect estimates about lightrail's tolerance for deviation in the geometry of the rails which occurs inevitably as a result of wear. The latter problem was related to the relative novelty of using former heavy rail for lightrail purposes.

During this process, the project organisation implemented a risk management programme. All the risks that were signalled were solved and the programme was later abandoned because it was considered superfluous during the later stages of implementation. At the moment that it was abandoned, however, not all the events requiring eventual changes had occurred yet. In fact, the complexity of the project increased further. Functional managers had reservations about scope changes and their impact on the manageability of the project if implementation time and cost did not grow parallel to the scope. The client's board considered the risks acceptable though, particularly because it related them primarily to service availability rather than safety. But the disturbances that occurred immediately after the opening of the project affected both.

Naturally, decision-makers would not deliberately compromise the quality of the work carried out, but the combination of extending the scope of the project and retaining time and cost schedules implicitly meant that the client was demanding more for the same resources. In the case of RandstadRail, more work was to be carried out within the same period of time. It violated the balance between the project management values. This required greatly increased coordination and seriously affected controllability and manageability. The consequence was a flawed system.

3.5 The Probabilistic Relationship between Managing Project Values and Safety

Safety became a salient issue, particularly as a result of the incidents. Safety is not considered one of the main project management values, because trade-offs are rarely possible on this factor. Noncompliance with safety regulations would, after all, be illegal. Safety is also an implicit aspect of quality. However, neither of these reasons prevents safety from being influenced by trade-offs of project management values. For example, strict time management may, in a case such as RandstadRail, reduce the time for testing. In combination with the extensive works to be carried out in little time, a situation could emerge in which deviation was not detected and flaws were not repaired. This seriously complicated the conversion works. Both the strict time management and the scope extensions implicitly reduced the safety situation of the project. Furthermore, since RandstadRail was a new modality, no clear safety norms were available. As a result, it was hard to determine whether the system was safe enough. The project managers set their own conditions and decided to run a trial schedule of three days. Thus, a *probabilistic* relationship exists between managing the project management values and safety results. The reduced manageability of the conversion work was therefore the pivot between the management of time, cost, scope and quality during preparation and the compromised safety situation and increased fallibility in the operation phase, which resulted in incidents.

4. An Analysis of the tensions in RandstadRail

4.1 RandstadRail's Management Tension

The open terms of reference and the dynamics related to scope definitions required regular changes in the plans and the terms of reference throughout the preparatory phase. Many of the changes required additional construction work that could only take place while operations on the former heavy rail lines were halted. This period was, despite the numerous changes and additional works, only once extended from six weeks to three months, and all the additional time was immediately taken up by the required replacement of the rails on the Zoetermeer line. All other activities had to take place simultaneously. This required extensive coordination by the project management. These parallel works resulted in one subcontractor damaging the work previously completed by another subcontractor. Because the last derailment was caused by a broken switch device, it has been assumed that this damage was inflicted during the conversion work and, therefore, that these works were not properly supervised. Also, the test and trial activities were considered, in hindsight, too short. No regulations had yet been introduced on the required length of test and trial activities and so it was a convenient value for cutbacks. A relatively successful testing phase of three days masked fundamental flaws in the system.

Here we see that the objectifiable value of time (timely completion) prevails over the implicit value of quality in the form of manageable conversion works and an extensive test and trial trajectory. On an organisational level, we see that the functional managers (agents) urge for a time extension for the conversion works and testing, while the client's administrators (principal) try to guard against inefficiency in the conversion and testing period and possible subsequent delays. The principal tried to fend-off the possible moral hazard that occurred as a result of the divergence of interest in combination with interdependence that characterised principal-agent relationships, therewith fuelling the creation of a situation of vulnerability for flaws.

4.2 RandstadRail's Transaction Costs

The lump sum/turnkey contract arrangements used in the RandstadRail projects are usually used in very stable and clear projects with little uncertainty. It requires few transactions and induces the best cost control for the client. If they were used in projects involving greater uncertainty, either the risks for the contractor would be so large that his offer would turn out to be adverse (incorporating all potential risks as a debit item), or each change made during implementation would have to be paid by the client. That is why different contract arrangements are used in projects with high uncertainty, such as cost reimbursement (Winch 2002).

Given the high degree of uncertainty in the RandstadRail project, a turnkey contract seemed a rather improbable arrangement, but was very beneficial for the regional authorities as client. The client could make scope changes throughout the preparation phase, while the risks for the project management values would effectuate in the client's management of the implementation. This can be credited to the role of the alderman *annex* regional administrator of Transportation. This was a positive effect of the type of set-up chosen.

4.3 RandstadRail's Principal-Agent Relation

The drawback of this construction is perhaps less visible, but certainly as important. Because the client, who made decisions on scope changes, did not bear the implementation risks, he developed a preoccupation with retaining time and cost schedules to bolster against possible moral hazard. The client consequently demanded scope extensions without any corresponding extensions in the budget or implementation timescale. The price for this is paid for in the fourth

value: quality. Due to the chosen arrangement in which principal and agent roles were combined, the functional managers were not able to properly fulfil their task. Although the principal may have curbed moral hazard, the agents could not provide the countervailing power that could have disciplined the principal's decision-making. Apparently, if there is excessive emphasis on the technical achievability of the project, the lack of limiting factors may lead to the unrestrained depletion of the resources to the point of unmanageability. If, by contrast, there is excessive emphasis on meeting time, cost and scope benchmarks, this may lead to project failure, as real complications within the project could be neglected. So, from the agent's perspective, possible reluctance of the principal to concur with the agent in concerns about the possible effects of time and cost cutbacks can be considered a moral hazard as well.

The double role of the alderman of The Hague annex responsible administrator for Transport in the regional authorities, which basically implied being both client and contractor, reduced transaction costs significantly and the client evaded the potential problems as a result of moral hazard. It did result in the awkward situation that this administrator had to make decisions on additional work that his own organisation (the Municipality of The Hague) would have to carry out within the margins set for the budget and implementation time, in effect complicating their own task.

This made the Municipality of The Hague an ideal contractor. In a normal turnkey relationship the contractor would resist such scope changes or charge the client heavily for the additional work. The client could extend the scope of the project and make changes to the design without serious implications for the relationship between client and contractor, or even without requiring changes to the conditions of the contract. The alderman was prepared to accept several scope changes, because he felt the need for a functionally optimal system. At the same time, though, he – and the other members of the committee – continued to insist on respecting the time and cost schedules. As far as the costs are concerned, this was not a real problem. Due to the generous subsidy and beneficial tenders, the funding available was ample. This may even have been an incentive to extend the scope. The alderman only had to accept a smaller surplus. The greater problem was timing: no spare time was available. Functional managers warned of this, but the project management insisted on sticking to the schedules. This unintentionally led to overvaluing of an end-result that was important to the client as decision-maker, but that was unlikely to be achieved. The client as principal was not aware of this due to his information deprivation and fear for moral hazard from the functional management. As the functional management had a particularly weak position in relation to the client, the client could easily ask too much.

This is an organizational issue where a confined focus on transaction costs does not suffice. Considering contract arrangements should therefore not only require assessment of the transaction costs, but a broader assessment of all project management values. It may even be necessary to trade-off a reduction of transaction costs against a sound balance of the project management values.

4.4 RandstadRail and decision-making under uncertainty

In the main trade-off the decision-makers of RandstadRail were confronted with, they favoured a small chance of achieving an optimal result by increasing the probabilistic risk over a 'safe' solution at slightly higher costs. This goes against the expectations from a utility point of view, but is in line with what might be expected when considering prospect theory. Apparently the client was preoccupied with time schedules, and so, the client's framework of reference played an important role. In addition, the decision not to extend the conversion and testing period despite the scope changes and engineers' warnings, indeed favoured immediate change of wealth (timely

deliverance) over the final asset positions (technical quality of the system) as prospect theory suggests (Kahneman and Tversky 1979).

Where does this preoccupation come from? The first important aspect in the 'gamble' that the client as decision-maker made, was in his reference to the risk he took. Judging this as mainly an availability risk made the gamble acceptable, even if the odds were against (which they did not know). If the consequence was acknowledged to be a safety risk, the same gamble might have resulted in a totally different decision. That brings us to a very vital point: the obscurity of the possible gains or losses of a decision. Contrary to situations considered in prospect theory on decision under risk, both the possible end-results *and* the probability of occurrence of either a gain or a loss are unknown. This makes the situations at hand considerably more difficult than for instance for person considering participation in a lottery or purchasing insurance.

A second aspect is served with a reconsideration of the cases mentioned in section 1.2. We can see that in case 1 the client may still be relatively well able to calculate the effects of his decisions; in 2 and 3 he cannot. There is an important reason for this. Time and costs are quantifiable, hence measurable and therefore objectifiable. It does not really matter that the results of these calculations in the end regularly turn out to be flawed. What matters is the shape of the results, i.e. 'hard' figures. Uncomfortable feelings about manageability – which is most particularly related to quality or safety impact – can often not be rationalised in this way. As a result, clients – as the less knowing actors – can easily be preoccupied with objectifiable values.

5. Lessons

The administrators of RandstadRail have started their dealing with the management tension by departing from very open terms of reference and the optimisations the project has gone through make it unlikely that a system with a comparable service level and value for money could have been created if the terms of reference had been 'nailed-down' from the beginning. Project managers should be aware that it is rather likely that detailed terms of reference are not an option in a project with comparable complexity. To prevent unmanageability of time and cost schedules, lessons from this case on the main topics discussed in this article may be valuable.

Throughout the preparation of the project, administrators and managers have used flexibility to optimise the scope of the project. However, their management of implementation time was completely opposite, leading to uncontrollable events during the conversion works that have compromised quality and safety. This was not corrected because the way the project was organised, the principal evaded the moral hazard of the client's possible strategic behaviour, but also detached the client from disciplining forces that may derive from this agent as the actor with most information. The result is a further increase of uncertainty in decision-making, rather than a cure for it. This section presents a few lessons that can help us towards improvement.

5.1 Transaction Costs and the Principal-Agent Problem

It may appear that the clash of values between client and functional management could be easily prevented with a double role, such as that of to the alderman of Transportation of The Hague in the RandstadRail project, as it minimises transaction costs and aligns the interests of clients and contractors. This is not a safeguard, however. The fact that the scope could be increased throughout the preparation phase with no negative consequences for the client organisation, demonstrates the pliant attitude of the administrator towards his client role. Depending exclusively on the discretion of one individual should be prevented as it introduces a lack of transparency and checks and balances, particularly on project management values. Transaction

cost economics have had a large influence on project management. But, as RandstadRail shows, attempts to reduce or even control transaction costs can also have adverse effects.

In the RandstadRail project, engineers regularly warned of the consequences of the tight schedules in place, particularly each time a new scope extension was approved. In all cases except one, the client dismissed these warnings however, due to their different dominant values. The administrator may be preoccupied with certain values, such as – in this case – time, cost and scope. The values time and cost are measurable and objectifiable and clients do not feel the direct consequences of a change to the technical system to the manageability of the whole project, while they do feel the (political) consequences of failing to control time schedules and budgets. The functional managers, however, do not have the means to counter these implicit inclinations, and do experience difficulty coping with them. Since 'hard', objectifiable benchmarks such as time and cost prevail easily over less tangible (quality) or even implicit (safety) aspects, the latter can become insufficiently safeguarded.

These adverse situations could be prevented by retaining checks and balances, both between project management values or performance benchmarks *and* between the client and the functional management. The discretion in the relationship between the client as principal and the functional management as agent should be avoided with clear rules of play, which should also provide the required transparency. One should think of making a process design that predefines required actions or decisions in the occurrence of certain types of events. Another step could be separating the responsibility for the project management values time and cost on the one hand, and scope and quality on the other hand. It should preferably be achieved within the client board to prevent fear for moral hazard. One could think of making different administrators responsible for different values; under the condition that they predefine arrangements to facilitate the process, for example in case of conflict. If the actors involved agree on predefined responses to possible types of events, they can avoid conflict at the moment the project management itself requires their attention.

5.2 Dealing with Uncertainty

Uncertainty occurs in situations where actors cannot react to emerging developments or in situations where they can react to it, but cannot control or even estimate the outcome of these developments and the chance of their occurrence. A simple solution to this is not readily available, but a few lessons can be taken into account.

To start with, we have shown that the situations managers involved in complex infrastructure projects are confronted with may go beyond risk. The findings from the RandstadRail case diverge on certain aspects from what might be expected from utility and prospect theory, and that is where a possibly valid explanation of the decision-maker's acts may be found. It is important to distinguish between 'risk' and 'uncertainty'. Risk only encompasses the unknown outcome. The potential gains or losses and chances of occurrence are known. In truly uncertain situations, not only the outcome of the chance situation is unknown, but also all the preconditions: potential gains, losses, and the statistical chance of occurrence. As a result of information deprivation and intrinsic uncertainty of managing a complex technical system, which is typical for an infrastructure construction project, RandstadRail's client could not oversee all the effects and outcomes of its acts and decisions and hence dealt with uncertainty rather than risk. It could neither estimate what the possible gains or losses as a consequence of its decisions might be, nor the probability of the occurrence. There was no statistical or quantifiable ratio behind the options. The finding that the client's administrators considered the potential loss mainly an availability risk rather than a safety risk is most illustrative. This implies that we should be wary about expecting too much relief from risk management programmes, because

they predominantly attend risks and not necessarily these kinds of uncertainties. In fact, decision-making under uncertainty rather than just risk may require further research.

There is already an important notion available that relates to this uncertainty in relation to dealing with competing project management values. Project management value trade-offs do not concern either gains or losses; they concern gains *and* losses. We are dealing here with decision-making situations in which the outcome in terms of gains and losses may not be unequivocal. Project management values work as communicating barrels. A gain on one value implies a loss somewhere else. As we saw in the RandstadRail case, a quality or scope increase (gain) for instance will often cause higher pressure on budget and perhaps time schedules (loss). This makes the prospects in decision-making even more uncertain.

To prevent overlooking possible catastrophic losses as potential result of a decision, it may be worthwhile considering safety as a full project management value in itself, rather than as a given or a prerequisite or as just one aspect of the quality value. This may make the implicit and often indirect consequences of trade-offs on time, cost, scope and quality more visible to decision-makers and therewith provide the required checks and balances between values. It may also make the choice of higher or lower margin safety conditions more explicit. The inevitable uncertainty in complex projects will still make it difficult to set exact terms of reference for safety, but even unquantified and probabilistic effects, in terms of higher or lower strain or increased or reduced manageability do not require high profile estimates.

In relation to this, the piling up of one process approach onto the other can be a breeding ground for unmanageability. In a flexible process, that is open to emergent developments, trade-offs can take any direction, but somewhere the safety of the system should be measurable. The Transportation Inspectorate provided no countervailing power as it had adopted a more process-oriented role. This way, managers did not have a clear reference framework to minimum required safety prerequisites for themselves. As they were neither predefined in the terms of reference, there was no ultimate boundary to adhere to. Unfortunately, the circumstances do not always allow strict definition of safety prerequisite; most particularly if the level of innovation of the system is high. In such a situation it is primarily important that it is not the client himself who can set the prerequisites.

6. Conclusions

Many complex infrastructure engineering projects require flexibility in the terms of reference as such flexibility may be indispensible to be able to react to important emergent developments. An important disadvantage of the uncertainty is that events and decisions may affect the balance between the main project management values time, cost, scope and quality without the decision-maker being aware of crossing possible fatal boundaries. This is further increased by the principal-agent relationship between client and functional management, which may prevent the actor with most specific insight on this (the functional management) to provide the necessary countervailing power.

Lessons that can help us towards improvement include:

- A strong focus on optimisation of transaction costs may threaten a sound balance between the project management values;
- Non-objectifiable values such as quality and safety are more difficult to defend in value trade-offs than objectifiable ones, such as time and costs. These values should be made better defendable and counterintuitive policy, such as creating powerful intra-organisational opposition, may help;

- Distinguish between risk and uncertainty and accept that the much larger strain of uncertainty requires multi-value management in which actors should be able to trust each other in possible absence of 'hard' data.
- Prevent considering the value of safety self-evident. It can be harmed unintentionally. It is possibly the only value where measurable boundaries should be agreed upon, even is they are inevitably not unequivocal. After all, testing safety on emergent and intangible criteria if the technical system itself has come into existence under comparable conditions is a breeding ground for catastrophe.

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