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# **How Satisfaction is Achieved in the Implementation Phase of Large Transportation Infrastructure Projects: A Qualitative Comparative Analysis into the A2 Tunnel Project**

Stefan Verweij & Lasse Gerrits

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## **Abstract**

In the implementation phase of transportation infrastructure projects unplanned events will inevitably occur. Although this is increasingly acknowledged, little systematic research has been conducted into what management strategies are best for dealing with these unplanned events. This article investigates how managers respond to unplanned events that occur in the context of a project during implementation, and which management responses produce satisfactory outcomes. To evaluate what strategies work in what contexts, we introduce multi-value Qualitative Comparative Analysis (mvQCA) and apply it to the Dutch A2 Maastricht transportation infrastructure project (the Netherlands). We produced systematic evidence that (1) internally-oriented private management is associated with low satisfaction, (2) externally-oriented management is associated with high satisfaction in responding to social, local unplanned events, and (3) that internally-oriented management is associated with high satisfaction, depending in particular on the nature of the cooperation between principal and contractor in the project.

## **Keywords**

Project Management, Public-Private Cooperation, Complexity, Evaluation, mvQCA

# **How Satisfaction is Achieved in the Implementation Phase of Large Transportation Infrastructure Projects: A Qualitative Comparative Analysis into the A2 Tunnel Project**

## **1. Introduction**

Generally speaking, transportation infrastructure projects are characterized by i.a. cost overruns (Flyvbjerg, Skamris Holm, & Buhl, 2003) and lingering implementation processes (Advisory Committee VBI, 2008; De Hoo, 1982). One family of explanatory factors of this undesirable state of affairs is the context in which projects are being implemented. In studying five large U.S. transportation infrastructure projects Owens, Ahn, Shane, Strong and Gransberg (2012, p. 186) found that in addition to “factors found in the traditional management areas (cost, schedule, and design)”, external forces or context were considered a primary source of complications in those projects. Other scholars (cf. Mistarihi, Hutchings, & Shacklock, 2013) also demonstrate the importance of context for understanding complications in infrastructure development, especially in the implementation – i.e. construction and delivery – phase of projects. For instance, Teisman, Westerveld and Hertogh studied the Dutch Betuweline and the U.K. West Coast Main Line and demonstrated that implementation processes are compromised by unplanned events and that “managers cannot know in advance what the relevant context will be and how contexts will interfere with implementation and with one another” (2009, p. 72).

Although this uncertain and badly predictable context in the implementation of infrastructure projects is increasingly acknowledged (e.g. Atkinson, Crawford, & Ward, 2006), little systematic research has been conducted into which management strategies are best for dealing with (i.e. responding to) unforeseen and unplanned events in implementing projects (Mistarihi, Hutchings, & Shacklock, 2013). A generic distinction is made in management literature between two more or less opposite management strategies: (1) internally-oriented strategies that focus on the internal structures of project organization (e.g. Mantel, Meredith, Shafer, & Sutton, 2005) – e.g. doubling shifts or changing construction modes in an attempt to control planning and budget – and (2) externally-oriented strategies that emphasize interaction with the social (stakeholder) environment in which the project is developed (e.g. Koppenjan & Klijn, 2004). Research suggests that the latter approach leads to more satisfactory outcomes (Edelenbos & Klijn, 2009; Klijn, Steijn, & Edelenbos, 2010) although, importantly, not necessarily always so (Verweij, Klijn, Edelenbos, & Van Buuren, 2013). The scientific literature is rather ambivalent about this relationship between management strategies and outcomes in project implementation (Edelenbos & Klijn, 2009). Consequently, proposals focus on a balance between the two strategies (e.g. Atkinson, Crawford, & Ward, 2006; Edelenbos & Teisman, 2008; Hertogh & Westerveld, 2010). But what does this ‘balancing’ entail? And perhaps more importantly, how is it that sometimes a certain management strategy results in

satisfactory outcomes, and sometimes not? These are largely underexposed questions. Research into this can contribute to the successful management of transportation infrastructure projects in their implementation phases. Hence, the research question of this article is: *how do managers in the implementation phase respond to unplanned events occurring in the context of the transportation infrastructure project, and which management responses produce satisfactory outcomes?*

Methodologies to systematically evaluate these issues seem to run behind (cf. Verweij & Gerrits, 2013). For one thing, little structural attention is given to actual day-to-day management actions in specific circumstances, i.e. how managers respond to unforeseen and unplanned events, whilst these are pivotal to understanding how outcomes come about in projects (cf. Atkinson, Crawford, & Ward, 2006; Cicmil, Williams, Thomas, & Hodgson, 2006). Moreover, traditional evaluations of transportation projects tend to focus on comparing ‘before and after’ thereby often inadequately reckoning with context in their assessments. This significantly impedes learning from such evaluations because context is explanatory to how outcomes come about (Pawson & Tilley, 1997; Sanderson, 2000). Evaluation methodologies need to match the complex nature of transportation infrastructure development (Verweij & Gerrits, 2013). In short, we need a context-sensitive method that is empirically grounded so as to study management actions in response to unplanned events, and that is able to systematically evaluate when and why these produce certain outcomes and when they don’t, such that learning is facilitated in a meaningful way.

In two previous articles we have laid the groundwork for such a method, namely Qualitative Comparative Analysis (QCA). In this article we apply one of the proposed versions, mvQCA, to the Dutch A2 Maastricht transportation infrastructure project. This is done in a number of steps. First, in Section 2 we will briefly explain the evaluation method and the perspective on the complexity of managing infrastructure projects that underlies it. In Section 3 we introduce the A2 Maastricht project and the data we collected. This data is stepwise analyzed in Section 4. Following the grounded approach we first identify and define the conditions of our analysis: the nature of the unplanned event (physical – social); the management response (internally-oriented – externally-oriented); the interaction between principal and contractor (acting alone – cooperation); and the outcome (satisfaction with how the event was responded to). In Section 5 we conclude our article, and discuss implications for managers and evaluators of transportation infrastructure projects.

## **2. Researching complex transportation infrastructure projects**

In Section 2.1 we briefly outline our understanding of ‘complexity’, i.e. what it is about the projects that makes them complex. Following our understanding, we introduce the related methodology in Section 2.2. For a more elaborate discussion and explanation we refer to Gerrits & Verweij (2013) and Verweij & Gerrits (2013).

## *2.1. Properties of complexity in infrastructure project management*

An infrastructure project is implemented in a complex socio-physical context. Unplanned events (e.g. bad weather or stakeholder protests) may occur in this context. Naturally, these can impact the planning and aims of the project. Managers respond to such events in an attempt to safeguard satisfactory outcomes (e.g. prevent time delays and budget overruns (cf. Atkinson, Crawford, & Ward, 2006). Managers often have to respond to different and multiple such events, each of which may require various management strategies. Such instances are considered cases in this article; the project investigated here, the A2, can be considered a long-term spatial program that consists of series of cases. Thus, within a single infrastructure project there are multiple and different cases of ‘responding to unplanned events’.

This also means that, contrary to the positivist take on reality, in different contexts the same management response can produce different outcomes and different responses can produce similar outcomes (cf. Byrne, 2011a; 2011b; Pawson & Tilley, 1997; Sayer, 2000). For example, within a single infrastructure project one and the same management response may result in preventing the project planning to get out of hand in the case of one unplanned event but not in another; this depends on the nature of the event. Furthermore, there may be multiple conditions interacting with one another. That is, the effect of the management response is codetermined by other conditions, such as the cooperation between principal and contractor. This implies a research approach that can study the complex interaction between conditions (see Section 2.2).

In addition, knowledge about the management of such projects is situated and contextual. This applies to both the evaluator and the managers working in the projects. In short, the actions of managers are context-dependent. A manager interprets an event and consequently acts upon it with the intention to produce satisfactory outcomes. These actions, in turn, causally influence the project’s development. This means that in order to understand the ways in which the project develops, it is essential that the researcher looks at how the manager(s) interpret(s) the event. In other words, the interpretations of managers are the researcher’s ‘entrance’ to understanding and evaluating transportation infrastructure development. This perspective favors a qualitative (interpretative) grounded research approach in which managers are studied in their contexts – what they do, why and with what outcomes – upon which causal explanation is grounded (cf. Cicmil, Williams, Thomas, & Hodgson, 2006; Verweij, 2012).

Finally, in evaluating transportation infrastructure development it may not be possible to define beforehand what aspects should be researched. Because managers act in an uncertain and badly-predictable context (Atkinson, Crawford, & Ward, 2006; Teisman, Westerveld, & Hertogh, 2009), and because their responses are informed by their interpretations of events and not by the theories proposed by evaluators (cf. Pawson & Tilley, 1997), what constitutes a case of ‘management in response to an unplanned event’ cannot and should not be predefined by the researcher. That is, “it is not possible to construct verbal formulations [i.e. theory,

authors] that can embrace or contend with the complexity and diversity of the empirical world. For these and related reasons, cases often must be delimited or found in the course of research” (Ragin, 1992, p. 220, emphasis added). Discovering and studying cases is often a key object of the research (Sayer, 2000). Again, this favors a qualitative and grounded research approach.

## *2.2. Researching complexity in infrastructure project management with mvQCA*

Following these three properties the first step of the method involves the grounded collection of data. Open, qualitative interviews are especially suitable for this purpose (e.g. Weiss, 1994) because this allows the researcher to fully grasp the managers’ perspectives of the event (instead of testing those of the researcher), their consequent management responses, and the outcomes. The second step is to code the resulting data (e.g. Boeije, 2010) so as to facilitate the reconstruction of cases. Coding facilitates the synthesis of different manager perspectives into a single coherent reconstruction per case. By coding and memo-writing ideas about the collected interview data are recorded thus allowing for those ideas to be reinterpreted (Schwartz-Shea & Yanow, 2012). This interpretive process is influenced by existing ideas about complexity (theory) and managing infrastructure projects with which the researcher is familiarized. Ragin coins this quest ‘casing’ – which is best understood as a dialogue between ideas and evidence or theory and data – which can bring operational closure to the relationship between the empirical world and the way we reconstruct it (Ragin, 1992; Ragin & Amoroso, 2011). This second step results in the construction of conditions (see Section 4.1) that influence a case (cf. Byrne, 2005).

Qualitative Comparative Analysis – an umbrella term for several types of QCA (see Rihoux & Ragin, 2009) – is deployed in the third step. In short technical terms, QCA allows for the iterative examination of patterns of complex causality through pairwise comparison of cases as combinations of conditions (i.e. configurations) (Ragin, 1987; Schneider & Wagemann, 2012). Complex causality means that conditions combine in configurations; that there may be multiple, different, non-exclusive configurations for the outcome; and that the effect of a condition on the outcome depends on its interaction with other conditions in the configuration (see further Schneider & Wagemann, 2012). The specific type of QCA we use in this article is multi-value QCA (mvQCA) (Cronqvist & Berg-Schlosser, 2009), in which conditions can have multiple values e.g. 0, 1 and 2. We demonstrate mvQCA in Section 4.2.

The basic logic of the approach consists of several subroutines: (1) construct cases as configurations and put them in a ‘data matrix’ which includes assigning values to the conditions per case based on the coded data; (2) organize the cases over the logically possible configurations in a so-called ‘truth table’ (see Section 4.2); (3) assign values to the outcome condition per configuration; and (4) identify minimal (combinations of) (necessary and) sufficient conditions through pairwise comparison of configurations that agree on the outcome and differ in but one other condition (i.e. ‘minimization’).

A condition is necessary if the outcome cannot be produced without it. A condition is sufficient if it can produce the outcome by itself. Complexity causality, however, implies that necessary and sufficient conditions often combine. Within a combination, a condition is INUS, i.e. an insufficient but necessary part of an unnecessary but sufficient condition (Mackie, 1980). This combining ('intersection') of conditions is expressed by the operator logical and (\* sign); the existence of different and multiple combinations is expressed by the operator logical or (+ sign). The degree to which the empirical evidence supports claiming necessity and/or sufficiency is expressed in terms of consistency. Basically, this "gauges the degree to which the cases sharing a given combination of conditions agree in displaying the outcome" (Ragin, 2008, p. 44). The empirical strength of a (combination of) condition(s) is expressed in terms of coverage (see Schneider & Wagemann, 2012).

Importantly, interpretation of patterns occurs throughout the iterative process and is of pivotal importance in concluding (see Section 5.2) the analysis. For a detailed explanation and overview we refer to the large body of methodological literature on QCA (e.g. Ragin, 1987; Rihoux & Ragin, 2009; Schneider & Wagemann, 2012) but for methodological reasons it is important (see Schneider & Wagemann, 2010) to explain here why we selected the specific type of mvQCA. The first reason is that the conditions we constructed do not represent interval or ratio scales. Second, prior to the mvQCA analysis presented in this article, we performed a crisp set QCA (Rihoux & De Meur, 2009) and a fuzzy set QCA (Ragin, 2009) but these all produced quite a few contradictions which could largely be resolved with mvQCA. The mvQCA was performed using Tosmana software (Cronqvist, 2011).

### **3. Data-collection about the A2 Maastricht project**

The A2 Passageway Maastricht project concerns the construction of a 2.3 km long double-deck, double tube tunnel running under the city of Maastricht. The tunnel is constructed using the cut and cover method. It is managed by a cooperation between four governments – Rijkswaterstaat (RWS),<sup>i</sup> the Province of Limburg, and the Municipalities of Maastricht and Meerssen – on the one hand ('the Project Agency') and construction consortium 'Avenue2' on the other hand. The project replaces the former highway that divided the city. In addition, its construction is also used to instigate real estate development, landscaping, and the reconstruction of nearby highway junctions. The construction formally started in 2011 and the commissioning of the tunnel is planned for the end of 2016.

A total of eighteen open interviews with public and private managers of the A2 Maastricht project were conducted between 2011-09-13 and 2011-12-06 by the first author of this article. In addition, multiple site visits, observations of project meetings, project documents and the website [www.a2maastricht.nl](http://www.a2maastricht.nl) facilitated interpreting the interview data. The interviews were transcribed and then coded and recoded in iterative fashion (Boeije, 2010) using ATLAS.ti coding software.

## 4. Analysis

The analysis proceeds in three steps. First we construct eighteen cases of management responses to unplanned events in the A2 Maastricht project (Section 4.1). Note that a case does not equal an interview; their number both being 18 is a mere coincidence. Second, we compare these using mvQCA so as to find out which configurations of management responses and events produce (un)satisfactory outcomes (Section 4.2). Third, we explain these results in Section 4.3.

### *4.1. Case reconstructions of responding to unplanned events in the A2 Maastricht project*

Several attempts (i.e. iterations) at bringing operational closure are reported elsewhere. In what follows we report our latest effort. Table 1 describes eighteen unplanned events stemming from the project's context during implementation that we identified. Since we focus in this article on how managers act, and because we focus on the implementation process, the table only concerns events after the contract closure – project construction – between principal and contractor in October 2009.

*Table 1: unplanned events in the A2 Maastricht project*

<b>ID</b>	<b>Label</b>	<b>Brief description of the unplanned event</b>
TUN	Tunnel standard	Due to ambiguity hence discussions about the safety standards for Dutch tunnels and delayed commissioning of tunnels resulting therefrom, RWS established a Tunnel Director to develop a general tunnel standard to be anchored in legislation. At the time of interviewing, this caused uncertainty about changes in the technical system (VTTI) requirements and related rising costs of the tunnel and technical systems.
BI1	Bicycle bridge	The plan was to create a temporary bicycle bridge to compensate the closure of two bicycle tunnels. A subcontractor identified problems with the design (i.e. sheared risks) which caused discussion within Avenue2 about how to proceed.
BI2	Bicycle bridge	In the end, this bridge was cancelled by Avenue2 for technical and safety reasons not foreseen in the procurement of the plan. Consequently, the Cyclist Union objected. The Union mobilized politicians in the municipal council – who appeared not to be informed of the change – who called the alderman to account.
WAT	Waterboard <sup>ii</sup>	The Waterboard needed to issue permits for parts of the project. It imposed additional requirements related to water retention and drainage when a permit was applied for by Avenue2 which affected the project scope. According to several managers, this was due to not involving the Waterboard in the planning of the project.

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LAN	Land acquisition	Over 400 apartments had to be purchased by the Municipality of Maastricht (Project Agency) to be demolished. A small number of residents objected, and some even appealed at the Dutch Council of State. <sup>iii</sup>
ZON	Zoning plan	Leading up to the endorsement of the zoning plan by the Municipality of Maastricht, the content was agreed upon by the responsible municipal manager and the manager planning of the Project Agency. However, as a consequence of internal municipal dynamics – i.a. limited decision-making power of the municipal manager – the municipal manager reconsidered the agreements twice.
ENV	Environmentalists	Environmental interest group ‘Kloar Loch’ appealed at the Council of State to enforce a higher air quality near the tunnel mouths in the final situation, and during project construction. Parallel to the legal procedure, the group also contacted the Project Agency to negotiate an agreement.
LEE	Leeuwenborgh	Vocational school Leeuwenborgh lodged an objection at the Project Agency to the phasing of a road bypass during construction for reasons of safety, health and limited parking space.
WES	West8	In detailing the design of the project, the angle of a small tunnel relative to the highway was slightly altered by Avenue2 when they applied for the construction permit at the Municipality of Maastricht. Landscape architect West8 objected, mobilized i.a. the municipal Building and Housing Inspectorate, and demanded the undoing of the alteration.
RIJ	Rijkswaterstaat	RWS needed to verify the Route Decisions developed by the Project Agency. <sup>iv</sup> Leading up to the endorsement the content was agreed upon between the Agency and RWS, but then RWS specialists demanded some changes in the design for reasons of air quality which would affect the project’s budget.
TRA	Traffic audit	During construction RWS performed an unannounced audit concerning traffic measures. The audit judged that the measures taken by Avenue2 were insufficient and that unsafe situations existed.
CR1	Crisis	Part and parcel of the plan and Avenue2’s business case is the construction of 1.100 houses and 30.000 m <sup>2</sup> of commercial properties between 2016 and 2026. The financial and real estate crisis caused uncertainty regarding the balance of the budget.
CR2	Crisis- and Recovery Act	In the beginning of 2010 the Crisis- and Recovery Act was enacted. This law aims to shorten procedures at the Council of State.
SOI	Soil contamination	During the reconstruction of the ‘Geusseltvijver’ soil contamination was discovered that was heavier than expected in the reports. By law, this contamination had to be removed.
BAD	Badger	Leading up to the contract closure the local badger habitat was identified. After the contract closure it appeared that the habitat had changed resulting in the need for scope

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PRO Prorail	changes (i.a. badger tunnels). Decommissioning the railway near the project area is necessary for project construction purposes. When the Project Agency requested the decommissioning, Prorail acted obstructive since they felt passed over as they were not consulted about the issue during plan preparation. <sup>v</sup>
CIV Civil initiative	In 2011 a city artist and an architect approached the Project Agency with an initiative to perk up the construction site with sunflowers.
THE Theft	Construction materials were stolen from the Avenue2's site.

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We constructed these cases as configurations of conditions. The first condition concerns the nature of the unplanned event. Contemplating Table 1, the nature of the events varies widely. In some cases it originates from the physical situation (i.e. SOI and BAD), in other cases it primarily relates to the local social environment (i.e. BI2, LAN, ENV, LEE, and CIV), the project system (i.e. BI1, WES), the local governance system including mother departments of the public partners (i.e. BI2, WAT, ZON, WES, RIJ, TRA and PRO) or remote of the project (i.e. THE, TUN, CR1 and CR2). What sets the middle three categories apart is that these strongly relate to what Hertogh and Westerveld (2010) coin “social complexity” which is “prominently visible in the relationship between the project delivery organization and local stakeholders” and “between the project delivery organization and their principal and parent organizations” (p. 150). The first and latter categories could be said to be similar in that respect, but differ from one another in terms of their remoteness to the project. In sum, the first condition is broken down into five categories: physical, social, project, public, and remote (see Table 2).

The second condition concerns the way in which managers respond to the unplanned event. As can be seen from Table 2, they do so by focusing on their internal structures – e.g. doubling the shifts, changing planning and changing construction modes – or by (attempting to) engage with the social system, most prominently engaging with stakeholders, in which the project is embedded, or some combination of both. It is important to note here that not all the events are responded to by both public and private managers; some are of concern to only one party. This is expressed in the third condition.

The third condition specifically concerns the relationship between principal and contractor which appeared to be a focal point in the interviews. This condition consists of two dimensions. First, an unplanned event may be responded to by either principal (public managers) or contractor (private managers), or both (i.e. interaction). This concerns the presence of public-private interaction. Second, if interacted upon, this may be characterized, to greater or lesser extent, by either cooperation or conflict between principal and contractor, i.e. join forces or i.a. shear risks. This concerns the nature of the interaction. Hence four basic categories of public-private interaction can be distinguished: autonomous public, autonomous private, conflict and cooperation. The empirical manifestation of the interaction is at

least partly determined by the contract between principal and contractor which provides directions for how they are to interact.

The fourth and final condition concerns the 'outcome'. In this we follow Verweij, Klijn, Edelenbos and Van Buuren (2013) to the extent that no unambiguous measure of 'good outcomes' can be used in projects with multiple actors and interests. Also, the project was at the moment of interviewing in construction which implies that outcomes are provisional, i.e. that the final effect on the project outcome as a whole could not be established. For these reasons we take as an aggregate measure the satisfaction of managers "based on their realized preferences and goals, and the time and energy spent achieving those" (Verweij, Klijn, Edelenbos, & Van Buuren, 2013) in a case as the outcome, which predominantly concerns time, budget, quality and/or the public-private relationship (Verweij, 2012). For instance, if goals are realized but with much energy spent, satisfaction is assessed as moderately high. In the next section, the qualitatively described data in Tables 1 and 2 are calibrated (see Table 3) and quantified in a data matrix (Table 4).

*Table 2: responding to unplanned events*

<b>ID</b>	<b>Event</b>	<b>Management</b>		<b>Interaction</b>		<b>Satisfaction</b>	
TUN	Remote	Internal	Managers tried to anticipate the uncertainty, but no attempts were made to influence the tunnel discussion.	Cooperation	The Agency and Avenue2 explored the possibility of forming a VTTI alliance to share risks. The idea was abandoned when uncertainty decreased; the contract is amended and the partners will cooperate to implement design changes.	High	Public and private managers expected the standard to enhance clarity, additional costs will be paid by the Ministry, and going for contract amendment is preferred by both parties.
BI1	Project	Internal	In the end, Avenue2 changed the construction plan concerning the bridge.	Private	Avenue2 individually made the decision without timely communicating it.	Low	The result was societal unrest and a “political joust”.
BI2	Social/Public	External (primarily)	A meeting was arranged with a delegation of the municipal council and the alderman promised better communication. Also, Avenue2 and the Agency took stock of	Public (primarily)	The municipal-political manager of the Agency led the reconciliation process although Avenue2’s director was also involved in meetings.	Indifferent or moderate	Although the issue was settled in the end, and although it was felt that it was an “unnecessary mistake” that could have been avoided, the manager conveyed a sense of

		improvement points.				events like this being the daily affairs in such a local and political environment.
WAT Public	External	Managers arranged meetings with the Waterboard to negotiate a solution.	Cooperation	The Agency and Avenue2 went to the Waterboard together, cooperated on submitting a new permit application, and they agreed on some contract changes (i.e. additional work).	Indifferent or moderate	Although in the end construction activities could commence, it was felt that the ado could largely have been avoided if the Waterboard would have been involved from the outset.
LAN Social	External	Managers negotiated with landowners about the price of the acquisition, sometimes accompanied by the alderman to soothe emotions. Also during the Council of State meeting prices were informally negotiated between appellants and the Agency's director.	Public	The acquisition of land is the sole risk and responsibility of the principal.	High	Although some properties have to be expropriated, appeals were withdrawn and nearly all the land was bought up. These results were contrasted by some managers with a nearby project and assessed positively.
ZON Public	External	Initially the interaction with the Municipality	Public (primarily)	The negotiations were managed by the	Moderate to high	Although in the end the claims were

			was hardened as the Municipality was threatened with claims. Later, the interaction softened by negotiating a substantive solution.		Agency as the zoning plans were its responsibility, but Avenue2 also filed a claim to exert pressure. Later they helped with the solution.		withdrawn and the conflict between the Municipality and the project was settled, some plan changes had to be made and some frustrations with the situation remained.
ENV	Social	Internal	The strategy of the responsible manager was to maintain radio silence as long as the Council did not judge yet. There was invested in legal and air quality specialists.	Public	The Agency was responsible for getting the zoning schemes declared irrevocably by the Council.	High	The appeals were declared unfounded and the responsible manager expressed a great sense of accomplishment.
LEE	Social	External (primarily)	Via an informal process the manager tried to negotiate a solution with the school, at certain points aided by mobilizing the alderman. This also meant changing the planning and position of the road bypass.	Public (primarily)	The interaction and negotiation process was carried out by the Agency, but Avenue2 helped with the substantive solution (i.e. changing the planning).	High	The school's objection was waved aside, the Agency and school's rapport remained good and the responsible manager was admired for his good performance.
WES	Project/ Public	External (primarily)	The involved manager tried to negotiate a	Private	Avenue2 acted alone on this issue.	Moderate to high	In the end it appeared to be a communication

			<p>solution with West8 and the Inspectorate, and in the end decided to satisfy West8's wishes to prevent claim for damages.</p>				<p>problem and West8, the Inspectorate and the Agency were satisfied, at the expense of some additional costs for Avenue2.</p>
RIJ	Public	External	<p>A persuasion process was initiated (e.g. by showing the financial consequences of demanding plan changes) to ensure that RWS would endorse the Route Decision.</p>	Cooperation	<p>Avenue2 was mobilized by the Agency's manager in the persuasion process to pressurize RWS to endorse the plan without expensive plan changes.</p>	High	<p>The Route Decision was endorsed, and about a year faster than average Dutch projects.</p>
TRA	Public	Internal (primarily)	<p>A meeting was organized to let the auditors present their findings, improvement points were identified and recorded and physical measures were taken to enhance safety.</p>	Private (primarily)	<p>The meeting was organized by the Agency, but Avenue2 takes the organizational and physical measures.</p>	Low	<p>The involved manager expresses irritations regarding this case. It is a drain on his time and budget.</p>
CR1	Remote	Internal	<p>The effects on the budget are calculated and monitored.</p>	Private (primarily)	<p>This is the contractor's risk although public</p>	Indifferent or moderate	<p>This event is outside the sphere of influence and at the time of</p>

CR2	Remote	Internal	The Act reduces the amount of required permits and shortens planning procedures.	Public	managers express goodwill to jointly consider the issue once it becomes prominent. The planning process was the Agency's responsibility.	Moderate to high	interviewing, managers were yet mainly concerned with the tunnel construction. The Act accelerated decision making at the Council, but due to capacity shortage the effect was partly nullified.
SOI	Physical	Internal	The contamination is responded to by taking physical measures.	Private (primarily)	The contamination is obviously dealt with by the contractor, but the principal decided how and changed the contract (i.e. additional work) accordingly.	Indifferent or moderate	Such unforeseen events are not exceptional, as is the way it was dealt with.
BAD	Physical	Internal	The scope was changed, i.e. additional badger tunnels were constructed.	Private	Avenue2 was charged with the construction and migration of the badgers.	Low	At hindsight, insufficient sagacity resulted in unnecessary costs.
PRO	Public	External	Managers negotiated a contract with Prorail for the decommissioning of the	Public	The negotiations were managed by the Agency as that is its responsibility.	Indifferent or moderate	The influence of this case on the course of the project is limited, but not involving

			rail track.				Prorail from the outset of the project was a missed opportunity.
CIV	Social	External	The initiative was embraced.	Cooperation	The initiative was embraced by both parties.	High	The initiative benefits the project image and enhances societal support for the project.
THE	Remote	Internal	Insurance, buy new materials.	Private	This issue is the sole risk of the contractor.	Indifferent or moderate	Although aggravating, theft occurs on a daily basis and is part of building a project.

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#### 4.2. Comparing cases with mvQCA and results

The calibration rules for Table 2 are shown in Table 3. In the first mvQCA iteration we used Version A of the calibration. However, as it turned out, this produced too many logical contradictions, i.e. a configuration that is associated with the outcome in one case and with the absence of the outcome on another. In addition, Version A produced logical remainders, i.e. logically possible configurations that are empirically absent. The more contradictions and remainders, the less there is to compare.

Specifically, first, EVENT{0} and EVENT{2} did not distinguish between cases in any significant way (i.e. it did not resolve a contradiction), but it did produce more logical remainders. That is, the remoteness of the unplanned event to the project does not account for the difference in outcome between cases. However, the difference between the social or non-social nature of the event distinguishes different cases from one another. Second, INTERA{1} (i.e. conflict) is empirically absent in our data, and two of the four contradictions could be resolved by distinguishing between ‘autonomous private’ and ‘autonomous public’ interaction instead. That is, this first analysis with Version A of the calibration suggested that actions being performed either by the public or the private actor autonomously is possibly an important explanatory feature for assessing the satisfaction with how unplanned events were responded to. Following these first results, the calibration was adjusted to Version B (see Table 3). The data matrix resulting from Version B of the calibration is depicted as Table 4. In the remainder of the analysis we proceed with this data matrix based on Version B.

*Table 3: calibration of conditions for mvQCA*

<b>Condition</b>	<b>Abbreviation</b>	<b>Calibration mvQCA (Version A)</b>	<b>Calibration mvQCA (Version B)</b>
Event	EVENT	0 = Physical 1 = Social, project, public 2 = Remote	0 = Physical, remote 1 = Social, project, public
Management	MAN	0 = Internal 1 = External	0 = Internal 1 = External
Interaction	INTERA	0 = Autonomous public, private 1 = Conflict 2 = Cooperation	0 = Autonomous public 1 = Autonomous private 2 = Cooperation
Satisfaction	SATIS	0 = Indifferent or moderate, low 1 = High, moderate to high	0 = Indifferent or moderate, low 1 = High, moderate to high

*Table 4: data matrix (calibration Version B)*

<b>Case-ID</b>	<b>EVENT</b>	<b>MAN</b>	<b>INTERA</b>	<b>SATIS</b>
TUN	0	0	2	1
BI1	1	0	1	0
BI2	1	1	0	0
WAT	1	1	2	0

LAN	1	1	0	1
ZON	1	1	0	1
ENV	1	0	0	1
LEE	1	1	0	1
WES	1	1	1	1
RIJ	1	1	2	1
TRA	1	0	1	0
CR1	0	0	1	0
CR2	0	0	0	1
SOI	0	0	1	0
BAD	0	0	1	0
PRO	1	1	0	0
CIV	1	1	2	1
THE	0	0	1	0

In the next two steps we organized these cases over the logically possible configurations in a truth table. Our truth table has twelve logically possible configurations ( $2^2 \cdot 3^1$ ). Each configuration is presented as a row. Each row can be understood as a statement of sufficiency. Next, the outcome associated with each configuration is assessed (see Table 5) which, so to speak, allows claiming that a statement of sufficiency is true or untrue. Logical remainders are not included in this truth table.

*Table 5: truth table*

EVENT	MAN	INTERA	SATIS	N Cases
0	0	2	1	1 TUN
1	0	1	0	2 BI1, TRA
1	1	0	C	5 BI2, LAN, ZON, LEE, PRO
1	1	2	C	3 WAT, RIJ, CIV
1	0	0	1	1 ENV
1	1	1	1	1 WES
0	0	1	0	4 CR1, SOI, BAD, THE
0	0	0	1	1 CR2

In the fourth step we minimized the truth table via pairwise comparing configurations that agree on the outcome and differ in but one other condition (Ragin, 1987). For instance,  $EVENT\{1\} * MAN\{0\} * INTERA\{0\}$  and  $EVENT\{0\} * MAN\{0\} * INTERA\{0\}$  could be minimized to  $MAN\{0\} * INTERA\{0\}$ . Contradictory configurations are not included in this minimization process. The results are reported in Table 6.

Table 6: results of the truth table minimization

<b>Statement of sufficiency</b>		<b>Outcome</b>
[1] Cases	MAN{0}*INTERA{1} BI1,TRA+CR1,SOI,BAD,THE	SATIS{0}
[2A-C] Cases	MAN{0}*INTERA{0}+ ENV+CR2	EVENT{0}*MAN{0}*INTERA{2}+ TUN EVENT{1}*MAN{1}*INTERA{1} WES

### 4.3. *Explanation of the results*

The first solution formula [1] is associated with low satisfaction. It states that in six of the eighteen cases, irrespective of the nature of the unplanned event, internally-oriented private management responses to events are associated with lower satisfaction. This is certainly the case for BI1, BAD and TRA where satisfaction was low. In the other 3 cases (THE, CR1 and SOI) where satisfaction is indifferent or moderate, this is less clear-cut. For those cases it is reasonable to assume that those could not have been prevented by the contractor. This could explain the moderate or indifferent satisfaction expressed by managers in those cases. This may be different for the first three cases. We return to this issue in Section 5.2.

The second solution formula [2] consists of three terms [2A, 2B and 2C] (see Table 6). The first term [2A] indicates that in two cases, irrespective of the nature of the unplanned event, internally-oriented public management responses are associated with higher satisfaction. In the case of dealing with the environmental interest group 'Kloar Loch' (ENV), the responsible public planning manager did not engage with the group during the legal procedure. He managed by the adage of 'anything you say can and will be used against you in the court of law' (see Table 2). In the case of the Crisis- and Recovery Act (CR2) this is a different story. Here the unplanned event is remote to the project and the internally-oriented management qualification reflects this (see Table 2).

The second term [2B] indicates that a remote event that is responded to internally-oriented and in cooperation between principal and contractor is associated with higher satisfaction. In this case (TUN), internal management strategies were oriented at anticipating the impact of the future legislation on the project. This unplanned event was considered by the managers as a priority issue with a potentially large impact that could not reasonably be left to Avenue2 to be dealt with. This was recognized by both partners, and this provided a basis for public-private cooperation.

The third term [2C] indicates that a social, local unplanned event (i.e. from the project system) that is responded to by externally-oriented private management is associated with higher satisfaction. In this case of the objections raised by landscape architect West8 (WES), some plan adjustments were made which resolved the issue without significant delays or budget overruns. Although this finding is only formally supported by one out of eighteen cases, it is corroborated by the first solution formula [1] which states that when private managers do not engage with the social environment to deal with the issue (MAN{0} \* INTERA{1}) this is associated with lower satisfaction.

Arguably, these three statements of sufficiency towards high satisfaction can be said to be empirically weak. That is, although they are consistent (i.e. there are no contradictions on the outcome between the cases covered by them), the terms in the second solution formula [2A-C] are covered by no more than two out of eighteen cases. There is a tradeoff between consistency and coverage (e.g. Ragin, 2008). Utilizing this tradeoff to fortify the empirical strength of our results, we performed an

additional mvQCA where we included the contradictory configurations (see Table 5) in the minimization for SATIS<sub>1</sub>. Thereby we increased the number of cases covered by the solution formula [2] by eight (higher coverage), and simultaneously the inconsistency since the added cases BI2, LAN, ZON, LEE, PRO, WAT, RIJ and CIV do not all have a score of 1 on the outcome. However, only three of those eight cases do not score 1 (i.e. BI2, PRO, WAT) and none of those three cases has a score in the lowest scores, but not unacceptably low to exclude them.

This additional mvQCA iteration produced somewhat similar results. The first [2A] and second terms [2B] of the second solution formula remained unchanged. However, the third solution term [2C] that was solely covered by WES changed. It became more general since it does not matter whether interaction (INTERA) is autonomous public {0}, autonomous private {1} or cooperative {2}; higher satisfaction is 'produced' nevertheless. Hence, the INTERA condition is dropped from the solution term to yield the more general result: EVENT<sub>1</sub>\*MAN<sub>1</sub> → SATIS<sub>1</sub>. This means that externally-oriented management is an INUS condition, which means that it is necessary for dealing with social, local unplanned events, but that there are other combinations of conditions that are also associated with high satisfaction. This is indicated by the existence of the two other solution terms.

## 5. Conclusions and discussion

In Section 5.1 we conclude our analysis by answering the main research question. As announced in Section 2.2, in Section 5.2 we make a final interpretation of the results to conclude the analytical process, and in this discussion we point to some implications for managers of transportation infrastructure projects. Section 5.3 closes the article by briefly discussing some methodological issues and implications for evaluators.

### 5.1. Conclusion

In the introductory section we set out to investigate how managers in the implementation phase respond to unplanned events that occur in the context of the transportation infrastructure project, and which management responses produce satisfactory outcomes. We adopted a research approach that combines qualitative in-depth analysis – which is needed to consider context that is explanatory for how outcomes come about in projects – with comparison – which is required to be able to draw lessons for future projects (cf. Verweij & Gerrits, 2013). We were able to show in a systematic way how the influence of certain management responses depends on its interaction with other conditions. Although such claims are expectedly also made in qualitative/interpretative case studies of transportation infrastructure projects, QCA allowed us to do this in a systematic and transparent manner. Using a grounded and iterative research process we arrived at a number of results.

Specifically, we found that both internally-oriented and externally-oriented management responses are associated with high satisfaction but that this depends on

the nature of the unplanned event, and/or of the cooperative relationship between principal (private managers) and the contractor (public managers). In particular, (1) internally-oriented private management is associated with lower satisfaction, (2) externally-oriented management is associated with higher satisfaction in cases of social, local unplanned events, and (3) internally-oriented management is associated with higher satisfaction, depending in particular on the nature of the cooperation between principal and contractor. This shows that unplanned events are responded to in different ways and that balancing management strategies actually entails a *mix* of less balanced management responses *within* a project.

## *5.2. Discussion and management implications*

We pointed at a difference between cases that are covered by the first solution formula associated with SATIS{0}. In all these cases, the unplanned event was responded to by the contractor, and satisfaction was rather low. This is not to say that when private managers deploy internally-oriented strategies, low satisfaction 'automatically' follows.

As mentioned in Section 4.3, regarding three of cases six cases of this solution formula (THE, CR1 and SOI) managers expressed indifference in the interviews with respect to the outcome condition. They expressed that some events are just impossible to influence or prevent. The implication of this is not that managers should relinquish dealing with unplanned events, but rather that they should be aware that projects will inevitably encounter unexpected events (e.g. Weick & Sutcliffe, 2007).

In other remote unplanned events, the perceived potential impact on the project's critical path (planning) was too great for the managers to remain indifferent to. This is most prominent for the development of the new tunnel standard (TUN). The need to anticipate this impact was felt by both Avenue2 and the Project Agency; managers referred to the northerly A73 Roermond tunnel that is plagued by closures for safety reasons since its commissioning in 2008, resulting in limited regular service. With this bugaboo in mind, principal and contractor wanted to build a safe tunnel in Maastricht but not at the expense of construction delays and cost overruns. Indeed, the idea that the city has to endure the discomforts of the construction works beyond 2016 is deemed undesirable. It seems that this shared sense of urgency is a strong driver for enhanced cooperation as it provided a basis for contractor and principal to cooperate in the project (cf. Verweij, 2012).

Another possible condition underlying the differences within the first path associated with SATIS{0} may be the extent to which the contractor had a (too) strong focus on design and planning issues (BI1, TRA and BAD). Encouraged to meet deadlines, contractors tend to focus on making rapid progress thereby sometimes losing sight of the local, social environment in which a project is embedded. This may backfire on the project's process. The implication is that, generally, having an externally-oriented focus produces more satisfactory outcomes. This is supported by the results of our analysis. However, this does not seem a big issue in Maastricht

since the project enjoys local support given its clear added value for the city and its citizens. But in more contested infrastructure projects, this may be a whole different story. This implies that support for a project is important for achieving satisfactory outcomes.

The second solution formula [2] indicates that, internally-oriented management strategies are sometimes associated with higher satisfaction (ENV, CR2 and TUN). Although, the cases associated with these two configurations are quite diverse (see Table 2), they seem to have in common that they have a potentially large impact on the project's development. The TUN case was discussed above. For the ENV and CR2 cases, as public planning and procurement were interwoven (Van Valkenburg & Nagelkerke, 2006) and the bidder was selected before the public planning was finished, changes in the public zoning and Route Decision plans may result in a failed procurement and great costs since the bidder was already selected. Hence, there was a big relief when the Council of State declared the public plans irrevocably.

The analysis also showed that externally-oriented management is strongly associated with high satisfaction and that the opposite is often the case for internally-oriented management. The obvious implication of this finding is that externally-oriented management responses are recommended to deal with unexpected events. However, it should be kept in mind that this could be concluded after including two logically contradictory configurations. Bearing in mind that the contradictions are not very strong, the question still is: what explains these two contradictions? What the three cases with indifferent or moderate satisfaction (BI2, PRO and WAT) seem to have in common relative to the five other cases is that managers expressed their satisfaction in terms of missed opportunities to involve particular actors in the planning of the projects. Not involving the Prorail (PRO), the Waterboard (WAT) and the Cyclist Union and municipal council (BI2) respectively was perceived to have caused the unplanned event in the first place. This points us to the importance of closely involving stakeholders in the planning phase.

We showed that transportation infrastructure projects are implemented in a social context, and that this context gives rise to unplanned events. These events are often best managed not by ignoring them or managing inward, but rather by managing outward, i.e. engaging with the social context of the project. This points us to the pivotal importance of stakeholder management, not just in the planning phases of a project, but also during project implementation. In the A2 project, a lot of resources were allocated to this and with satisfactory results. The Project Agency and Avenue together run a communication office to provide local stakeholders such as citizens, companies and local governments, with information about (the progress of) the project. This is quite a success as there are no significant problems with stakeholder unrest during implementation.

### *5.3. Reflection on the method for evaluation*

“QCA does not in itself open up the ‘black box’ of complex phenomena and processes. However, it rather acts like a flashlight that points at some crucial spots in the black

boxes of the cases under investigation” (Rihoux, Ragin, Yamasaki, & Bol, 2009, p. 170). In this article we illuminated some spots, but many remain to be studied. Nevertheless, we hope to have shown that QCA is a systematic and transparent evaluation approach that on the one hand appreciates the uniqueness, diversity and contextual nature of projects, and on the other hand it searches for patterns. This is imperative to transfer lessons from individual project analyses to future projects. We finish this article with some final points for evaluators.

First, in this paper we have applied QCA to a single infrastructure project for in-depth analysis. However, it may also be interesting for evaluators to apply QCA to multiple infrastructure projects (e.g. Verweij, Klijn, Edelenbos & Van Buuren, 2013) to compare small-n or intermediate-n projects across or within regions (e.g. states) and sectors. Given the fact that evaluators often have to deal with relatively small numbers of cases which makes statistical analysis difficult, this is a significant advantage of QCA. Second, the time dimension is underexposed in QCA approaches. In this article we have carefully paid attention to time by constructing the cases in such a way that the unplanned event is chronologically prior to the other three conditions (MAN, INTERA and SATIS) in each case. Moreover, time is also expressed in the qualitative interpretation. Nevertheless, QCA is an approach that is weak on researching the dynamics of infrastructure projects whilst these are pivotal to explaining outcomes (Verweij & Gerrits, 2013). Third, we decided to work with mvQCA. This is arguably not the best method for any evaluation of infrastructure projects. What to use – csQCA, mvQCA or fsQCA – ultimately depends on the conditions to include in the analysis and how these are operationalized. Crisp, multi and fuzzy sets all have some distinct disadvantages and advantages (Schneider & Wagemann, 2012; Thiem, 2013; Vink & Van Vliet, 2009; 2013), as do the different software packages related to those methods (see [www.compass.org](http://www.compass.org) for an overview). Finally, through the iterative processes of data-collection, coding and casing, we arrived at a certain set of conditions to be included in the QCA process. Other projects with different characteristics, and other methods and techniques of data collection may result in a different set of conditions. However, this does not invalidate in any way the usability of QCA for evaluating infrastructure development.

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## **Endnotes**

i. Rijkswaterstaat is the executive arm of the Dutch Ministry of Infrastructure and the Environment. On behalf of the Minister and State Secretary, Rijkswaterstaat is responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands (see: <http://www.rijkswaterstaat.nl/en/>).

- ii. Dutch water boards are regional democratically elected governmental bodies charged with the management and maintenance of water barriers, waterways, water levels and water quality. The first water boards date from the thirteenth century.
- iii. The Council of State advises government and parliament on legislation and governance, and it is the country's highest administrative court (see: [http://www.raadvanstate.nl/the\\_council\\_of\\_state/](http://www.raadvanstate.nl/the_council_of_state/)).
- iv. The Route Decision is the national equivalent of a zoning plan for national infrastructures.
- v. Prorail is the organization responsible for the construction, maintenance, management and safety of the Dutch railway network.

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