How to Steer on the Cost Price of Projects within the Technical Service Delivery

Bachelor Thesis Civil Engineering

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I. Preface

In this report I present my thesis to graduate for the bachelor of Civil Engineering at the University of Twente. Before I started the period of the thesis the choice was already made to continue with the master of Construction Management & Engineering at the University of Twente next September. My preference for the management aspect of technical problems in combination with the strive for process optimisations, made it clear for me that my thesis had to be management related within the context of civil engineering.

Since the research period of ten weeks can roughly be divide into two parts, interviews and data analysis, I can see my research was quite divers, but also challenging to combine the two of them into one coherent research. In the end, the invitation to present and discuss the results of the research at the management team and the transmission of my results to a master trainee made me feel satisfied about the research conducted.

I want to thank both my supervisors Leentje Volker and Jaap Bongers for the pleasant communication and critical attitude from their own perspective. Besides, I want to thank Jos Schoorlemmer as my point of contact at the location of SPIE at Wijhe.

Roy Brinkhof

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Table of contents

II. List of equations

III. List of figures

IV. List of tables

V. Executive summary (English)

Questioning how to steer on the alignment of the project cost price is not one out of nowhere, 'the phenomena of cost underestimation and escalation appear to be characteristic for almost all types of infrastructure projects' (Flyvbjerg, Holm, & Buhl, p. 14). This thesis provides insight in the control of cost price alignment and recommendations/presumptions are reported to improve the process of cost price alignment. The research is conducted within the 'Smart city' division of SPIE, a profit organisation operating within the technical service delivery. In almost all projects a governmental body is involved, and tendering is everyday's business. Because of the competitive aspect of tendering it is of necessity to draw up well-structured cost price calculations, such that the eventual bid will not lead to an underestimated cost price due to time delay and/or cost overrun (Ramanathan, 2012).

At first, interviews are conducted with twelve project managers. The interviews focused on three subjects, respectively 'excellent projects', 'disappointing projects' and 'general improvements'. The mentions of interviewees are categorised, using eighteen different categories of time delay and cost overrun in construction projects (Ramanathan, 2012). For each subject this resulted in a top five of categories, notable is that only eight of eighteen in total appear in each of the three subjects (Table 1).

Table 1: Top five of mentioned categories for each subject

Excellent projects	Disappointing projects	General improvements
5. Contractor	5. Contractor	17. Scheduling & Controlling
17. Scheduling & Controlling	7. Design	8. Coordination
14. Contractual relationships	17. Scheduling & Controlling	5. Contractor
4. Owner/Client	11. Labour/Manpower	11. Labour/Manpower
11. Labour/Manpower	14. Contractual relationships	2. Project

In combination with the underlying mentions for each category four propositions about the alignment of the cost price are drawn up:

P1. The intended project team is not involved during the tender phase due to a lack of capacity and availability. This leads to shortcomings in the cost price calculation and stiff transmission from tender team to project team;

P2. To overcome time delays during the engineering phase, decision-making should be left to the technical management, such that engineers only have to design and construct;

P3. Investing in more staff will eventually result in better alignment of the cost price, because it is easier drawing up a project team and less hired staff is needed;

P4. The relation with a client is essential in successfully completing projects, transparency and involvement of the client in decision-making processes seem to be key in maintaining a good relation.

After the observational part, interviewing project managers, an experimental analysis is conducted using the financial data of approximate 320 projects over the past three years of the division of Smart City focusing on 'wet' infrastructure.

Using ANOVA seven variables derived from the financial dataset are analysed. The analyses of the variables 'prognostication of net margin', 'project manager' and 'type of work' resulted in a significant

difference, with an confidence interval of at least 90%. The significant differences strength the presumption that those variables influence the cost price. Although, it must be said that due to the quality and amount of data available it can't be stated that the significant differences are reliable and applicable results.

Through a session with the management team of the organisation the results are discussed. As well the results itself as the restrictions and limitations influencing the results are discussed. With respect to validation purposes, the management team reacted positively on what was studied. They agreed that this topic needs attention within the company. However, the biggest part of the session zoomed in on verification purposes. Per analysed variable the result and underlying method are discussed. All in all, it is concluded that the results give an presumed indication/confirmation of what was already known, but most important, the data is not adequate to come up with reliable results.

In contrast, the interview results and the procession of them were obtained as reliable, although the management team would like to split the results into the three subjects 'excellent projects', 'disappointing projects' and 'general improvements' which is eventually done as already reported.

To close, there can be distinguished two types of recommendations, respectively short-term and long-term. Short-term it should be applicable to add more detailed data into the financial system, e.g. the column 'Profession' can quite easily be detailed by indicating whether a project is really 'Electricity'-related or has more or other professions. Besides, being transparent and involve the client in decision making are 'do's' which are almost directly applicable.

As a long-term solution, it is recommended to develop a more structured list of risks and opportunities in addition to the limited list already available. Parallel with this risk and opportunities it is of importance to map competencies of staff and develop a system such that the capacity is scheduled to query for knowledge by the tender team. Eventually a well-considered Go/No Go can be proposed.

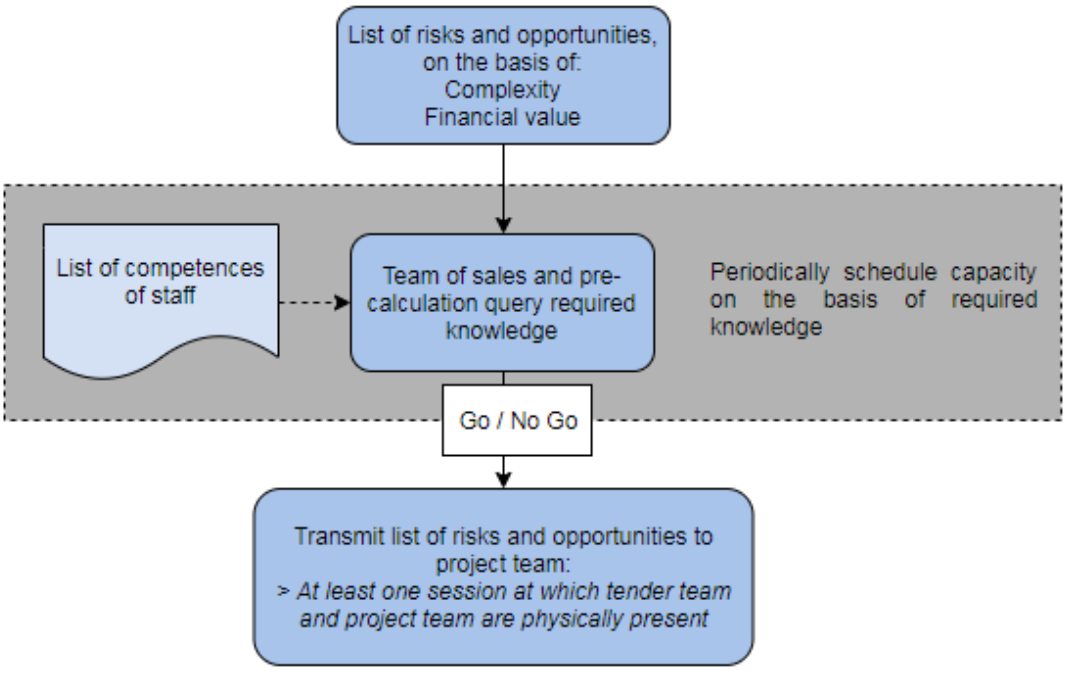

Figure 1: Optimisation of initial cost price calculation and transmission

VI. Executive summary (Dutch)

De vraag 'Hoe kan er beter gestuurd worden op het controleren van de initiële kostprijs van projecten?' komt niet uit het niets. 'Het fenomeen van onderschatting en escalatie van kosten is kenmerkend voor bijna alle infrastructurele projecten' (Flyvbjerg, Holm, & Buhl, p. 14). Middels deze afstudeeropdracht wordt de controle op initiële kostprijs inzichtelijk gemaakt, daarnaast worden enkele aanbevelingen gedaan hoe het proces van controle op de kostprijs verbeterd kan worden. Het onderzoek is uitgevoerd binnen de 'Smart city' divisie van SPIE Nederland, actief in de technische dienstverlening. Voor bijna alle projecten is betrokkenheid van de overheid van toepassing en is aanbesteden een reguliere vorm van aanbieden. Essentieel is dat op voorhand goed onderbouwde kostprijscalculaties worden gemaakt, zodat bij de uiteindelijke bieding weloverwogen risico's en kansen al dan niet kunnen worden afgeprijsd.

Allereerst zijn twaalf projectmanagers geïnterviewd, waarbij de focus is gelegd op (financieel) uitstekende projecten, teleurstellende projecten en algemene verbeterpunten. Voor ieder van deze drie onderwerpen zijn de vermeldingen door geïnterviewden gecategoriseerd volgens de achttien categorieën van vertraging en/of kostenoverschrijdingen in constructieprojecten onderscheidden door Ramanathan (2012). Voor alle drie de onderwerpen is de top vijf van categorieën weergegeven (Table 2), opvallend is dat alle onderwerpen samen slechts acht van achttien categorieën bevatten.

Table 2: Top vijf categorieën per onderwerp

Excellent projects	Disappointing projects	General improvements
5. Contractor	5. Contractor	17. Scheduling & Controlling
17. Scheduling & Controlling	7. Design	8. Coordination
14. Contractual relationships	17. Scheduling & Controlling	5. Contractor
4. Owner/Client	11. Labour/Manpower	11. Labour/Manpower
11. Labour/Manpower	14. Contractual relationships	2. Project

In combinatie met de onderliggende vermeldingen per categorie zijn vier propositions opgesteld met betrekking tot het beheersen van de kostprijs:

P1. Het beoogde projectteam is tijdens de tenderfase niet of nauwelijks betrokken door een gebrek aan capaciteit en beschikbaarheid. Dit leidt tot tekortkomingen in de kostprijscalculaties en maakt de overdracht van tenderteam naar projectteam moeizaam;

P2. Tijdens de engineeringsfase moet besluitvorming meer bij het technisch management worden gelegd zodat engineers kunnen focussen op de essentie van tekenen en construeren;

P3. Investeren in meer eigen personeel draagt bij aan een betere kostprijsbeheersing, door tijdsbesparing in het vormen van projectteams en een afname van ingeleend personeel;

P4. De klantrelatie is essentieel voor het succesvol afronden van projecten. Transparantie en het vroegtijdig betrekken van de klant in besluitvormingsprocessen lijkt hierin de sleutel.

Aansluitend op de interviews is een data-analyse uitgevoerd op het financieel systeem. Deze bestaat uit een set van ongeveer 320 lopende en afgeronde projecten over de afgelopen drie jaar, binnen de afdeling 'Bruggen, Sluizen & Gemalen' van Smart city. Zeven variabelen, afgeleid uit het financieel systeem, zijn geanalyseerd met ANOVA. Drie van deze variabelen, prognotisering van de

netto marge, de projectmanager en het type werk hebben geresulteerd in een significant verschil, met een betrouwbaarheidsinterval van op zijn minst 90%.

Middels een sessie met het management team (MT) van het bedrijf zijn de resultaten van het onderzoek geëvalueerd. Met betrekking tot de validatie van het onderzoek, kan worden geconcludeerd dat het MT zeer te spreken is over datgene wat is onderzocht, en is ingestemd dat er op het gebied van kostprijsbeheersing verbetermogelijkheden zijn. Het grootste deel van de sessie is echter gefocust op verificatie van het onderzoek. Concluderend kan worden gesteld dat de statistische analyse vooral laat zien dat middels het huidige financieel systeem niet voldoende betrouwbaar is voor dit type analyses, aangezien niet alle benodigde data adequaat wordt verwerkt en gerapporteerd.

In tegenstelling tot de data-analyse, worden de interviewresultaten als betrouwbaar geacht. Desondanks kwam naar voren da teen splitsing van de drie onderwerpen wellicht een beter en completer beeld geeft van de categorisatie. Zoals hiervoor besproken is dit uiteindelijk ook gedaan (Table 2).

Tot slot kunnen er twee type adviezen als resultaat van dit onderzoek worden onderscheiden. Op korte termijn zou het mogelijk moeten zijn om de data in het financieel systeem dusdanig uit te breiden dat deze wel voldoende adequaat gerapporteerd kan worden. Daarnaast is het onderhouden van een goede klantrelatie iets wat vrijwel direct gedaan kan worden, aangezien ‘transparant zijn’ en de klant ‘actief betrekken bij besluitvorming’ berust op daden afspraken die gelijk in praktijk kunnen worden gebracht.

Op lange termijn wordt aangeraden om een risico-/kansenlijst te ontwikkelen op basis van financiële waarde en complexiteit, toepasbaar op ieder project. Parallel aan deze lijst is het van belang om competenties van personeel in kaart te brengen en een systeem te ontwikkelen zodat gevraagde kennis eenvoudig uitgevraagd kan worden door het tenderteam, om de calculatie van de kostprijs nauwkeurig uit te voeren . Uiteindelijk kan dan een weloverwogen Go/No Go worden afgegeven.

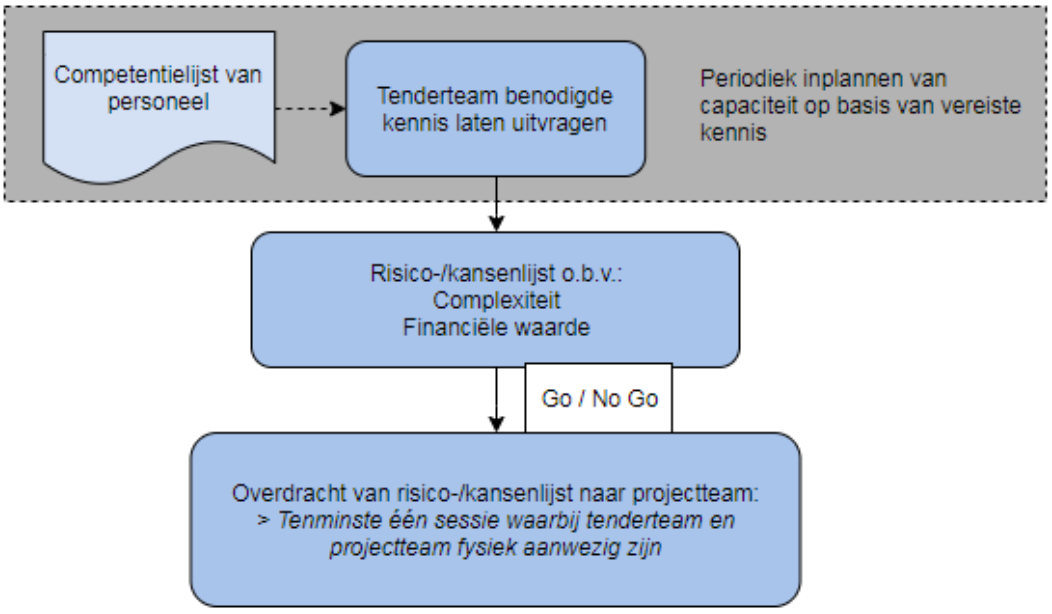

Figure 2: Optimalisatie van initiële kostprijscalculatie en overdracht

VII. List of abbreviations and jargon

Term	Explanation
Companies/Organisations	
SPIE	Company name, 'Société Parisienne pour l'Industrie Electrique'.
Jansen Venneboer	Former company located in Wijhe, before acquisition of SPIE.
Alewijnse	Former company located in Zwolle, before acquisition of SPIE. Acquisition almost simultaneously with Jansen Venneboer.
Rijkswaterstaat (or RWS)	Dutch ministry of infrastructure and water
Waterschap	Organization concerned for water management in a particular area
Divisions of SPIE	
Smart City	One of the four major divisions of SPIE in The Netherlands.
BS&G	'Bruggen, Sluizen & Gemalen', sub-division of Smart City concerned with 'wet' infrastructural projects.
BU	Business Unit (a single location), within BS&G there are three business units: Amsterdam, Sliedrecht and Wijhe
Organizational structure	
MT	Management team
As. 1	Part of Smart City – BS&G responsible for commerce and sales. Roughly said this 'as' does tender and (pre)calculation of projects.
As. 2	Part of Smart City – BS&G responsible for project management. After winning a tender they get in charge after transmission from as. 1.
As. 3	Part of Smart City – BS&G responsible for technical management of projects.
As. 4	Part of Smart City – BS&G responsible for site management of projects.
As. 5	Part of Smart City – BS&G responsible for asset management of projects.
Abbreviations for professions	
PM	Project manager / project management
TM	Technical manager / technical management
SM	Site manager / site management
MT	Management team – responsible for the entire BS&G department
Contract types	
UAV-GC	Type of contract for construction projects. In Dutch 'Uniforme Administratieve Voorwaarden voor Geïntegreerde Contractvormen', literally translated to English 'Uniform Administrative Conditions for Integrated Contract Forms'.
BVP	Type of contract for construction projects. 'Best Value Project'.
Systems and terms uses within SPIE	
AX	Financial system used within SPIE for reporting project updates.
PPO	'Projectprognose', monthly (financial) update of a project. Serves as input for AX.
Abbreviations in statistical analysis	
CI	Confidence Interval
cf	Correction factor
MYM	Multi-year maintenance
ReM	Regular maintenance
CoM	Corrective maintenance
PrM	Preventive maintenance

1. Introduction

Questioning how to steer on the alignment of the project cost price is not one out of nowhere, 'the phenomena of cost underestimation and escalation appear to be characteristic for almost all types of infrastructure projects' (Flyvbjerg, Holm, & Buhl, p. 14). In addition the broader perspective, not only considering infrastructural projects, but construction projects in general tend to have time delays and cost overruns (Ramanathan, 2012) resulting in disruption on the initial cost price of projects.

The research presented in this report, which is the basis of a bachelor thesis, focusses on the question: *'How to steer on the alignment between tender bid, initial cost price and final costs for projects within the technical service delivery?'*

The thesis is conducted at SPIE, a company which is within the top-3 of biggest companies active in the technical service delivery in The Netherlands. Since the research is conducted within the 'Smart city' division of SPIE, first this quite recent market is explained. Subsequent the scope of the research is defined, and finally the outline of the report is given.

1.1. The market of smart city

Smart city is a quite recent market, focusing on the way our living space is organised nowadays due to urbanisation (Heida, 2018), (Eremia, Toma, & Sanduleac, 2016). The (re)organization of living space is very broad since it focuses on optimization from buildings up to data availability. The overarching factor of all Smart City projects is that it is always related to the government. As Jan Arends, director of the Smart City and Energies section of SPIE, stated entrepreneurs are willing to offer solutions to improve for example the flow of traffic, but they want to get paid. Therefore, it is always the government that will be concerned in the provision of 'Smart city' projects.

So, first it is of importance that the government offers projects. Secondly, it is for the sake of the firm's profitability that tenders of concerning projects are won. In the competition of winning projects there is always the paradox between the aim of winning and offering a promising project delivery, without losing credibility (Manzoni & Volker, 2017). When you 'just' focus on winning tenders you cannot consider other strategic goals of the company such as improving the reputation of the firm or diversification. It is quite tempting to strive for envisioning promises during the tender phase, because it will enhance your chances of winning. However, for future projects and to keep the collaboration with the client steady it is essential that you can really deliver these promises. In other words, for the reputation of your company it is of importance that you are reliable and credible.

The relevance of this paradox with respect to smart city is clearly present, because the society nowadays asks for "sustainable and connected solutions" (SPIE Jaarmagazine 2017, p. 6). Only by smart innovations the living environment of people can be kept liveable, safe and accessible. Because of the need for smart solutions it can be implied that strategies and expertise beyond the lowest price only are required. A broad strategy which also encounters reputation of the company and sustainability aspects become more and more integrated in the market. However, the major point of attention is the implementation of a lot of pilots into one business case (Klein Obbink, 2019) to create uniformity in designing smart city aspects. The government offers enough space for 'experimental' pilots (SPIE

Nederland, 2018), (Klein Obbink, 2019) but as stated, it is the case for the near future to really implement smart solutions.

1.2. Research questions

During the research it is of importance that the main question is always kept in mind. In the end, it is tried to answer the question how steering on the cost price during projects can be controlled and eventually suggest concrete points of improvement to achieve more positive (financial) margins.

As already mentioned in the first paragraph of section the main question of this research is as follows, and can be divided into four sub-questions:

MQ How to steer on the alignment between tender bid, initial cost price and final costs for projects within the technical service delivery?

Q1 How are the cost price and tender bid of projects determined?

Q2 How to keep a grip on a project in relation to its available budget and cost price?

Q3 How to steer on the alignment between tender bid, initial cost price and final costs within the Smart city division of SPIE?

Q4 What are the possibilities for SPIE to affect factors such that the difference between the initial and actual efficiency can be decreased?

1.3. Outline

At first, chapter 2 'Problem context' sketches organisational structure of SPIE within The Netherlands, and its approach to the market of Smart city is explained. Relevant theories about risk management and time and cost overrun in (construction) projects are reported (section 2.3 and 2.4). In addition, dispersed projects and contract types occurred during the research are explained in the remaining sections. In the third chapter, Methodology, first the observational part of the study is reported (Part I). The possibilities and risks offered by interviews are explained and the procession of interviews is exposed. In section 3.2 the data analysis is reported, at which is focused at descriptive as well as statistical analysis (Part II). Nearing the end of the research a session with the management team provided a validation and verification of the results (Part III, section 3.3).

Chapters 4, 5 and 6 present the results of respectively part I, II and III. The interpretation of the results, limitations of the research and restrictions of datasets are discussed in chapter 7. The conclusion of this research (chapter 8) consists of three parts, focusing on project properties, process optimisation of initial cost price calculation and transmission and maintenance of a good relation with the client.

2. Problem context

The company, SPIE, at which the research is conducted is sketched through its organisational structure and approach with respect to handling projects. Besides, the theoretical framework of the research is presented in this chapter. Risk management in projects (section 2.3), categorisation of time and cost overruns (section 2.4), the concept of dispersed projects (section 2.5) and contract types mentioned during the interviews (section 2.6) are reported.

2.1. Organisational structure of SPIE

The organizational structure of SPIE starts at its management board, with one managing director with right below the directors of the three divisions of the company, respectively 'Smart city & Energies', 'e-fficient buildings' and 'Industry services'. The division of 'Smart city & Energies' is in its place divided into four departments, 'Energies', 'Network Solutions', 'Verkeer & Vervoer' and 'Bruggen, Sluizen & Gemalen' (BS&G). The location of Wijhe is part of BS&G, in collaboration with the locations at Amsterdam and Sliedrecht. Since the thesis will only focus on Smart City – Bruggen, Sluizen & Gemalen the further explanation of the organisation only focusses on this department.

Management team and structure of BS&G

Within BS&G the organisation is divided into 'kennis-assen', literary translated as 'knowledge axes'. Each as has its own expertise, in total there can be distinguished five assen (Table 3).

Table 3: Structure of BS&G

Axis	Expertise
As. 1	Commerce and sales • Tender • (Pre)calculation of project costs
As. 2	Project management • Responsible for project after transmission from tender team
As. 3	Technical management • Engineering • Control on budget and time for design
As. 4	Site management • Responsible for on-site activities
As. 5	Asset management • Inspections • Maintenance • Work preparation

2.2. Project process within Smart city & Energies

For each division within SPIE there is set up a standard procedure for projects, so this is also the case for the division of 'Smart city & Energies', all methods of SPIE are shared within SKID. The main process consists of eight primary processes (Table 4), enclosed by the client, its surroundings and stakeholders. The primary processes depend on administrative and supportive processes, Table 4 is derived from this process, the original process can be found in appendix A 'Main process of projects'.

Table 4: Processes in Smart city & Energies projects

Primary process	**1. Order recruitment**	**2. Project definition**	**3. Design**	**4. Work preparation**
Sub-processes	*Acquisition* *Request criteria* *Pre-qualification* *Request of handling* *Project handling*	*Project transmission* *Analysis of scope* *Kick-off*	*Analysis of technical requirements* *Pre-design* *Final design* *Implementation design*	*Production and pre-montage* *Execution of work preparation*
Primary process	**5. Execution**	**6. Testing & put into operation**	**7. Closure & aftercare**	**8. Management & maintenance**
Sub-processes	*(Pre)fabrication and off-site production* *On-site montage and testing* *Inspection and mechanical readiness*	*Testing system* *Testing integration* *Boot up and transmission* *Testing performance*	*Closure and evaluation of project* *Demobilization* *Warranty*	*Arrange object-tree* *Service design* *Service transition* *Service operations*

2.3. Risk management in projects

Managing projects cannot be seen individually from risk management, and in fact all project teams perform risks, although sometimes unconsciously (Simister, 2004). Despite, projects and project management have relation to a huge set of subject areas, more than engineering and technical services alone, there can be distinguished three important elements relevant all project risk management (Winch & Maytorena, pp. 347-349):

- The best way to identify risk management is by a cyclical procedure;
- A list/register of risks and possibilities (or opportunities and threats) lays at the base of the process;
- Powerful toolsets are available and highly recommended in supporting (parts) of the cyclical risk management process.

The three elements above can be schematized into risk management cycle (Figure 3). In fact, the first two elements can be recognized in the cycle. What remains, is choosing the right toolsets for a particular project by the project team.

Although, it seems quite trivial drawing up a risk register, in practice it turns out to be hard mapping all opportunities and threats and value them in a proper way. For a profit engineering company, such as SPIE, economic and decision sciences are of importance in mapping and deciding whether particular opportunities and threats should be considered or not. Within the EU the expected utility paradigm lays is fundamental for these kind of sciences (Winch & Maytorena, pp. 349-351). This paradigm is explained as that "…the rational decision-maker can clearly distinguish between two (or more) alternative courses of action by combining arithmetically the probability of an event…" by Winch & Maytorena (2010, p. 349). As can be deduced from the quote, threats and opportunities are commonly translated into probabilities . The general rule 'chance of occurrence times the (financial) result' substantiates this paradigm. Operating within this paradigm requires two conditions (Winch &

Maytorena, 2010). First of all, decision-makers should have the ability make reliable and suited calculations and estimate this reliability by reflecting on their calculations and knowledge about (computer) models used. Secondly, the probability of occurrence and the result/impact have to be measurable.

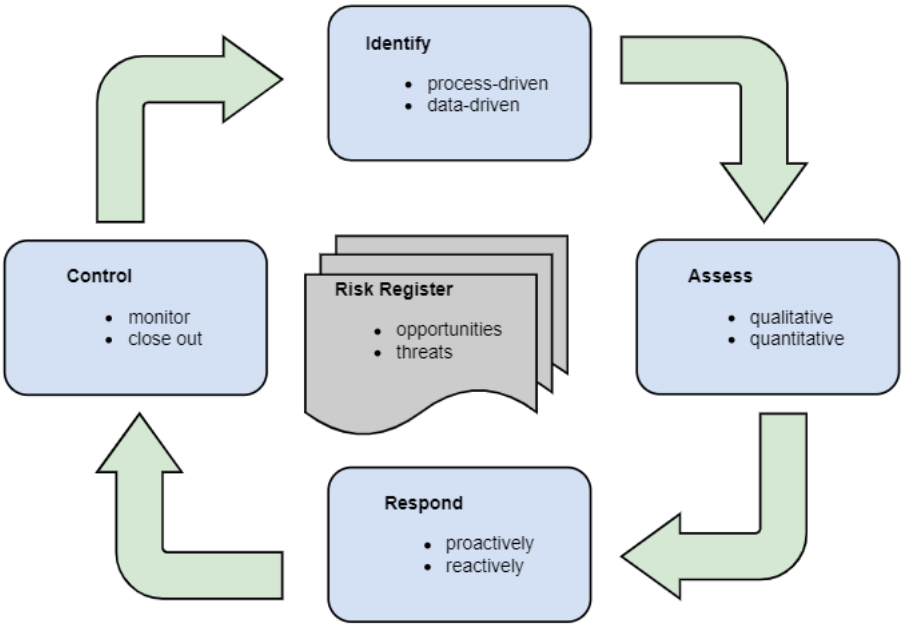

Figure 3: Risk management cycle (Winch & Maytorena, 2010)

Although it is assumed by Savage (1971) that personal probability of decision-makers results in usable data, decision-makers tend to not communicate why they chose certain probabilities (1971, pp. 794-800). In other words, with respect to threats and possibilities (often) the right knowledge and expertise are available, but because of a lack of communication not accessible for all people concerned.

2.4. Time and cost overrun

Exceeding the initial time and cost budget of construction projects is a major risk and one which is increasing more often in construction projects (Ramanathan, 2012). In the article of Ramanathan delay factors for construction projects are classified into groups on the basis of 41 studies. In the end, 113 factors for delays resulted in eighteen different categories that can be distinguished as potential cost and/or time overruns. In Table 5 for each of the categories the interpreted definition is given based on the 113 examples given by Ramanathan (2012, pp. 51-53). The results derived from the interviews and data analysis will be connected to the regarding categories, such that it is insightful what kind of (potential) time and cost overrun factors influence the initial cost price of projects the most within the policy and project implementation of SPIE (Part I and Part II, respectively chapters 4 and 5).

Table 5: Categories of time and cost overruns

Category	Explanation / Definition
1. Financial	Rapidity of payment, financial situation of contractor
2. Project	Necessary variations of work, kind of project
3. Project Attributes	Relevance and recency of used technology

4.	Owner / Client	Realness of requirements, rapidity of giving approvals and making decisions, readiness of project site
5.	Contractor	Capability of management, capacity of personnel, realisation of planning and way of constructing
6.	Consultant	Quality and rapidity of consultation to contractor
7.	Design	Applicability of design, conformity of design with reality, on time finish of design
8.	Coordination	Information flow within project team / company and within the relation client - contractor
9.	Material	Quality and quantity of used materials, price and delivery time of materials
10.	Plant / Equipments	Availability and quality equipments needed during implementation
11.	Labour / Manpower	Capability and availability of manpower
12.	Environment	Weather conditions, available utilities at site
13.	Contract	Evidence of contract
14.	Contractual Relationships	Relation with client, willingness of parties
15.	External	Problems with direct surroundings of site, unforeseen site conditions, kickbacks and/or fraud
16.	Changes	Conditions on site and mapping of conditions on site, impossibilities that occur during implementation on site
17.	Scheduling & Controlling	Capability and availability of planner and management, estimation of time and resources, waiting times for deliveries and approvals
18.	Government relations	Obtaining permits, leading building codes

2.5. Dispersed projects

Because of specialized knowledge, project teams get more and more dispersed. Geographical, but also time lead to more dispersed projects. Not only different buildings, but also a floor within one building dividing the project team results in dispersed projects (Hoegl, Muethel, & Gemuenden, pp. 483-485). To succeed in projects it is of importance that teamwork quality is guaranteed, certainly in dispersed projects, which increase the complexity of working together. Hoegl & Gemuenden (2001, p. 447) constructed a Teamwork Quality model consisting of six variables, defining behaviours that occur at all highly collaborative teams (Table 6).

Table 6: Teamwork Qualities (Hoegl, Muethel, & Gemuenden, pp. 488-491)

Variable		Explanation
1.	Communication	Openly communicate relevant information
2.	Coordination	Coordinate (own) activities
3.	Balance of member contributions	Ensure that all members can contribute their knowledge to their full potential
4.	Mutual support	Support each other in team discussion and individual task work
5.	Effort	Establish and maintain work norms of high effort
6.	Cohesion	Foster and adequate level of team cohesion such that the group can be maintained

By the use of dispersed project teams, shared leadership of team members can't hardly be evaded since the geographical and or time separation leads to time delays if team members can't have some

leadership at all. However, a formal hierarchical project manager (2010, pp. 491-492) can be very important in facilitating and supporting this shared leadership within the project team.

To let projects, at which shared leadership is applicable, run smoothly the facilitation and support of hierarchical project manager should consist authority in the participative decision-making process. Besides, when conflicts occur or project goals are threatened to be achieved a hierarchical project leader should give attendance to overcome the (potential) problems (2001, pp. 491-492).

2.6. Contract types

In the base, tendering has three major principles, which are transparency, objectivity and non-discrimination. However, most contract types nowadays are more complex than those three principles alone. Because the contract types UAV-GC and BVP are mentioned during the interviews, and not commonly known, they both are short explained in this section.

UAV-GC

The contract type UAV-GC ('Uniforme Administratieve Voorwaarden voor Geïntegreerde Contractvormen' in Dutch) is an integrated form of contracting. Within the frame of UAV-GC there can be distinguished four roles (Projectburo B.V., 2015):

1. Initiative
2. Design
3. Implementation
4. Multi-year maintenance

The first role, initiative, belongs to the client. It is the responsibility of the client to have a voice in shaping the project from start up to manage and/or exploitation phase. UAV-GC offers the possibility to negotiate about responsibilities and involvement between client and contractor.

BVP

Best Value Procurement (BVP) is an approach to tender at which is strived for the contractor offering the most value for the best price (Rijkswaterstaat), (Van de Rijt). In this way contractors are offered the opportunity to show their expertise completely. For the client this can lead to innovative solutions and for the contractor for a favourable price. The series of four phases (see below) that can be distinguished during BVP offers the opportunity to obtain a structured process with intermediate communication/evaluation appointments between client and (potential) contractor(s).

1. Preparation
2. Assessment
3. Concretisation
4. Implementation

3. Methodology

During the research three important phases can be distinguished. The first two of them, interviews (Part I, section 3.1) and analysis of financial data (Part II, section 3.2), have taken a period of a few weeks. The third one, reflection of the results with the management team (Part III, section 3.3) is conducted within one session. For each of the three phases the methodology is elaborated in this chapter. Certainly with respect to part I and part II it can be said that those are substantiated and relying on the theoretical framework.

3.1. Part I: Semi-structured interviews with project managers

The methodology of the interviews conducted with project managers can be divided into two components. At first, the collection of data is reported. In second, it is explained how the collected data will be analysed and processed.

Data collection

During this thesis qualitative research plays an important role in the form of interviews. However, taking interviews as part of a research study requires some fundamental challenges to prevent mistrust in biased or selective presentation of results (Bleich & Pekkanen, 2013). These challenges are formulated as the following:

- Representativeness of sample
- Type and quality of information obtained
- Accuracy of reporting

Representativeness of sample

The interviewees are all of the same category, namely project managers of the concerning company. Since there is no distinguish in categories of interviewees it is good to be aware of this 'snowball' technique (Bleich & Pekkanen, pp. 90-91), which contains that you limit the qualitative research to a one-sided group. When you are aware of this as a researcher you it is easier to discuss bias and tackle potential biases by premediated strategies (2013, p. 91). Besides 'snowball' sampling, a key element in the representativeness of interviewees is to point out the moment of saturation (2013, p. 91), which is basically the moment when you do not gather new information from interviewees with respect to those you already interviewed. Because the group of interviewees is from a quite one-sided category, this not necessarily means that you should stop interviewing after perceiving saturation, but to mention this a point of discussion when all interviews are conducted.

Type and quality of information obtained

Of course the type and quality of an interview itself is of importance. But one of the fundamental challenges, which is often forgotten, is to report the nature of the interview in the processing phase. Although, it seems obvious to structure the characteristics of the interviews for yourself it is often reported. To obtain a more confident and reliable result it is fundamental to report the characteristics of the interviews (2013, pp. 88-89, 91-92):

- The way the interview is processed;

    - By taking (reproducible) notes (Van Tulder, p. 207);
    - By recording (audio or video);
    - Post-event note-taking (as soon as possible) (Van Tulder, p. 208).
- Structure of the interview;
    - Structured;
    - Semi-structured;
    - Unstructured.
- Length of the interviews.

Conducting interviews often results in occurrence of recognizable patterns/problems. Van Tulder (2012, pp. 202-203) listed a number of problems and corresponding reactions that are of relevance in most interviews:

Table 7: Potential problems and reactions in conducting interviews (Van Tulder, p. 203)

Problem	Reaction
Respondent is:	
Not telling the truth	Be patient, include control questions.
Talking too much	Not intervene abruptly, smoothly go back to the original issues.
Questioning your legitimacy	Refer to contact persons, promise secrecy.
Asking you opinion	Don't be afraid, but do not be too blunt.
Giving answer to later questions	Let happen, keep control over structure.
Not answering question(s)	In case of priority questions, keep rephrasing until you get an answer.
Taking charge of interview	Regain initiative by asking direct questions.
Not very talkative	Figure out what the reason is for silence, react on reasons.
Hostile	Show understanding, if needed proceed interview at another time.

Although there can occur some problems in conducting interviews, it is possible to react on these problems. Besides, interviews offer the possibility to obtain high detailed answers. Even though it might be harder to obtain significant findings in (a limited set of) interviews, as compared to e.g. data analysis. Taking into account the potential problems and limitations of interviews, they can eventually provide founded conclusions/recommendations based on experience and high detail.

Accuracy of reporting

Considering the most optimal scenario, it is an idealization to transcribe every word of every interview conducted (2013, pp. 92-93), such that all interested people can relate results in a report to the interviews conducted. However, due factors as money and time it is (almost) impossible to achieve this idealization. Besides there are several arguments for not publishing a fully detailed transcript in public (2013, p. 93) and to the interviewee (Van Tulder, p. 209). Even without a fully detailed transcript it is possible to gain insight in the accuracy of reported interview data. It is not hard to imagine that answers of interviewees more or less match with each other. To give a particular consensus more reliability it is more powerful to state that X% of the interviewees agreed on point Z, instead of reporting 'a majority agreed'. Therefore, it is of importance to systematically structure and code conducted interviews as described in the section 'Type and quality of information obtained'.

With regard to quoting interviewees it is more reliable to substantiate 'eye-catching' quotes, rather than just throw them in your report as attending and good-looking results. Substantiating these quotes by the intensity and representativeness makes the report of the interviews more reliable. When you achieve a situation at which your "sample frame is sound, if saturation is reached, and if all respondents answer in same way" it can be stated that the results are quite certain. It needs to be remarked that you need to strive for a particular situation, but that it is more or less an idealization rather than a realistic goal.

Data analysis

On the basis of the fundamental challenges of Bleich & Pekkanen (2013) a template for interview methods is created to give insight in general principles of conducted interviews to enhance the reliability and confidence of the qualitative research (appendix B.1. Template processing interviews). During the first week of the research, appointments have been made with almost all project managers of the division 'Smart City – Bruggen, Sluizen & Gemalen'. Including manager projects and supervisor of the research, Jaap Bongers, twelve project managers covered by him are interviewed. As a result of not giving response the total amount of fourteen project managers is not reached.

As a final preparation on the interviews in the first week there is been spoken with staff from 'As. 1', responsible for the tender phase and therefore at the basis of activities of project managers. On forehand all interviewees are informed via e-mail, containing a short explanation on the interviews (in Dutch, appendix B.2. Explanation on interviews). It is a conscious choice to only give a short introduction on the interviews, because interviewees should have enough former knowledge answering the questions. Besides, it takes less time only reading one page instead of three pages with questions.

As recommended by Bleich and Pekkanen (2013, pp. 98-102) appendix B.3. Properties of interviews is added to make insightful who is interviewed. The table in the appendix contains practical information. As can be seen, there is made distinguish between the more or less 'conversations' with staff from 'As. 1' and the project managers from 'As. 2'. For all interviews with 'As. 2' it can be said that notes are taken during interview using the template of appendix B.1. Template processing interviews. In addition, some interviews are also recorded by audio. On behalf of one interview (four days), the transcript is consists a summary written right after or within one day after the interview.

The summary of each interview is (anonymised) added in appendix B.4. . On the basis of these summaries three lists are drawn up:

- (Financial) excellent projects – Three properties why;
- (Financial) disappointing projects – Three properties why;
- General improvements – Properties not specified on one particular project but on policy and/or projects in general.

Subsequent, each property (most of the time a short sentence) is translated into one or more factors (C.1. Overview of factors covering all) (one or two words) to get overlapping properties insightful. For example, during one "create a 'we'-feeling was mentioned. This property was translated

to the factor 'team structure', just as the property mentioned by another interviewee to have "permanent teams per client".

Finally, per excellent/disappointing project and for general improvements per interviewee the properties in combination with underlying factors are translated to a set of categories for time and cost overruns in construction projects according to the research of Ramanathan (2012), elaborated in section 2.4.

Formulating propositions

Using the mentions and categorisation of those mentions, it is possible to formulate some propositions about potential recommendations and point of interest within projects of SPIE. As described in section the propositions can eventually be used to set up some variables which can be tested statistically.

3.2. Part II: Quantitative data analysis of financial data

The methodology of the quantitative data analysis of financial data can be divided into two components. At first, the collection of data is reported. In second, it is explained how the collected data will be analysed and processed.

Data collection

Fundamental for insertion of experimental analysis into research is the availability of required data. The (dis)advantage of using data is the restriction that "only what gets coded gets noticed" (Smalheiser, p. 48), which can be contradictory. Measuring according to the most simple and time efficient way might be the best if it is sufficient for you own purpose. However, the paradoxical purpose of (your) research is also to provide information/data for future purposes (2017, p. 48). In practice, this means you can just consider the available data as the truth, or you take time improving/elaborating the data.

Based on a proposition during research, variables can be drawn up. After transmission from proposition to variable it can be tested whether the proposition is true or not. To conduct a test, the type of testing should be determined. There can be distinguished four types of (statistical) tests, choosing a particular test depends on the independent and dependent factors of a dataset.

Table 8: Different types of tests (Dr. Prüst, 2009)

Type of test	Independent factor	Dependent factor	Explanation/example
T-test	Nominal	Interval or ratio	Significant differences in mean between two groups.
ANOVA	Nominal	Interval or ratio	Significant differences of mean of at least one group in a set of more than two groups.
Correlation	Interval or ratio	Interval or ratio	Significant relation between two variables/factors.

Chi-square test (X^2)	Nominal	Nominal	Significant deviations between expected and observed factors.

Since the data analysis of this research will be more of a comparison between different types/values of a particular factor, the independent factor can be estimated as nominal (type of client, project, project manager, etc.).

ANOVA

Analysis of variance (ANOVA) is statistical test method which maps variability *across* groups versus variability *within* groups. If the variability across groups is much greater than the variability within groups, then it can be concluded that at least one of the groups has a mean that is significantly different from the others (Smalheiser, ANOVA, 2017). Since the ANOVA test is a parametric test there are some assumptions about the distributions used for several groups:

- Each group is sampled from a normal distribution;
- Within each group the datapoints are independent of others, randomly sampled, and follow the same underlying population distribution;
- The variance of all groups is similar.

In addition to the assumptions in an ANOVA test, it is also useful to mention that it is unwise to use ANOVA if there are groups with less than five datapoints. In general a minimum of twenty datapoints per group is recommended.

An ANOVA test can only indicate that there is at least one group significantly different, but it does not indicate which groups are different. Therefore, the second step after an ANOVA test is to investigate pairwise which groups are different from each other. It is obvious to use a t-test to conduct a pairwise investigation of significant differences. Depending on the chosen interval of confidence (P=0,05 or P=0,01) it can be stated whether there are significant differences between the mean values of groups or not with regarding certainty.

One Way ANOVA

As already stated in the introduction of this section, the data analysis focuses on single factors (type of client, project, project manager, etc.) to see what happens if the variable factor is alternated. This type of analysis only focuses on one particular variable, instead of more variables at once. The variance within a group (Equation 1), variance across groups (Equation 2) and the total variance (Equation 3) describe the process of one way ANOVA (ANOVA, pp. 149-150), Table 9 up till Table 11 elaborate on the symbols used in each equation.

Equation 1: Variance within group

$$Within\ group\ variance = \frac{SS_w}{df_w}$$

Table 9: Elaboration of symbols Equation 1

Symbol	Calculation
SS	$SS_i = (x_1 - m_i)^2 + (x_2 - m_i)^2 + \cdots + (x_n - m_i)^2$
SS_w	$SS_w = SS_1 + SS_2 + \cdots + SS_n$
df_w	$nk - k$

Equation 2: Variance across groups

$$Across\ group\ variance = \frac{SS_a}{df_a}$$

Table 10: Elaboration of symbols Equation 2

Symbol	Calculation
SS_a	$SS_a = (m_1 - M)^2 + (m_2 - M)^2 + \cdots + (m_k - M)^2$
df_a	$k - 1$

Equation 3: Variance of total

$$Total\ variance = \frac{SS_{tot}}{df_{tot}}$$

Table 11: Elaboration of symbols Equation 3

Symbol	Calculation
SS_{tot}	$SS_{tot} = (x_1 - M)^2 + (x_2 - M)^2 + \cdots + (m_n - M)^2$
df_a	$nk - 1$

Equation 4: Variance across groups as result of difference between total variance and variance within groups

$$\Rightarrow Accros\ group\ var. = Tot.var - Within\ group\ var.$$

T-test

Both ANOVA and T-test are parametric statistical techniques, however the T-test is used when means of two groups are compared and ANOVA when means of more than two groups are compared (Surbhi, 2016). For some variables that are analysed the data only offers two groups, for these groups the T-test is used. Besides, when ANOVA indicates that there is a significant difference of means between groups, the second step is to conduct a pairwise T-test. Conducting T-test for all possible pairs indicates by what groups the significant difference is caused. The T-value can be calculated by using Equation 5 (explanation of calculation at Table 12).

Equation 5: Formula for T-test (Trochim, 2006)

$$t = \frac{\overline{X_1} - \overline{X_2}}{SE(\overline{X_1} - \overline{X_2})}$$

Table 12: Elaboration of symbols Equation 5

Symbol	Calculation
$\overline{X_1} - \overline{X_2}$	Difference of means of the two groups
$SE(\overline{X_1} - \overline{X_2})$	Standard error of the difference between means: $\sqrt{\frac{var_1}{n_1} + \frac{var_2}{n_2}}$

F-test

When ANOVA is used the variance of groups is already taken into account. However, for the variables with only two, so for which only a T-test is conducted, the variance of the means is not

evaluated. To indicate whether the variances between two groups are significant different a F-test is used (Equation 6 and Table 13) in addition to a T-test resulting in a non-significant relation.

Equation 6: Formula for F-test (BYJU's)

$$F = \frac{{S_1}^2}{{S_2}^2}$$

Table 13: Elaboration of symbols Equation 6

Symbol	Calculation
S^2	Sample variance: $\frac{\sum(x-\bar{x})^2}{n-1}$

Correction for multiple testing

Whenever multiple statistical tests are conducted corrections are necessity (Smalheiser, p. 153). The correction method used during the analysis is the Bonferroni Correction. This correction method is depending on the number of T-tests that are done after the ANOVA resulted in significant result. If the confidence interval of each separate test is set on 95% (0,05) the Bonferroni Correction states that a single test is significant if $P = \frac{0{,}05}{N}$, at which *N* is the number of T-tests conducted (Smalheiser, p. 154). When there are e.g. ten T-tests conducted, the result of one single test can be considered as significant if $P \leq \frac{0{,}05}{10} = 0{,}005$.

Data dredging

To overcome the misuse and wrong interpretation of statistical analysis, it is tried to match propositions as good as possible to available variables which can be analysed. However, testing several propositions increases the probability of finding significant results by due to coincidence (Streiner, 2015). Although it is tried to keep the data as relevant as possible, limit multiplicity and correct for multiplicity it should be kept in mind that results can still rely on coincidence. Therefore, "data dredging" or "P-hacking", which is misuse/wrong interpretation of significant results, should be considered for the results deduced from the experimental analysis

Data analysis

The interviews conducted with all project managers delivered a lot of information. The properties in combination with the linked categories (chapter 4) can (partly) be reformulated as propositions about causations of cost price overruns and potential points of improvement. Subsequent, the propositions can be translated into one or several variables, which clears the way to conduct statistical analysis of the available data (Figure 4).

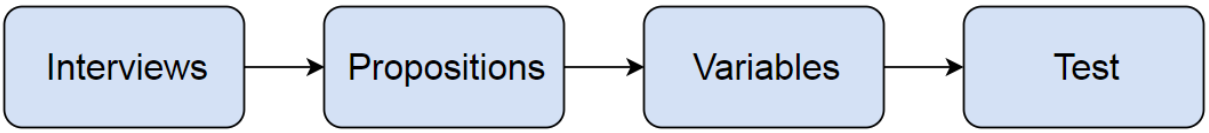

Figure 4: From interview to test

Availability of information

The purpose(s) of the analysis disregarded, it is of importance to know what the available data can and can't tell you. The financial system AX of SPIE only contains 'financial numbers' based on the most recent PPO of a particular project. Therefore, the propositions distracted from the observational study can only be translated to a limited set of variables. For every project information is available with several possibilities for variation on each project.

Restrictions and possibilities of data

As already mentioned the available data limits the amount of variables that can be translated from the reported propositions. However, the data also offer some possibilities wider than the distracted variables only. The analysis of data will be done by using the ANOVA method for variables with more than two possibilities. For the variables with only two possibilities a T-test and F-test will be used (section 3.2 - Data collection).

The base point for all variance-analysis is the net margin. Grouping of the net margin per group of a set of variables can best be illustrated by an example. Table 15 is a cutout of the table used for the ANOVA on type of client. The numbers listed beneath each other are net margin based on the last PPO of a project[1].

Table 14: Available information

Information available	Possibilities
Type of work	Contracted work Project on directory Multi-year maintenance (Regular) Maintenance Corrective maintenance Preventive maintenance Malfunction Remaining
Business Unit	Sliedrecht Wijhe
Project manager	Anonymised code (23 in total, from which 11 with 5 or more datapoints)
Total incomes	[€]
Total costs	[€]
Net margin	[€]
Production up to know	[€]
Client	Name
Type of client	Rijkswaterstaat Province Municipality Waterschap Contractor

[1] The list of projects contains those already rounded, but also projects which are still in progress. The net margin of monthly PPO-meetings is therefore expectation for those projects that are still in progress. The percentage of work per projects is known.

Profession	Electricity Electrical maintenance Engineering and Installations – Automation & software Mechanical maintenance Multi-technical maintenance

Table 15: Cutout of analysis for 'Type of client'

Type of client				
Rijkswaterstaat	Province	Municapality	Contractor	Waterschap
-16,03	6,17	6,08	6,06	11,54
0,89	5,69	6,08	4,95	4,15
1,78	2,24	6,91	3,04	6,04
2,05	5,65	6,17	4,49	4,2
…	…	…	…	…

Assumptions for self-created variables

For the variables 'Type of work' and 'Type of client' it has to be noted that those two variables are self-created variables derived from the data available.

Type of work

For 'Type of work' two already available columns are taken into account, the project name which has the type of work most of the time adapted in the name, and the column which distinguishes contracted work and work on directory. However the column indicating 'Contracted' or 'On directory' is not filled in properly and therefore always on 'Contracted'. Since the project name betrays a more detailed type of work these are manually inserted. The types of work derived from the project name are project on directory, multi-year maintenance, (regular) maintenance, corrective maintenance, preventive maintenance, malfunction and remaining. For all other projects, without one of these types in the name it is assumed that it is contracted work.

Type of client

The variable 'Type of client' is derived from the already available column 'Client'. However, comparing types of clients requires more general names since a company is working with a lot of profit and non-profit organisations together, which are in itself 'loose' data points. Bundling all provinces, contractors, etc. provides a better overview of differences and similarities between types of client.

Concretisation of analysis

To overcome the gap between qualitative and highly detailed information that can be derived from the interviews (section 3.1) and statistical analysis on 'raw' numbers of net margins the first part of the analysis of financial data consists descriptive analysis only. With the most important conclusions of the interviews and the availability and possibilities offered by the data in mind, some variables are combined set against the net margin (section 5.1). For example, for all projects the type of client is plotted against the net margin. For each project is indicated within which interval of the variable 'Project value' this one can be scheduled. This gives more insight in the nature of net margins achieved on projects for a particular type of client.

Because of practical and time depending reasons not all pairwise variables are observed. Only those combinations (five in total) which considered possibly relevant are reported. In addition to the

descriptive analysis of paired variables a Shapiro-Wilk test is conducted to check to which extent the dataset of net margins matches with a normal distribution.

Propositions to statistical analysis

The propositions are known as result of the interviews, besides the content, restrictions and possibilities offered by the data are mapped. This combination leads to a set of seven variables that are analysed using a parametric statistical technique. Depending on the number of groups per variable ANOVA or a T-test is used (appendix F.1. Conducted tests). Because of the unreliability of test with less than five datapoints (section 3.2 - ANOVA) all groups of a variable with less than five datapoints are not considered at all during the analysis. If an ANOVA results in a value indicating a significant difference, the ANOVA is done twice. During the analysis only groups with more than twenty datapoints are considered. When the result of this analysis opposes the significant difference of the first test, it will be assumed that the probability of coincidence is to high due to a lack of datapoints.

In the end, significant differences are whether or not demonstrated. In combination with the propositions presumptions and significant differences can be drawn up. The full schedule of analysing variables is given in Figure 22 (appendix E Explanation data analysis).

3.3. Part III: Reflection of management team

A session with the management team (MT) of BS&G is planned nearing the end of the research period. The presented results and used methods led to a discussion validating the research, which is reported in chapter 6 ‘Part III: Reflection of management team’. This chapter forms an important basis for the discussion of the eventual result of the research. As already stated, the session with the management team can be seen as a validation of the research. In addition, also the limitations, restrictions and assumptions made during the research played a particular role in the discussion. Therefore, the session also contributes to the verification of this research.

The input given from the management team will form an important input for the eventual conclusion and discussion of the entire thesis (chapter 7 and 8).

4. Results part I: Semi-structured interviews with project managers

The results of the observational study of the research are presented in this chapter. At first the categorisation of interview results is reported for every particular project mentioned during the interviews, and for general points of improvement suggested by each interviewee. Finally, the interview results are interpreted into conclusions/presumptions by keeping in mind the number of mentions per category (2.4 Time and cost overrun) and the underlying mention during the interview.

4.1. Categorisation of interview results

During the interviews is focussed on three main aspects, respectively financial excellent projects, financial disappointing projects and general improvements proposed by the interviewees. As described in section 3.1 for each of the three parts the mentions of each interviewee are reported and translated into categories of time and cost overrun (section 2.4) using properties which label each mention. Because of confidential reasons all results are anonymised. In appendix 'Processing mentions into categories' Table 21, Table 22 and Table 23 provide insight in the mentioned properties and their translation into categories.

Excellent projects

The properties mentioned for financial excellent projects are categorised (Figure 5). Since the categories are indicating time and cost *overruns* the other way around counts for excellent projects, when the same categories are taken into account. Within the top five the categories 'Contractor' (SPIE), 'Owner / Client' and 'Contractual relationship' might indicate that the combination of willingness of the client, capability of the contractor and the communication between these two can be a key factor in the realisation of a successful project, which tend to lead to financial successful results in the end.

Disappointing projects

Based on the properties mentioned for disappointing projects it seems that project managers tend to search the problem their own organisation (the contractor), particularly with respect to design, which encounters as well the pre-calculation phase as engineering during the project. Also the ability of scheduling and controlling is multiple times pointed out as a category resulting in time and/or cost overrun (Figure 6).

General improvements

After zooming in into as well excellent as disappointing projects, the interviewees were asked how the alignment on the initial cost price can be controlled in a more stable way. The categories mentioned most are 'Scheduling & Controlling' and 'Coordination' (Figure 7), which can be stated as quite remarkable because this seems to suggest that an important role is there for project managers themselves to better steer on the project team and the management team steering on the organisation overarching the projects.

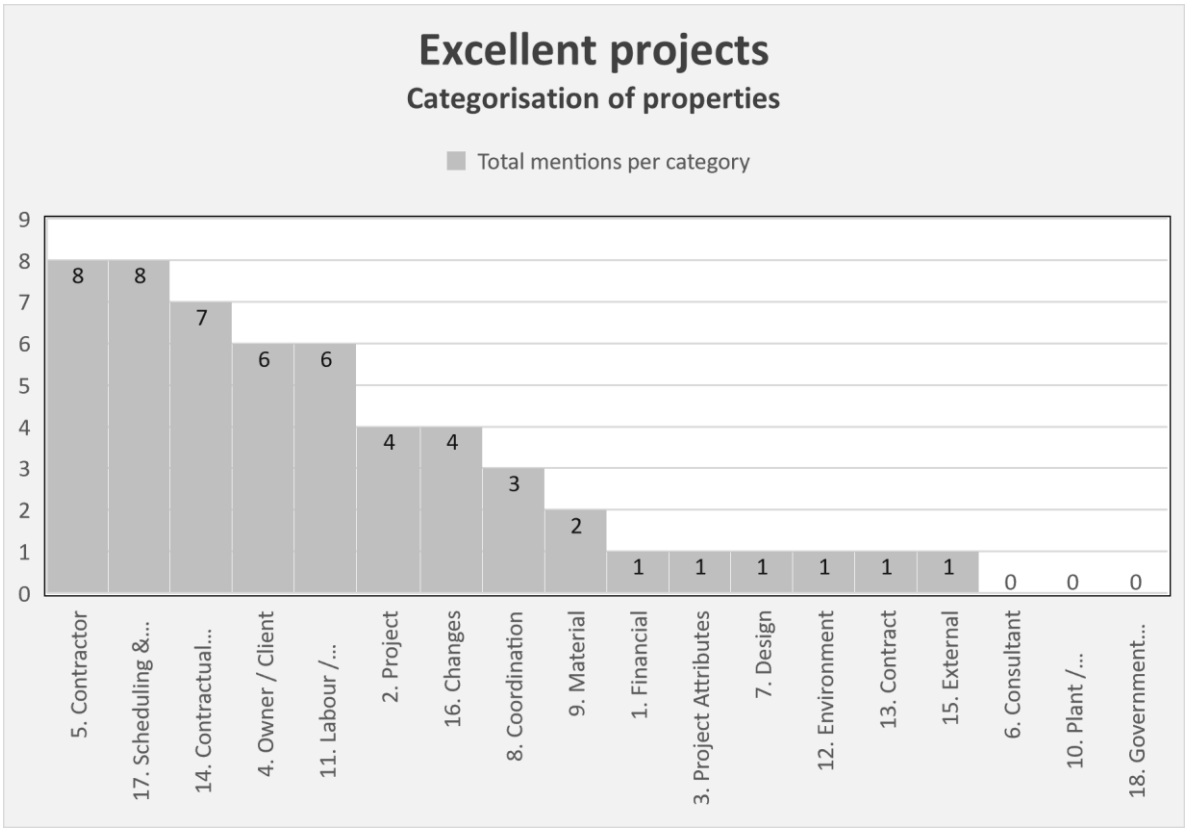

Figure 5: Ranked categories for (overcoming) time and cost overruns for excellent projects

Figure 6: Ranked categories for time and cost overrun for disappointing projects

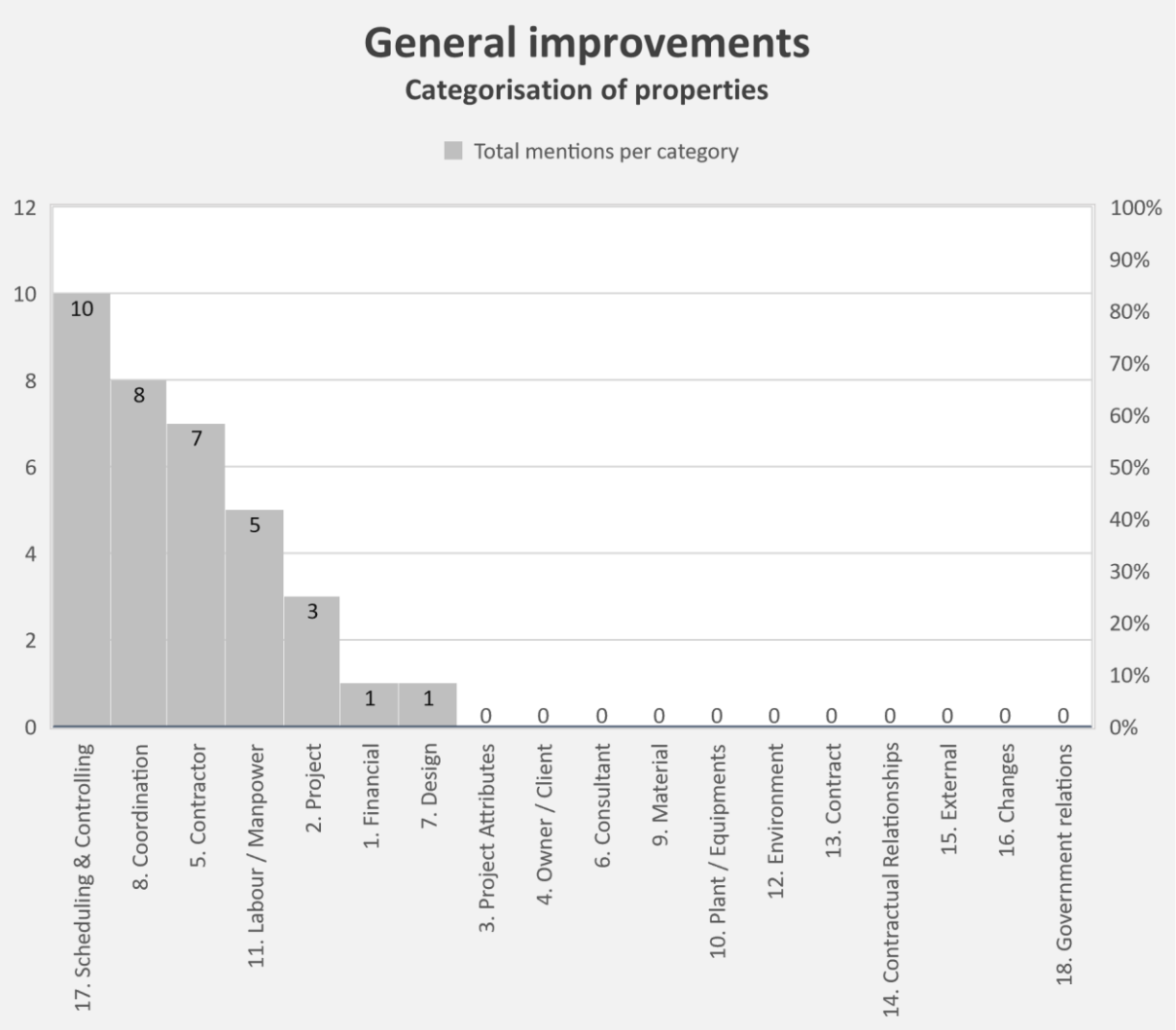

Figure 7: Ranked categories for time and cost overrun for general improvements

4.2. Interpretation of category ranks

As can be seen in Table 16 the top five all three groups have clear similarities. The variation of categories is limited, since all top fives can be formed with eight out of eighteen categories of time and cost overrun. Category 5. 'Contractor', which encounters the organisation as a whole, without detailed aspects, is mentioned a lot. The categories giving more detail to this factor seem to be 'Scheduling & Controlling' and (timely) availability of manpower (11. Labour/Manpower) as particular causes.

Table 16: Top 5 of mentioned categories for each subject

Excellent projects	Disappointing projects	General improvements
5. Contractor	5. Contractor	17. Scheduling & Controlling
17. Scheduling & Controlling	7. Design	8. Coordination
14. Contractual relationships	17. Scheduling & Controlling	5. Contractor
4. Owner/Client	11. Labour/Manpower	11. Labour/Manpower
11. Labour/Manpower	14. Contractual relationships	2. Project

From the interviews and the categorisation of properties mentioned some propositions/presumptions can be drawn up. Some of them form a basis for the data analysis of the financial system.

P1. The intended project team is not involved during the tender phase due to a lack of capacity and availability. This leads to shortcomings in the cost price calculation and stiff transmission from tender team to project team;
P2. To overcome time delays during the engineering phase, decision-making should be left to the technical management, such that engineers only have to design and construct;
P3. Investing in more staff will eventually result in better alignment of the cost price, because it is easier drawing up a project team and less hired staff is needed;
P4. The relation with a client is essential in successfully completing projects, transparency and involvement of the client in decision-making processes seem to be key in maintaining a good relation.

5. Results part II: Quantitative data analysis of financial data

In section 3.2 is already described that there can be distinguished seven variables within the set of financial data. One of them can be defined as a time variable, the remaining six as project properties. For some of these properties the interviews raised the suspicion that some of these variables, more or less in combination with each other, influence the net margin of projects. In section 5.1 via descriptive analysis is indicated whether the suspicion of cohesion between particular variables can be enhanced or not. Secondly, for each variable an statistical test is conducted in relation to the net margin (section 5.2).

5.1. Descriptive analysis

From the financial data six 'project property' variables can be derived (Table 17). For some of these variables it seems, based on the interviews and research question, interesting to investigate potential cohesion/relations between particular variables.

Table 17: Project related variables

No.	Property
1	Type of client
2	Project manager
3	Project value
4	Profession
5	Type of work
6	Business unit

Therefore, five pairs are set against the net margin. The variables 'Type of client', 'Project manager', 'Type of work' and 'Business unit' are set against the net margin. For each datapoint it is indicated within which interval of project value it can be divided. Finally, all types of work are set against the net margin, at which the responsible business unit is indicated for each data point. In appendix 'D.2. Indication of relation between variables' Figure 17 up till Figure 21 visualise all the pairs against the net margin. For each pair the following can be concluded:

Type of client – Project value (Figure 8)

Projects for Rijkswaterstaat have relatively high financial values. Although these high valued projects can also be distinguished at 'Provinces', mainly the high valued projects (> €1 million) score quite stable when the client Rijkswaterstaat. For provinces the range seems to more unstable, which can be quite negative because of the outliers beneath the limit of 0% net margin.

Since the order size of big projects for Rijkswaterstaat and provinces seems to be in the same range, it might be the case that steering on the cost price for projects of provinces is harder.

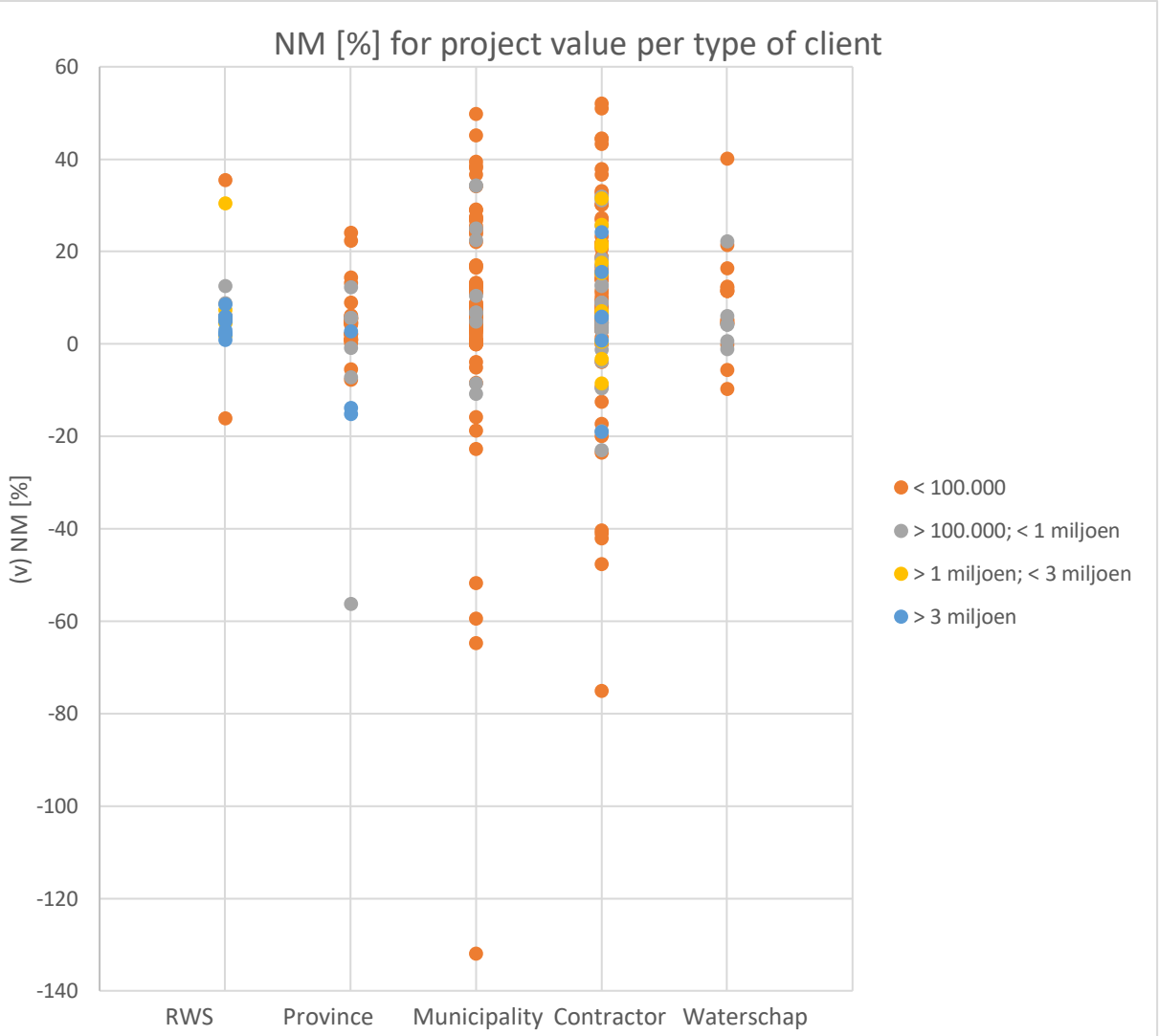

Figure 8: Net margin for project value per type of client

Business unit – Project value

As can be seen in Figure 18 (appendix E.2) the variation per project value clearly indicates the suppositions resulted from the interviews that, in general, at Wijhe more 'small' projects are conducted, and the high valued projects are managed from Sliedrecht. Some exceptions disregarded.

Project manager – Project value

For all project managers the net margin per project is reported (Figure 19), the colour indicates the interval of financial value. As can be seen when a lot of projects are conducted, the financial value is often in the lowest range and the variance quite high. When number of projects is decreasing, the financial value is increasing and it seems that the course of net margins is becoming more stable when the amount of projects is lower.

Type of work – Project value

For the majority of the projects > €100.000 it can be said that they fall within the (although quite spacious) range of -20% and +20% net margin. Furthermore, Figure 20 confirms that corrective maintenance and preventive maintenance have in general low financial values on the contrary of multi-

year maintenance projects. Besides, in general it can be stated that the higher the financial value, the more a project is on the basis of a contract.

Type of work – Business unit

Because of the 'multi-year' aspect of multi-year maintenance the financial value is often quite high. In combination with Figure 18, indicating the difference of financial value of projects between Wijhe and Sliedrecht, for the MYM projects can be derived that the majority is conducted in Sliedrecht, which is in line with Figure 9.

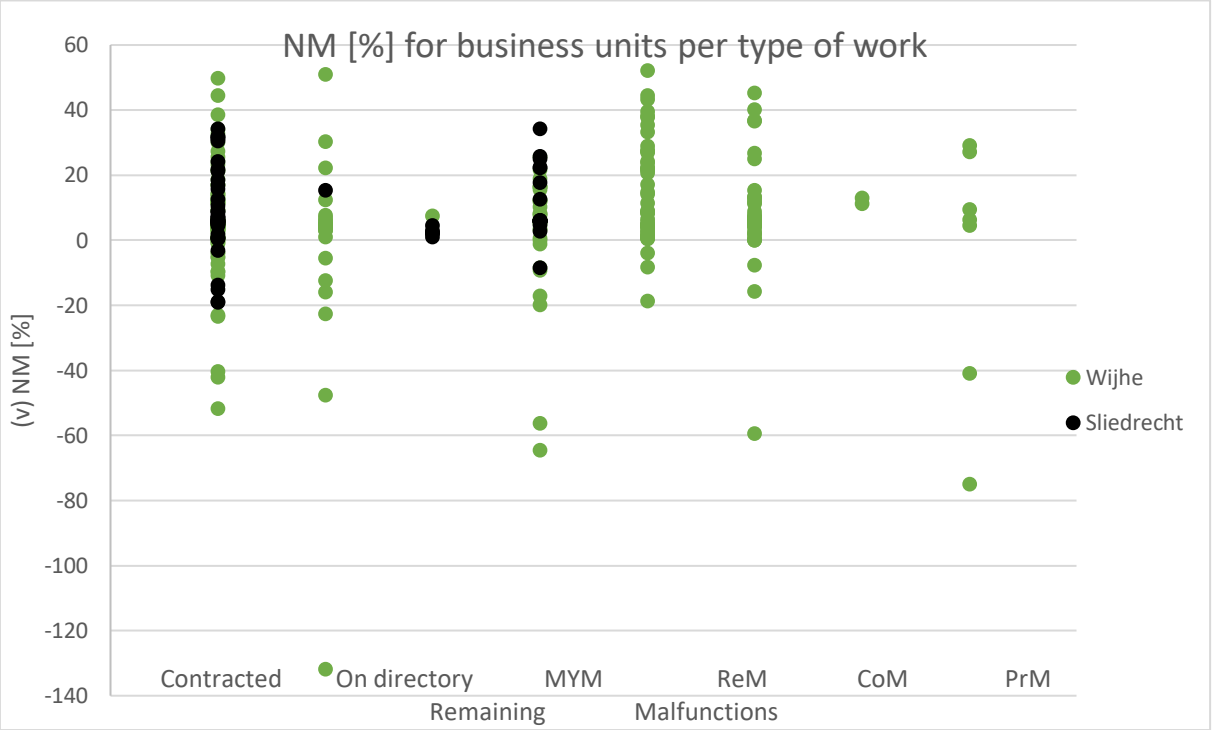

Figure 9: Net margin for business units per type of work

Normal distribution financial data

During the research the financial data is analysed using ANOVA, T-test and once a F-test. For these statistical methods it is assumed that the available dataset is normally distributed. Due to time restrictions at some time the decision had to be made to use a particular kind of method. Although, it is not tested on forehand if the dataset approaches a normal distribution.

As a verification of the statistical analysis, afterwards a Shapiro-Wilk test is conducted on the total dataset of net margins. The p-value of Table 18 indicates that the chance that the dataset is normally distributed is quite small. Besides, the P-P plot (Figure 10) also indicates that the dataset is atypical distributed in relation to a perfect normal distribution.

Table 18: Shapiro-Wilk test on financial data

W	0,799
p-value (Two-tailed)	< 0,0001
alpha	0,05

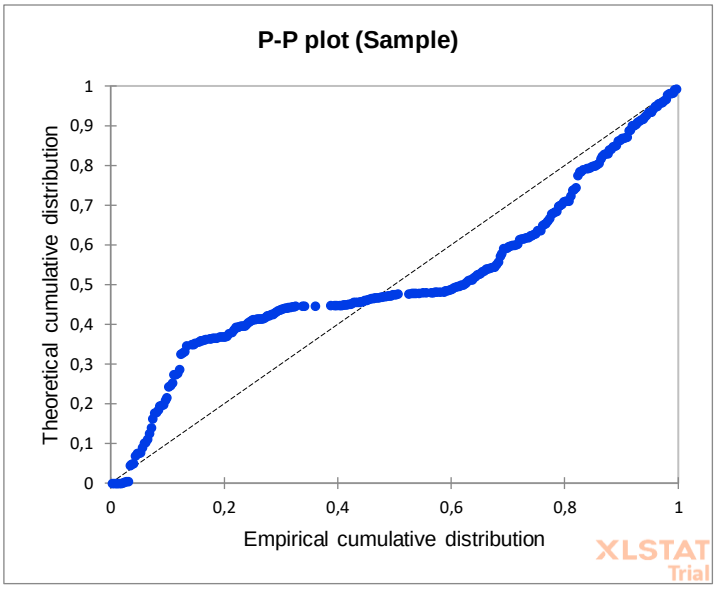

Figure 10: P-P plot of Shapiro-Wilk test on financial data set

It can be said that the choice for the strict but conservative correction method of Bonferroni (section 3.2 - Correction for multiple testing) is a well-made decision with the atypical distribution in mind.

5.2. Statistical analysis

In addition to the descriptive analysis all variables are tested using ANOVA. Besides, some variables might result in stronger substantiated propositions derived from the interviews. However, due to the nature of some propositions and restrictions of the available data not all propositions can be completely covered in variables.

H4 can be set to the variables, 'Type of client' and 'Type of work'. H1 and H2 more or less refer to the involvement and skills of the project management. However, the data does not require to vary on the extent of decision making or involvement by the management. Although not completely covering the propositions, the variable 'Project manager' is analysed.

To take the maximum out of the available data, there will be added some extra variables to analyse, which gives a more complete image of the total of projects done by SPIE, whether or not successful. The additive variables analysed are 'Prognostication of net margin', 'Project value', the concerned 'Business unit' and the 'Profession' defining a project.

The following sections summarise the results of all seven analysis conducted. Figure 22 (appendix E 'Explanation data analysis') provides detailed information about each analysis.

Prognostication of net margin

Variable	Time dependent • Project production [%]
Significant difference	Yes, $T_{prognostication} \approx -2{,}87 \leq T_{crit} \approx -1{,}59\ (CI = 99\%)$
Found between groups	Production [0 – 90%] ↔ Production [90 – 100%]
Appendix	F.2. Prognostication of net margin

Reflection

Although the statistical test pointed out that there is a significant difference between two intervals it is questionable to state that there really is a strong difference between those two groups. First of all, it can be the case that net margins alone are not suited well to do pronunciations about prognostications of the financial aspect of projects. In that case, it is possible that data dredging (section 3.2 - Data dredging) occurred. Secondly, it is possible that current projects actually have lower margins then projects conducted in the past. In that case it is not the prognostication that is necessarily of influence.

Finally, it can be the case that prognostication is a significant factor, but the reason why is of higher priority. The suspicion exists that a more psychological aspect could be the basis of this difference. Project managers, and maybe people in general, want to cover themselves as much as possible. Therefore, it could be the case that windfalls, but in particular disappointments are blurred as long as possible. When a great windfall is reported in an earlier PPO-meeting, which is nullified later, it might be the case that you, as a project manager, are kept responsible. On the other, you want limit the amount disappointments, it might be the case that disappointments are moved forward as long as possible, so you don't have to mention disappointments every single meeting with the management team.

Type of client

Variable	Project dependent • Rijkswaterstaat • Province • Municipality • Contractor • Waterschap
Significant difference	No, $F_{client} \approx 0{,}27 \leq F_{crit} \approx 2{,}40\ (CI = 95\%)$
Found between groups	N/A
Appendix	F.3. Type of client

Project manager

Variable	Project dependent • P1 up till P11
Significant difference	Yes, $F_{PM} \approx 1{,}81 \geq F_{crit} \approx 1{,}62 (CI = 90\%)$
Found between groups	P2 ↔ P4
Appendix	F.4. Project manager

Reflection

For one relation (P2 ↔ P4) the analysis showed a significant difference in performances of project managers with a confidence interval of 90%. For the remaining part, it can be presumed that project manager 4 scores overall better than his colleagues, which is substantiated by his very high average net margin and relatively low variance within his own results (Table 32, appendix F.4. Project manager).

Project value

Variable	Project dependent • < €100.000

	• > €100.000; < €1 million • > €1 million; < €3 million • > €3 million
Significant difference	No, $F_{value} \approx 0{,}11 \leq F_{crit} \approx 2{,}63\ (CI = 95\%)$
Found between groups	N/A
Appendix	F.5. Project value

Profession

Variable	Project dependent • Electricity • Electrical maintenance • Mechanical maintenance • Multi-technical maintenance
Significant difference	No, $F_{profession} \approx 0{,}04 \leq F_{crit} \approx 3{,}02\ (CI = 95\%)$
Found between groups	N/A
Appendix	F.6. Profession

Business unit

Variable	Project dependent • Sliedrecht • Wijhe
Significant difference	No, $T_{BU} \approx -0{,}96 \geq T_{crit,double} \approx -1{,}97\ (CI = 95\%)$
Found between groups	N/A
Appendix	F.7. Business unit

Type of work

Variable	Project dependent • Contracted projects • Projects on directory • Corrective maintenance • Multi-year maintenance • Preventive maintenance • Regular maintenance • Malfunctions
Significant difference	Yes, $F_{type\_work} \approx 2{,}76 \geq F_{crit} \approx 2{,}13\ (CI = 95\%)$
Found between groups	Corrective maintenance ↔ Multi-year maintenance
Appendix	F.8. Type of work

Reflection

With respect to the type of work it is demonstrated that there is a significant difference between groups. For one pair, corrective maintenance and multi-year maintenance, it is demonstrated that corrective maintenance activities score significantly better with a confidence interval of 95%.

In addition, corrective maintenance in general turned out to be the best performance type of work, although not significant. For five of the six pairs of corrective maintenance the probability of its better margins is 8% less depending on coincidence.

6. Part III: Reflection of management team

Approaching the end of the research period, the results of the interviews as well as the data analysis were presented to the management team (MT) of BS&G. This session resulted in a discussion in which the conclusions are presented found during the study, but also what the limitations and restrictions of this research are. The remarks derived from this session are presented in this chapter.

6.1. Overall remarks

To start with, the session began positively. All the members of the management team already received the presentation on forehand. First of all, this made them enthusiastic about *what* is studied. As a result of that they show interest and curiosity in the explanation of the results presented in the slides.

Doing research into process optimizations or profits requires highly structured and available data. For the time being it occurred that there are too many limitations and underlying factors influencing the results. So, the most certain conclusion from the session is that the data needs to be made more suitable for investigation by applying more standardised and detailed terms and applications.

The management could find themselves, more or less, in the results, the 'gap' between MT and personnel was not discussed. This might declare that the members of the management team are really dedicated and ambiguous in creating optimised processes and improving alignment on the cost price, but there is lack of communication about this subjects with staff.

6.2. Remarks per variable and result

Since it is reported what the input of the MT was in general during the sessions, it is of interest to know which remarks were made with respect to specific parts of the research and particular variables. The feedback given on the categorisation of the interview results is reported. Subsequent for each of the seven variables the discussion is reported.

Categorisation of interview results

During the presentation at the management team all categorisations were summarised into one histogram. To become more clear about the nature of particular mentions (positive/negative) it is chosen to divide the result into three histograms categorising the mentions of respectively 'excellent projects', 'disappointing projects' and 'general improvements' (section 4.1). However, the management team reacted between amazed and agreeing on the findings that most of the mentions are categorised into 'Scheduling & Controlling', 'Coordination' and 'Labour/Manpower'.

Prognostication of net margin

By presenting the prognostication of net margin all members clearly agreed that the result is highly depending on other factors rather than prognostication itself. Although the difference between the groups turned out to be significant, this kind of variable will be more reliable if the prognostication is done for each project separately. Initially it was obtained to analyse the projects separately, because of restrictions of available data it was only possible to prognotise by plotting projects in different phases.

Type of client

With respect to the type client, the averages and variances were presented. Although there were no significant differences to remark, the management team did not have a lot of relevant remarks. The quite low mean in combination with the high variance of projects for other contractors was received as recognisable. As a declaration for the low margins on projects for provinces a lack of knowledge at the side of the client was pointed out as a potential reason. However, they more or less expected that this should also be applicable onto projects for 'waterschappen', but the suspicion is that projects for this client score relatively high.

Project manager

Since the variable project manager regards the expertise of people and necessarily 'just' properties of projects, the explanation in which way the project managers were anonymised was an important aspect during the discussion about this variable. Because of the statistical aspect of the analysis, the project managers with less than five projects were not take into account at all. The reaction of the management team was understanding with respect to this decision, however they agreed on the fact that a particular project manager can really make a difference by some processes. Therefore, it might be interesting to re-translate the study into a qualitive research to indicate which differences there are between activities conducted by project managers.

Project value

By presenting the project values, the MT was positively surprised by the fact that the mean value of net margin for project within the interval [> €100.000; < €1 million] was quite high and the variance low. Since the high valued projects are still finished with positive net margins, although with minimum percentages, this variable made the MT agree that bet on high valued projects can only result in high profits when remaining critical on additional activities of those projects.

As an additive for further research it is suggested to also take into account the actual profits per interval, and not only the net margin as a percentage.

Profession

Because the information label 'Profession' is not reported adequate the suggestion was proposed to give this label more detail, because the interviews made the impressions that there might be a difference in the successions of mechanical and electrical related projects. On the basis of the interview results a descriptive analysis with the pair 'Profession – Type of work' against the net margin might result in findings about particular projects scoring relatively high or low.

Business unit

When the results were presented with respect to the variable 'Business unit' it was already remarked that high variation of projects conducted at each location is probably one of the main reasons for the results. All members kept undermining this statement during the discussion of this variable. The value of the variable is not deemed very high and remained unfolded during the session.

Type of work

The reaction on the variable in itself was quite positive. The fact that corrective maintenance projects seem to score significant better than others was surprisingly for the MT. Although very interested, and remaining critical, there is not found a clear explanation for this result. However, the reaction on selecting the types of work was critical since most projects are labelled as 'Contracted' because of a lack of data availability (section 3.2, part 'Restrictions and possibilities of data'). As already mentioned for the variable 'Profession' it seems advisable to better report the type work, such that further research can be more accurately and reliable.

7. Discussion

The way at which results are (proposed) to be interpreted is at first discussed. Secondly, assumptions made during the research and limitations of research methods and available data are reported, to frame the value of the results of this research.

7.1. Interpretation of results

Initially, it was proposed to conduct the research as (roughly) described in section 3.2 (Figure 11). As a result from the interviews some propositions could be derived, which can be translated into variables in their place. Subsequent (statistically) testing those variables could whether or not result in statistically substantiated results proposed by interviewees. However, due to the restrictions and uncertainties of the financial data, the interview results itself can better be interpreted as an result in itself. Although the variables used in the descriptive and statistical analysis can more or less be related to the interview results, the results will be more valid if the two analysis (interviews and financial data) are approached as separate results.

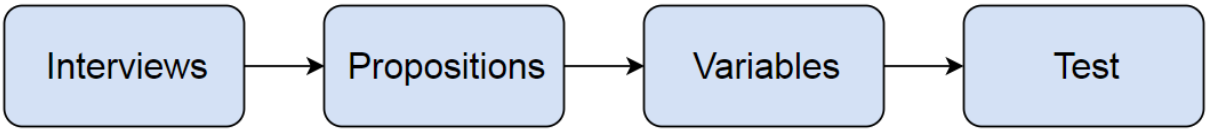

Figure 11: From interview to test (repetition of Figure 4)

For the results in general it can be said that they give an indication of project properties and processes conducted that might positively or negatively influence the cost price of projects. The conclusion of this research is based on this indications.

7.2. Assumptions

For all methods, data and processes used in research it counts that at some height assumptions have to be made, to realise a suitable research within available time and with available tools. Relevant assumptions made during the research are described in this section. First the translation of interview results to categories of time delay and cost overrun are discussed. Finally, it is taken into account in which way the progress of projects is calculated.

Properties interviews suitable for categorisation

The categories for time and cost overrun for construction projects from Ramanathan (2012) are considered as reliable. With respect to 'disappointing projects' and 'general improvements' (chapter 4 'Results part I: Semi-structured interviews with project managers') the categories are applicable, since time delay and cost overrun are at the basis of properties mentioned. However, for 'excellent projects' it is assumed that the categories can be used the other way around. The properties mentioned for excellent projects are positive, so if a particular property refers to e.g. 'Scheduling & Controlling' it is classified into that category of *overcoming* time delay and/or cost overrun.

Progress of projects

For the variable 'Prognostication of net margin' the progress of a project needs to be taken into account. Calculating the progress of a project is done according to Equation 7, which does not take

into account that the production costs in the future will transcend the total contract price agreed on forehand by client and contractor. The variable 'Prognostication of net margin' therefore depends on a non-fixed number, which substantiates again that this variable is debatable.

Equation 7: Progress of project

$$Project\ progress = \frac{prod.up\ to\ now\ [€]}{total\ contract\ price\ [€]} \times$$

7.3. Limitations

In addition to the assumptions made during the research, limitations of methods and data are also of necessity. The honesty of interviewees and the availability of data are reported in this section.

Honesty of interviewees

Van Tulder (Table 7, section 3.1 - Type and quality of information obtained) listed several problems to occur during the procession of interviews. Certainly the first one, "Respondent is not telling the truth", is a potential problem to keep in mind. As an interviewer you can't read the mind of the interviewee. Therefore, it might be the case that an interviewee gives a sort of twist to his answers, consciously or unconsciously. Besides, some interviewees tend to move too far from the scope of the research because of frustrations or passion they want to tell.

All in all, it is tried to obtain answers as reliable as possible by asking further onto answers and steer on declarations on answers. Therefore, the categorisation is considered as a quite reliable result about what project managers experience as factors (overcoming) time delays and cost overruns in projects.

Availability of data

In fact, two different sets of data can be distinguished used during the research. At first, the interviewees are a dataset and the financial data of all projects is a dataset. For both sets it can be stated that they have some limitations.

Set of interviewees

During the research is spoken with some people of the department of sales and pre-calculation. The interviews itself are limited to the division of project managers. Due to time restrictions it was not possible to speak to a wider range of people, e.g. site managers, technical managers, engineers, etc. Although the expertise and experience of project managers is proposed as sufficient with respect to management of cost price, it can be the case that some knowledge and/or experience with relevant for the subject is hidden behind other divisions.

Financial system

The descriptive and statistical analysis depend on the dataset derived from the financial system, containing financial data registered per project. Although the data is approached as complete during the analysis itself, some remarks have to be made with respect to particular variables derived from the dataset.

For the prognostication of the net margin it was proposed to analyse the prognostication per project over time. However, it turned out that it was only possible to analyse the most recent update per project. Therefore the prognostication (section 6.2 - Prognostication of net margin) literally shows independent projects with different progress, which are compared on the basis of their (proposed) net margin.

As well for the 'type of work' as 'profession' it can be said that reporting in the financial system is restricted and for now on with too few detail. Not for every project the type of work is reported consequently. The profession for each project is reported, but almost all projects are taken off as 'electricity', however on the basis of the interviews a combination of consequent and proper registered type of work and profession might lead to more reliable results with respect to different types of work.

For research purposes analysing the net margin of several project value intervals as a percentage can be quite interesting. However, for a profit organisation as SPIE also the volumes [€] per interval are interesting, which is not considered during this research, but can quite easily be applied in further research.

8. Conclusion

The question how to improve the alignment between initial and actual cost price of projects turned out to be one which cannot be answered crystal clear. However, the research delivered insights in how the cost price of projects is controlled for the time being, and what can be improved in this process. In the first section a process optimisation is proposed for the initial cost price calculation. In section 8.2 the importance of the relation with the client is reported, which was often mentioned during the interviews. At last, the project properties from the data analysis are presented. In addition, it is proposed how the analysed data can be improved to conduct more reliable analyses.

8.1. Process optimisation of initial cost price calculation

The categorisation of interview results can be traced back to the pre-calculation phase and its transmission from tender team to project team. Improving the alignment between initial and final cost price of a project requires a well-substantiated calculation during the pre-calculation phase. Therefore, not only financial value should be taken into account, but also the complexity of particular risks and/or opportunities. Based on the conversations with staff involved in tenders, the suspicion exists that their knowledge about their own skills and disabilities is sufficient. Therefore, the team responsible for the tender phase is considered as capable enough to query for required knowledge of experts by themselves (e.g. a project manager, technical manager, mechanical engineer, etc.). Often it is the case that queried staff members are not available, or it is unknown which skills particular staff member have. When queried staff is indeed available the tender team is deemed to be capable enough to decide whether or not go for a tender (Go/No Go) based on a well-considered list of risks and opportunities.

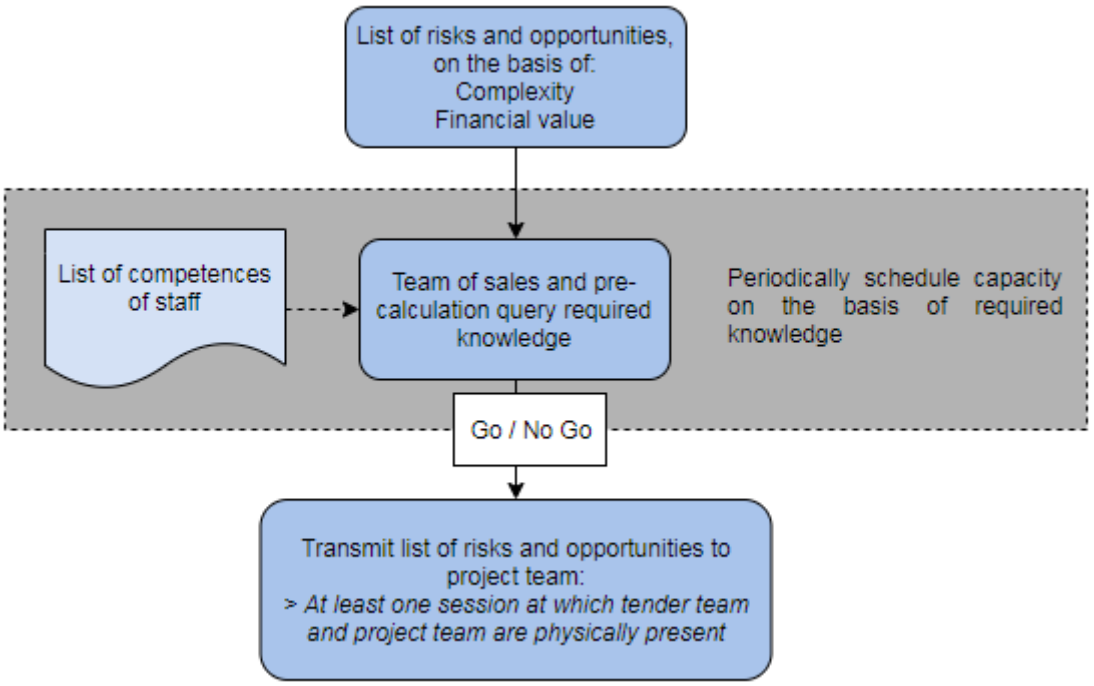

Figure 12: Optimisation of initial cost price calculation and transmission

Secondly, when it is decided to go for a tender and eventually it is won, poor communication between tender team and project team is often mentioned as a problem during transmission. Certainly when staff from the intended project team can be queried during the pre-calculation phase this can already be overcome for a large part. In addition, it seems recommended to schedule at least one session at which the tender team and project team are both physically present. Based on complexity and/or financial value it can be decided to schedule more sessions. The optimisation of the pre-calculation phase and transmission described can be summarised in a flowchart (Figure 12).

8.2. Relation with client

In addition to the process optimisation recommended on the basis of the interviews, the aspect 'relation with client' was often mentioned as positive in excellent projects as well as negative in disappointing projects. This suggests that the relation with a client can influence the cost price due to unforeseen time delays because of decision making or cost overruns because of poor agreements about activities to conduct as a contractor. Underlying the aspect of 'relation with client', the interviewed project managers largely agreed that it is key to insure two factors:

1. Transparency – Openly communicate with you client, report (potential) changes but also continuations timely;
2. Involve client in decision making – Invite client to give his opinion about particular decisions that have to be made and be clear about which input you will take into account and which not.

8.3. Strategy on the basis of project properties

Initially, it was proposed to conduct a quantitative data analysis of financial data to check whether propositions from the interviews can be substantiated or even debilitated. However, it turned out that the data did not really match with the propositions. In addition the conclusion of the data analysis is that the current dataset offers too few quality and detail to conduct reliable analyses. Although, the results of the analysis are presented. In second the quality of the data is reported and improvements are recommended.

During the statistical analysis seven variables were tested with ANOVA. 'Prognostication of net margin', 'Type of client', 'Project manager', 'Project value', 'Profession', 'Business unit' and 'Type of work'. For three variables a significant difference was found between at least two datapoints within a group of one variable. 'Prognostication of the net margin' resulted in a significant difference of means between the intervals [0 – 90%] and [90 – 100%] production ($CI = 99\%$). However, because of the proposed unsuitability and doubts about the reliability of this variable, the result is not considered as relevant.

Within the group 'project manager' a significant difference was found within a set of eleven project managers, all with at least five data points ($CI = 90\%$). Since the project managers are anonymised it is not relevant to mention at which pair(s) of project managers resulted in this significant difference. Although, the result strengths the presumption that a project manager (or team) can make a difference in financial results by additional inserted processes and uses, in addition to those aspects which are standardised in the project approach of an organisation.

'Type of work' resulted in a significant difference ($CI = 95\%$) because of the pair corrective maintenance – multi-year maintenance. Besides, the relatively high average and low variance of the set of corrective maintenance projects suggest that corrective maintenance projects might have a high probability in succeeding financially successful.

Improvement of quality of data

All in all, when you focus on project properties, as an organisation you can steer into two directions to better control the cost price. At first, you can bet on projects containing particular properties at which you score well. Secondly, you can decide to try improving particular properties which result in disappointing results, such that the range of projects you conduct with financially good results increases.

As a final remark, it must be said that the most important conclusion of the statistical analysis might be a lack of quality of the data available. Already mentioned in chapter 7 'Discussion' the data in the financial system contains restrictions and shortcomings making it hard, if not impossible, coming up with reliable results of (significant) differences of particular variables. Therefore, it can be concluded that the data has to be reported more consequently and standardised to come up with project properties of which the probability of success or disappointment is quite certain.

8.4. Recommendations

All in all, it is presumed that the conclusions of this research can be distinguished into two parts. On the one hand short term solutions (up to one/two years) and other hand long term solutions (more than one/two years).

Short-term it should be applicable to add more detailed data into the financial system. E.g. the column 'Profession' can quite easily be detailed by indicating whether a project is really 'Electricity'-related or has more or other professions. Besides, being transparent and involve the client in decision making are 'do's' which are almost directly applicable.

As a long-term solution, it is recommended to develop a more structured list of risks and opportunities in addition to the limited list already available. Parallel with this risk and opportunities it is of importance to map competencies of staff and develop a system such that the capacity is scheduled to query for knowledge by the tender team. Eventually a well-considered Go/No Go can be proposed.

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Appendices

A. Main process of projects

Figure 13 provides a layout of the main process and influencing/supporting factors. Behind every process there are more served out processes with their own flow charts. As can be seen in the figure the project management plays an important role in every transition from one to another process.

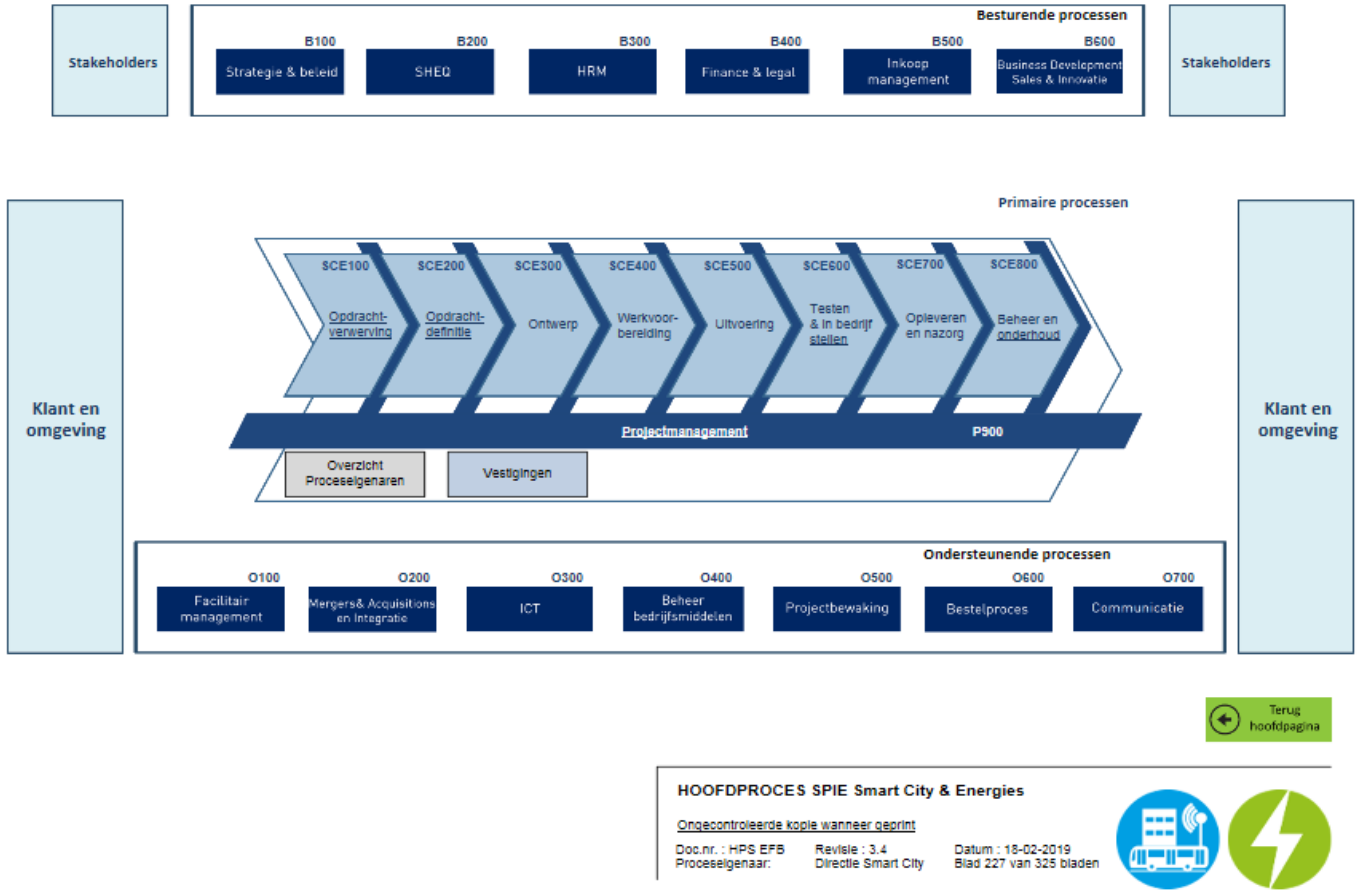

Figure 13: Main process Smart City & Energies

B. Reporting of interviews

This appendix provides insight in the design and procession of the interviews. At first the template for each interview is reported. This template is used to make notes during every interview. In appendix B.2 the document sent to all interviewees as a preparation on the interview is inserted. Finally appendix B.3 and B.4 give insight in the type of interview conducted, the way recording and processing, and a summary of every interview is reported.

B.1. Template processing interviews

Interviewee

Date + time

Location

Q1

1	**Welke stappen kunnen worden onderscheiden in het calculatieproces? Wie zijn hierbij betrokken binnen SPIE?**
1.1	**M.b.t. bieding in tenderfase;**
1.2	**M.b.t. kostprijsberekening;**
1.3	**M.b.t. uiteindelijke kosten.**
2	**Zijn er gestandaardiseerde procedures voor kostprijsberekeningen voor soortgelijke projecten?**
3	**Hoe wordt het risicoprofiel van een project of specifieke factoren meegenomen in de kostprijsberekening?**
4	**Welke factoren beïnvloeden de bieding in de tenderfase?**
4.1	**Kortingen door bepaalde omstandigheden, capaciteit, etc.**

Q2

5 **Welke factoren zijn van invloed op het rendement tijdens de uitvoering van een project?**

6 **Kun je een project noemen waarbij het rendement zeer gunstig uitpakte?**

6.1 **Wat is/zijn hiervoor de belangrijkste reden(en)?**

6.2 **Kun je stellen dat deze goede prestatie te generaliseren is tot een set van soortgelijke projecten of is het betreffende project buitengewoon?**

7 **Kun je een project noemen waarbij het rendement zeer teleurstellend was?**

7.1 **Wat is/zijn hiervoor de belangrijkste reden(en)?**

7.2 **Kun je stellen dat deze teleurstellende prestatie te generaliseren is tot een set van soortgelijke projecten of is het betreffende project een uitzondering?**

8 **Op basis van je eigen ervaring, welke factoren (positief of negatief) beïnvloeden de aanvankelijke kostprijs het meest?**

9 **Zijn er bepaalde fases/processen gedurende een project die, meer dan andere, 'key' zijn in het bereiken van goede (financiële) resultaten?**

Q3+Q4

10 **Binnen de afdeling zijn jullie over het algemeen in de veronderstelling dat het 'gat' tussen tender en uitvoering te groot is met betrekking tot het verlies van rendement.**

10.1 **Wat is/zijn de belangrijkste reden(en) dat de tender prijs/het aanvankelijke budget uiteindelijk (te veel) verschilt van de uiteindelijke kosten?**

11 **Wat kan er worden gedaan om de aanvankelijke en uiteindelijke kosten/opbrengsten meer gelijk te trekken?**

11.1 **Door het tender team;**

11.2 **Door mensen die betrokken zijn in de uitvoering van het project;**

11.3 **Door het management.**

12 **Ter afsluiting: Wat kan SPIE doen om het verschil tussen het aanvankelijke en werkelijke rendement te verkleinen?**

13 **Hoe kunnen deze overtuigingen worden geïmplementeerd in een project/in de bedrijfsvoering?**

Overige opmerkingen

B.2. Explanation on interviews

Ter voorbereiding op het interview in dit document een korte toelichting van de onderzoeksvragen waar de afstudeeropdracht zich op richt (Figuur 1) en het onderwerp van het interview.

MQ (hoofdvraag): Hoe kunnen de tender prijs, aanvankelijke kostprijs en uiteindelijke kosten het beste worden beheerst in de technische dienstverlening?
Q1 **Hoe worden de kostprijs en de hoogte van de bieding bepaald?**
Q2 Hoe kunnen het budget en de kostprijs van een project worden beheerst?
Q3 Hoe kunnen de tender prijs, aanvankelijke kostprijs en uiteindelijke kosten het beste worden beheerst door SPIE binnen de afdeling Smart City?
Q4 Welke mogelijkheden liggen er voor SPIE om de verschillen tussen aanvankelijk en uiteindelijk rendement te verkleinen en/of te verbeteren?

Figuur 1: Onderzoeksvragen afstudeeropdracht

De interviewvragen zijn opgesteld met Q1 t/m Q4 in het achterhoofd. Hoewel Q1 en Q2 als vraag op zich betrekking hebben op de technische dienstverlening in het algemeen, zal het interview zich met name richten op de bedrijfsvoering en processen binnen SPIE. De onderwerpen per vraag zullen als volgt aan bod komen:

Q1 Hoe worden de kostprijs en de hoogte van de bieding bepaald?

- Stappen in het calculatieproces/kostprijsberekeningen;
- Inachtneming van risico's.

Q2 Hoe kunnen het budget en de kostprijs van een project worden beheerst?

- Invloedrijke factoren;
- Excellente/geflopte projecten;
- Eigen ervaringen.

Q3 Hoe kunnen de tender prijs, aanvankelijke kostprijs en uiteindelijke kosten het beste worden beheerst door SPIE binnen de afdeling Smart City?

+

Q4 Welke mogelijkheden ligger er voor SPIE om de verschillen tussen aanvankelijk en uiteindelijk rendement te verkleinen en/of te verbeteren?

- Factoren die verschillen veroorzaken tussen initieel en uiteindelijk rendement;
- Wat kan worden gedaan om factoren te beïnvloeden;
- Hoe dit te implementeren.

B.3. Properties of interviews

For all interviewees the status of the interviews the interviewee (anonymised) is viewed in the first column of Table 19. As can be seen there is made distinguish between staff from as. 1, to which is spoken on informal basis, and project managers from as. 2. The source indicates the reference of the regarinding interviewee. At the format interviews can be indicated as unstructured, semi-structured or structured (section 3.1). The length of interviews is reported, as well as the way of recording and the transcript written after the interview.

Table 19: Interview methods

Interviewee	Status	Source	Format	Length	Recording	Transcript
As. 1 – Account & tendermanagement						
Two as. 1 staff members	Informal conversations 8-4-2019 up till 12-4-2019	Referred by supervisor and accompaniment	Unstructured	N/A	Document 'Vragen 'Lessons Learned''	N/A
As. 1 staff member	Conducted in person 16-4-2019	Referred by supervisor	Unstructured	45 min.	Recorded by audio, processed as final input in interview questions (B.1. Template processing interviews)	Taken through orally
As. 1 manager	Informal conversation (6th of May)	Referred by supervisor	Unstructured	15 min.	N/A	Transmission process from tender to project talked through
As. 2 – Project management						
P11	Conducted in person (18th of April)	Sample frame	Semi-structured	50 min.	Recorded by audio, notes during interview	Reported as summary within one day
P16	Conducted in person (25th of April)	Sample frame	Semi-structured	40 min.	Notes taken during interview, not recorded	Reported as summary right after interview
P5	Conducted in person	Sample frame	Semi-structured	45 min.	Notes taken during interview, not recorded	Reported as summary within one day
P23	No response	Sample frame				
P9	Conducted in person	Sample frame	Semi-structured	60 min.	Notes taken during interview, not recorded	Reported as summary within one day

Interviewee	Status	Source	Format	Length	Recording	Transcript
P17	Conducted via Skype	Sample frame	Semi-structured	30 min.	Notes taken during interview, not recorded	Reported as summary within one day
P18	Conducted in person (24th of April)	Sample frame	Structured	45 min.	Recorded by audio, notes during interview	Reported as summary within one day
P1	Conducted in person (23th of April)	Sample frame	Semi-structured	30 min.	Recorded by audio, notes during interview	Reported as summary within one day
P3	Conducted in person (23th of April)	Sample frame	Semi-structured	70 min.	Recorded by audio, notes during interview	Reported as summary within one day
P6	Conducted in person (26th of April)	Sample frame	Semi-structured	60 min.	Notes taken during interview, not recorded	Reported as summary within four days
P20	Conducted in person (26th of April)	Sample frame	Semi-structured	60 min.	Notes taken during interview, not recorded	Reported as summary right after interview
P25	Conducted in person	Sample frame	Semi-structured	50 min.	Notes taken during interview, not recorded	Reported as summary within one day
P4	No response	Sample frame				
P10	Conducted by phone	Sample frame	Unstructured	60 min.	Notes taken during interview/conversation, not recorded	Reported as summary right after interview

B.4. Interview summaries

Interviewee 1

Date + time	18th of April, 11.00h
Location	SPIE Sliedrecht

Interview report

As a project manager there is low responsibility in the process of calculation. It is mainly 'As. 1' which is responsible for the entire tender process and regarding calculations. However, the project management is more and more taken along these processes, so that it can't be the case that the eventual project team is not informed about the knowhows drawn up during the tender phase. In the end more expertise during the tender phase ends up in more stable prognostication.

Since the process of cost price calculations is in the hands of 'As. 1', it is not known that there are standardised procedures. However, it is not hard to imagine that calculators will use certain formats, norms and prefixed numbers as a first indication for similar projects. To what extent this is applicable is not known.

Excellent projects

- Additional work: €500.000 to €800.000 sales volume, 6% net margin
- Good relation with client (Rijkswaterstaat) → "short lines"
- Motivated project team with expertise

In 2017 a lot of hired staff, which were not motivated and had a lack of expertise. However, in 2018 the capacity within SPIE was available to continue the project with own staff. The team in 2018 turned out to work very efficient and motivated which resulted in a change from lean fives up to nines in the 'Prestatiemetingen' of Rijkswaterstaat. The project had a duration of seven quartiles, the evolution of the project can be represented by the evolution of the rating from Rijkswaterstaat (Table 20).

Table 20: Evolution of 'Prestatiemeting' for Maeslantkering

Contractnummer	2017-Q1	2017-Q2	2017-Q3	2017-Q4	2018-Q1	2018-Q2	2018-Q3
31117531	4.9	6.9	6.6	8.2	9.4	9.6	9.3

It can be said that this result is one of its own, but it is a fact that this project is one with a low factor of engineering. As a result of that, it is easier to map risks in the early stage of the project. Besides, it turns out that a motivated team with good collaboration is key.

Groot onderhoud Purmerend

- Good start by addressing the client onto the contract, since their perception did not came across with the formulated requirements in the contract. With success a 'VTW' was submitted.
- Technical manager conducted an analysis on the requirements, followed by an evaluation with the client → the ideal image sketched by himself

Disappointing project

- Underestimated calculations → too less consideration of engineering, which eventual turned out to be an item with high costs
- Stribling client using a 'functional program of requirements' which often led to debatable points
- Inefficient execution of work due to a lack of expertise resulting in doing activities twice → wrong measuring
- The high component of electricity resulted in hiring electrical mechanics, because there was no capacity within SPIE.

The project can be seen as one of its own, since it is certainly not always the case that there are shortcomings in the availability of electrical mechanics.

Improve estimation of work and consider risks and opportunities

To create more entity and knowledge during a project it is of importance that the triangle of project manager (PM), technical manager ™ and site manager (SM) is already involved during the tender phase of a project. On the one hand they offer more practical expertise which contributes to a more structured plan, plus after the tender phase the concerning triangle can easily transmit the plan to the project team, to guarantee a good start.

Realising a good transition from tender to execution also depend on the extent in which the promises in the EMVI-plan are taken into account during calculation. Often the EMVI-plan is considered as more of an 'annoying appendix', that has to be implemented during execution but after doing an analysis on the requirements. The importance of the EMVI-plan needs to be subscribed since this plan is one of the main reasons the client chose your company as the winning one. In theory, not realising the promises in an EMVI-plan can result in a financial penalty of 1,5 times its proposed added value. It can be helpful to process requirements (also EMVI) into Relatex.

Ideally, at the moment a tender procedure starts, the team and its availability is known and there is started with a relatively small team (the triangle) to conduct an analysis of requirements. Subsequent this small team needs to validate their requirements by the use of an evaluation in assistance with the client. Time management should be determined in collaboration with the concerning engineers, so they know what to do and they are responsible for their own time management, but to prevent loss of time choices need to made by the technical management so that engineers can directly focus on specific tasks without losing time in decision making.

In short

- Clear and specific arrangements with engineers;
- Evaluation of spent hours and budget on regular basis (weekly, monthly, …);
    - PPO with management only, so this cannot result in stress for engineers;
    - Feedback from engineers, also when everything goes well.
- Division of time in small parts to make them more specific;
    - Essential is keeping this monitored.

- Let engineers report deviations, because potentially they can be the responsibility of the client and not SPIE.
    - Consider the budget as you own;
    - Keep emphasizing the budget of costs and time.

Budgeting and alignment of time plus mapping risks and opportunities on forehand. It might be useful to implement standardised project management documents.

Interviewee 2

Date + time	23th of April, 11.00h
Location	SPIE Wijhe

Interview report

When generating a cost price it is of importance to make an inventory of 'numbers' for a particular project by people with accompanying expertise. As a project manager it is the case to steer on the way in which people with the right expertise also make good estimations. During the process of calculation you need to run through several steps:

- What is needed to build an artefact?
- How many hours do you need per activity?
    - Amount of management hours etc.
- To what extent can you use time and space?
    - With respect to obstructions etc.

Involving people responsible for the implementation, such as mechanics, in the calculation phase is often done. This improves the possibilities to make well-thought decisions with regard to time scheduling. This can be done because, on forehand, most of the time it is known which people are needed during the project. For the majority of the projects it counts that there is already a relation with the client based on former projects. Because of that, you can easily start negotiating and consider how many and which people should work on the project.

On the basis of the relation with the client a certain margin is calculated and often varies from ten up to fifteen percent. To manage time and maintain the initial efficiency it is essential to have a well-structured time schedule. This requires a clear scope of the project otherwise you will do too much and run out of time unless you can justify that as extra work at the client. Everything fails or succeeds by communicating, therefore you need to be sure that the order is interpreted right in the mind of every project member. For relatively high valued projects every week a moment of evaluation is scheduled with the project manager, the planner and technical manager. Although, it depend on the complexity of a project whether a technical manager is needed or not.

The risk profile of a particular project depends on the amount of stakeholders and what kind of stakeholders are involved. Besides, the type of projects is divided into four areas:

- Preventive
- Malfunctions

- (Additional) work
- On the basis of directing

So, for every client there are created different client numbers when it occurs that there are activities within different areas. Separation of these four areas gives insight in what kind of processes are profitable and which are not. This method is introduced since approximate five up to six years. To which extent this separation is also applicable for projects and clients for the locations at Amsterdam and Sliedrecht.

It is quite remarkable that Hans Kooijker, in collaboration with Marco Siemens, created a simple structure for projects with their own 'Lessons learned', but is only used by them and not aligned with the other project managers. In practice this is a structure that can be used for every project and is divided in several folders. Because of the shared online area adaptions that are required can be implemented directly. Since this 'simple' project structure is only known by a few people within the location of Wijhe, and not shared, it can be imagined that are a lot of this structures throughout the entire company.

Excellent project

- Including additional works €321.000 and a net margin of €70.000
- Initial calculation too high → lack of knowledge at the client
- Excellent production planner, technical and organizational competencies
- Subcontract delegated to different SPIE location (Hoogezand) which leaded to higher profits

The role of software within this project was significant, which is often the case for projects leaded by Hans Kooijker. However, it can't be said that every "software" project is successful, but software engineers are quite cheap, so there is a lot of potential margin. In addition, clients like municipalities have a lack of knowledge with respect to software. Therefore it is possible a relatively wide amount of working hours. On the contrary subcontracts are most of the time problematic in achieving a desirable efficiency.

Disappointing project

- During the preliminary stage there were less hours calculated for safety engineering
- The organizational structure was not known and completely available

At the phase of getting in the project, it is not considered if there was availability of staff members with the right amount of knowledge and expertise. This can be seen as a result of poor communication between as. 1 and as. 2. So it is the case to get insight in the time schedules of every single staff member.

In general can be concluded that the expertise and knowledge is almost always available within SPIE, but there is often a lack of available staff members. As an example: there were calculated 90 hours of work for one single employee if want to do all the work calculated for him.

In short

Control, manage, and if required adjust time schedule. It is key to have a well-structured time schedule on forehand including the staff available and their expertise (from sales up to mechanics). During a project it is essential to keep an eye out on the schedule and adjust if needed.

Secondly “by-catch” of big projects eventually leads to high profits with low risk, provided that the big work itself is delivered with quality, also if this results in lower profitability.

The management team (MT) is diligent and listens to the advices. As a result of these input they are very ambitious in standardising processes and align the work done by different people.

Interviewee 3

Date + time	23th of April, 13.00h
Location	SPIE Wijhe

Interview report

The activities conducted by Erik Kok contain maintenance contracts, at which two types can be distinguished, respectively preventive and corrective activities. Preventive maintenance is regular maintenance, based on calculations and can contain electrical and/or mechanical engineering aspects. Corrective contracts aren’t on forehand calculated and can be described as malfunctions of a system. With respect to clients which are known, as a project manager he is always involved in the phase of sales and calculation (as. 1), however new clients often come in via the sales division without interference of project managers.

With respect to calculations of cost price and budgeting of working hours the summary is just overviewed/reviewed, but there is no additional interference in that process of project managers in the maintenance contracts. Negotiation about hourly rates depends on the type of the client and the former experience with that client. In addition, the hourly rates are depending on the location. Characteristics of a freight route have for example more blocks than an installation on the side of a road.

Whether a particular client gets more or less a discount is highly depending on the feeling with a client. The team responsible for contracts with that client together decide if discounts need to applied or not. Site manager and technical manager are not involved in these process with respect to maintenance contracts. However, it can be imagined that the role of a site manager and technical manager is more of importance during this process when the value and/or complexity of projects requires more competencies. The maintenance projects though have a value from €5000 up to €500.000. The advantage of these relatively low-valued contracts is a low risk profile, resulting in easily provided compensations for additional work and financial efficiencies which are quite high.

Excellent project

- Permanent team working on the contract
- The location was already known based on former projects
- Low risk profile

Mainly the low risk profile can be generalised to maintenance contracts overall.

Disappointing project

- Jansen Venneboer at the time was involved in the mechanical engineering
- Alewijns at the time was involved in the electrical engineering
- At the side of electrical engineering it is quite hard to achieve the break-even point
    - Prices during tender phase were quite low because Alewijns did not have a lot of work to do at that time.

It is certainly not always the case that electrical engineering projects turn out to give problems.

Working in permanent teams per client, with respect to mechanics but also coordination, is according to Erik Kok key in achieving positive financial results and simultaneously keep up a good relation with the client → former experience with clients and locations is useful in coming projects. However, it must be mentioned that there is a risk of estrangement of systems and malfunctions that not occur at the set of clients and a mechanic needs to do other activities.

'SPIE Simpel' is a registration system for corrective maintenance contracts. However, at the location of Wijhe is worked with 'SPIE too Simpel'. It is expected that during this year a new system will be launched for all locations with regard to corrective maintenance.

In short

Although the margin of 'management and maintenance' is small the efficiency is quite high. So, doing a lot of these small projects eventually leads to high profits in contrast of high valued projects which often have significant risks resulting but often low margins. However, to keep yourself in the market it is of importance to preserve these projects, which leads to the case that 'management and maintenance' should be elaborated, but not at the expense of project for new artefacts.

Interviewee 4

Date + time	24th of April, 10.00h
Location	SPIE Wijhe

Interview report

Wilco Hollegien mainly leads projects regarding the VEVA (movable barrier) and CADO (emergency barrier) and is responsible for which system and method can be used for a particular project area. So it can be said that in the pre-stadium it is his responsibility to decide what the best system is. Subsequent, the project moves onto as. 1 for the calculation process, however he is not responsible for the acquisition of new clients. With respect to the calculation he verifies the costs of different components calculated by as. 1 by comparing them to the opinion of people responsible for that component. When there are (potential) mistakes made during the calculation, this will be evaluated, if not the project is continued without any feedback/evaluation.

During the implementation of the project the detailed calculation is converted into a detailed budget, containing hourly rates, materials, remaining project costs, etc. Since the VEVA and CADO are

quite concrete products a standardised budgeting can be used which is already in development. Risky factors in these kind of projects are relatively low. Of course there is always a certain risk profile for a project, depending requirements of clients (mainly abroad) where perceptions can be very different from Dutch ideas. Besides, the continue development of the systems requires continuous adaptions in approach and organisation. Overall the market of these flexible barriers is quite small and, certainly in The Netherlands, SPIE is almost monopolist. Because of the small market the focus is more and more on countries like Germany and Slovakia. Discounts on projects do not often occur, but sometimes it is good to give some discount on projects to set foot on the ground in new areas, which is possible since the margins are wide enough.

Excellent project

- Sales volume of €700.000, net margin of €100.000;
- Client not demanding trusts the knowledge of SPIE ("We want that system, you have it, so you can say how to build it.");
- Since the project concerns six CADO's, which is quite a lot, the purchase price was favourable.
- Easily scored additional work because of deviations from the client;
- Wide set of scenarios that could be kept open during calculation;
- Since Viales was subcontractor of the main project leader, there was some pressure on their organisation which leaded to possibilities for SPIE to respond for them in a positive way.

For both projects it can be stated that they are one of its own and cannot be related to a particular set of projects.

Disappointing project

- Electricity project, but shortcomings with respect to capacity, knowledge and skill (from Alewijnse);
- Request for delay already in the first evaluation;
- Hourly rates turned out to be higher and activities more complex than initial calculated.

In general it can be said that 'E-projects' lead more often to financial problems due to a lack of knowledge and capacity. However, the market of 'E-projects' is interesting for SPIE so it should not be the case to focus less on these kind of problems, but gather more capacity and knowledge with respect to electrical engineering.

In short

All in all, it is of importance to provide a situation in which the project management is more involved in the sales and calculation phase, rather than improving the transmission from as. 1 to as. 2 and further, certainly in high valued and complex tenders. Besides, it is of importance to create more entity within the all the teams by standardisation, mapping changes and risks and documentation. Also Wilco Hollegien uses his 'own' template a 'project CV' to improve transmissions. Finally, the expertise of Alewijns with respect to electrical engineering is doubtful.

Interviewee 5

Date + time	25th of April, 10.00h
Location	SPIE Wijhe

Interview report

Since the acquisition of Alewijns it was expected that the calculation team for 'Bruggen, Sluizen en Gemalen' should be expanded with two calculators. However, these calculators have been moved to the SPIE location of Zwolle, which belongs to the division 'E-fficient buildings'. Therefore, the capacity and expertise with respect to cost price calculations for electrical construction projects is too low, which is a major concern according to the interviewee. Since there are no suitable calculators available, it is his responsibility to these calculations. However, due to time spent on project which are already in the implementation phase, and a lack of knowledge about project locations and key figures he is not able to come up with a well-considered cost price calculations.

Because of the interviewee's technical background it do not often turns out to be a problem to 'just' calculate components of, for example, a bridge. However, accessibility and blocks[2] during a project are just as important as the components. To overcome this, it is essential to have 'dedicated' calculators. In addition, it is essential to involve at least the project manager and planner concerned during this phase. It should be their task to evaluate calculated work, and offer help to the 'front' in compiling the project team. Besides, the management team needs to create a list of risks and possibilities in a proper way, such that this list can be judged by the managing board. In the end, decisions should be made by them, with respect to risks and possibilities need to taken along in the cost price and which not (crossing pluses and minuses out against each other).

Excellent project

- Time for risk estimation wide enough → VTW's submitted on time and accepted;
    - Resulted in almost double hourly rates, but delivered extra incomes as compensation.
- Critical attitude against client and order.
- UAV-GC (2.6 Contract types - UAV-GC), contract turned out to be not suitable for twenty different objects which all required different renovation activities → type of contract for some of the activities unnecessary, for some a shortage.

Disappointing project

- Underestimations during calculation phase;
    - Renovation project requires temporary provisions which were more or less not considered;
- Capacity of engineers was too low (with respect to hardware and software).

[2] Accessibility and mainly blocks are especially applicable to renovation projects, because it is often needed to deal with temporary solutions. For example redirection of cabling during the execution phase. During implementation, it often occurs that during the calculation phase a lack of knowledge was available to map, and potentially, budget these blocks.

Influential factors

In general, it can be said that engineering and experience of a project team with a permanent composition can influence the cost price of a lot in positive way. Besides, it is key to map competencies of each project manager (PM) within BS&G so that project and PM can be connected to each other in the most efficient and suitable way.

Experience and more or less group feeling eventually spare hours spent on a project. Steering more on the alignment between initial and actual costs of projects highly depends on the social cohesion within the company. People need to feel themselves more concerned with SPIE and feel responsible for the budget like it is their own wallet. Creating a “we” feeling and clarify which manger and board member is responsible for which subject.

Additional, it is of necessity to contract more electrical engineers to prevent failure costs of hired engineers. Besides, the difference between renovation and new constructions should be known by people responsible for sales and calculations, since there are more factors to cope with in renovation projects. Finally, the capacity of hardware engineers and calculators (with expertise in electrical installations) needs to be increased.

In short

With respect to the business operations clarification of the structure of managers and board is necessary, as a first step to create more “we” feeling, in addition it will make clear which management member is responsible, and can therefore be addressed, for a particular process or task. Looking at the policy of projects, the competencies of project managers should be clear, so that they can organise a team in the right way from the start.

Finally, the capacity of electrical engineers (mainly hardware) and calculators with expertise in electrical installations need to be increased.

Interviewee 6

Date + time	26th of April, 9.00h
Location	SPIE Amsterdam

Interview report

The recent project Seedoksluis at Den Helder was for the interviewee the first project as a project manager in which he was already involved in the tender phase. With his practical knowledge as an input in the tender phase, this helped in to improve the tuning between as. 1 and as. 2. This practical knowledge consisted of schematising functions needed during the project. Although, the functions were due to the involvement of a project manager filled out, it was not checked whether there was enough availability within SPIE to conduct the functions. According to the interviewee the organizational structure of SPIE is not developed enough to make predictions about availability during the tender phase, but also because the uncertainty about winning a tender. However, from his point of view it should theoretical be possible to do predictions about available staff members for certain functions when the sales volume per location is documented precisely and with discipline. On the basis

of precise sales volume data you know how many PM's, TM's, SM's, planner, etc. you need on yearly, or even monthly basis.

For the time being, his impression is that there are no standardised cost price calculations used. He is convinced that the references/knowledge are available within the firm, but is it not clear for calculators how they can gather or access this knowledge. Because of the lack of accessibility there is no clear structure in the sales and calculation, or it is the case that people from as. 1 just muddle along or there is a few direction given by Danny Boer.

To achieve a point at which knowledge is indeed widely spread it is of necessity to create clear links to the available knowledge and references. On the one hand this means that 'knowledge by head' needs be documented carefully in a shared area, but also it needs to be clear which knowledge is useful for which tasks. When this is done, you can pull people out of their fixed pattern. Secondly, the involvement of project managers during calculation can give calculators more feeling with the project, so that they don't just calculate prices and hourly rates, but get some dedication and realisation what the purpose is of their calculations.

Excellent project & Disappointing project

- All VA's separately calculated in 2014/2015;
- Time schedule made on basis of separate calculations;
- To keep the entire project stable pluses and minuses of hourly rates between sub-projects;
- Overall margin is small, profitability is in generating additional works;
- The (core) team is dedicated and skilful (consist of 68 approx.. 40 people);
    - From that aspect a good relation with RWS.

The VA 'Railbaanconstructie', a project on directory, was quite disappointing. The interviewee dedicates this to the 'directory' aspect of this project. You cannot take into account risks yourself since the price is fixed by the client, so practically you can only loose and not win margin. Certainly when the administration is not in order you cannot justify hourly rates and costs and therefore they won't be paid by the client.

Influential factors

It is essential to keep good relations with clients, because only then you grant each other with sound prices and payments, which, in the end, lead to quality for the client and good margins for the contractor

In short

According to the interviewee concrete solutions are:

- Report 'Leegloop' hours carefully so that you always have insight in real hours spent on a project in the past;
    - Helps in the determination of potential efficiency.
- Conduct less contracts on the basis of directory;
- Be honest in acknowledging problems;

    - Solutions can only be found when problems are insightful and negotiable.
- Less 'shuffling' with hourly rates between projects.
- As PM: involve staff more and make conscious of budgets.
    - Apply pressure in a positive way;
    - Create a "we"-feeling;
    - Let staff participate to create support.

Interviewee 7

Date + time	26th of April, 10.00h
Location	SPIE Amsterdam

Interview report

Within SPIE the calculation process is more one of its own than a process in which the concerning project manager is involved. However, more and more people come to the insight that practical knowledge of at least a project manager is essential in doing predictions during calculations about production related topics in the tender phase. The project management has a lot of experience, it is quite tragic that this knowledge is totally not or barely used during tendering and calculation. After tendering calculations of projects are monthly reported in AX to get insight in stabilisations and deviations. However, it is completely unclear what is concrete done with the output of PPO's from AX. Besides, the transmission from as. 1 to as. 2 is more of a 'look, this is the calculation of the project, good luck with it' than a process in which the tender team slowly lets the project go into the hands of the project team. To improve this transmission questions as "How do you see the transmission?" and "Who do you need?" need to be asked.

Excellent project & Disappointing project

- After calculation phase good mapping of risks and react on these risks;
- Good relation with client.

However, some point could be done better:

- Budget in calculation phase (forgotten activities):
    - Engineering
    - Sub-projects
    - Hiring expertise

Influential factors

The management structure of BS&G can be explained in two different, which gives the opportunity to escape from responsibilities from those who are intended to be responsible. On the one hand the structure can be explained as in Figure 14, which suggests a structure based on matrices. Between as. 1 and as. 2 transmission of information takes places, subsequent transmission from as. 2 to as. 3, etcetera. This implies that every 'as'-manager is responsible for the tasks concerned to their part.

Figure 14: Organisational structure via 'assen'

On the contrary of the structure of matrices, at the same height the operational manager of BS&G is responsible for calculation and realisation (Figure 15). Within this hierarchical structure you can accommodate all 'assen'. Accommodating all 'assen' within this structure should imply that the operational manager is responsible for the managers per 'as', however, since they are at the same height it often occurs that people avoid their responsibilities due to uncertainties about responsibility. The interviewee therefore proposes to integrate the structure of Figure 14 as a chain of values into the hierarchical structure of Figure 15 to overcome uncertainty about responsibility.

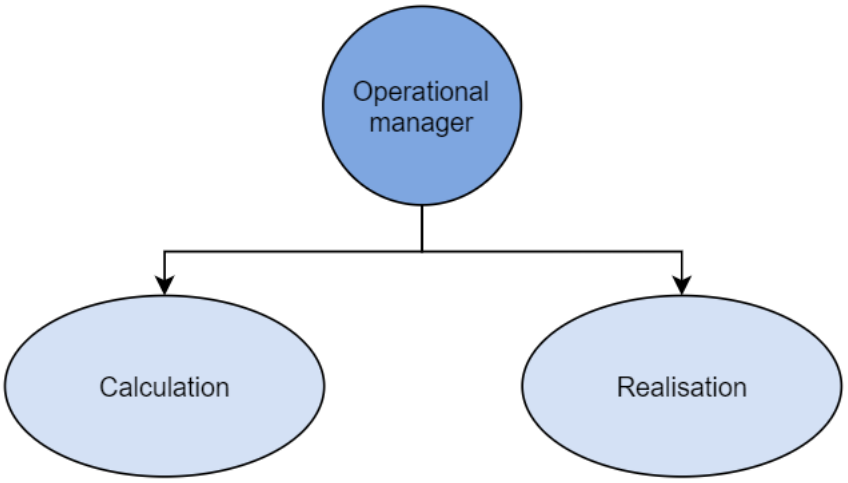

Figure 15: Organisational structure via operational manager

The organisational structure should, according to the interviewee, be transformed to a structure as in Figure 16. Within this structure the current managers per 'as' could still be responsible for their part, but the operational does not float on the same height beside these managers, so the entire process is the responsibility of the operational manager.

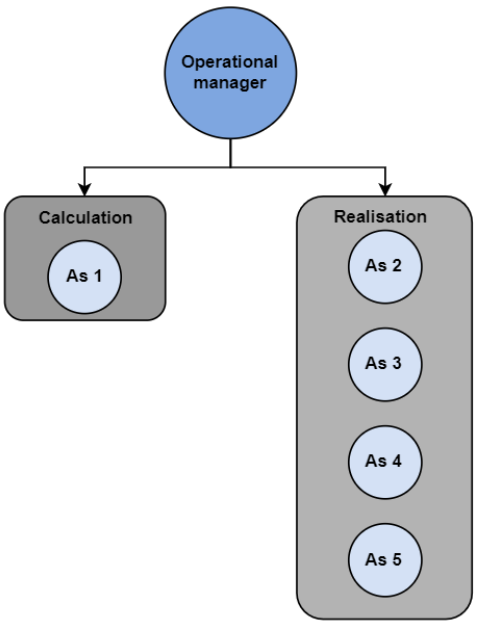

Figure 16: Proposed organisational structure

At the moment a potential project enters the company, the tender team (as. 1) needs to question themselves what kind of knowledge they need to handle the incoming question with the right expertise and skills. Thereafter, staff from as. 2 up till as. 5 need to be invited depending on the expertise and skills demanded. Subsequent, the transmission is not necessarily always from as. 1 to as.2 and further, but it might also be the case that as. 1 already transmit information to one of the other parts.

In short

Explanation of the organisational structure is necessary within all layers of the company, since this is not clear for the majority of the staff members. Besides, it is of importance to define the difference between knowledge (the 'assen') and operational responsibility. Thereafter, it is needed to create some hierarchal structure in total.

Interviewee 8

Date + time	29th of April, 13.00h
Location	Noordersluis, Ijmuiden

Interview report

During the process of calculation and tendering, the interviewee tries to be active and present during this phase as much as possible, although the intended project manager and team are not always known at this point. His presence focuses on advising qualitative requirements such as EMVI or other kinds of quality registers. To control the initial costs it is needed to report quality conditions, translate them into requirements , and finally prove those requirements. In the documentation it is important that everything is formulated in a way that negative interpretations are excluded, but that there are possibilities to interpret them more positive under certain conditions. In the past sentences as "We guarantee that …" were formulated. Although clients not often penalize contractors for not realising extra qualities, it is of high risk to 'guarantee' things.

For his own projects he always draw up a report regarding risks and possibilities of a project. Depending on the value of a (potential) project some managers or board members have the ability to sign contracts (for example contracts of higher than three million need to pass the board in Paris). More or less there are standardised documents available for drawing up qualities, requirements, risks and possibilities, however the interviewee is not up to date to which extent these documents are used and accessible for all concerned staff. When risks and possibilities are valued and multiplied by their intended impact you have in potential a well-considered documentation of the risk profile of a project. Subsequent, the different gradations in which contracts may be signed by managers and board members depending on their value.

By the interviewee it is suggested to plan a kind of 'Lessons Learned' sessions on regular basis to evaluate former tender in preparation on upcoming tenders. At least as. 1 should be present at these kind of sessions, but if useful also project managers and/or other staff from the execution phase should attend these sessions. Since the interviewee questions in which extent references are available and documentation is done this kind of sessions might help in improving the policy with regard to improvements.

Possible discounts inserted in a bid depend on the amount and impact of particular scenarios and finding a balance in this.

Excellent project

- Ability to signal and anticipate on potential risks;
    - Capable team (with regard to technical aspects), plus a project management that is able to translate the technical aspects into well-considered decisions.
- Conduct what is promised;
- Project management is concerned and responding fast.

The excellence of this project cannot particularly be assigned to a set of projects. However, it can be said that communication and always be informed are essential aspects for a project manager. Besides, get through a project in a successful way is highly depending on the willingness of the client. Being transparent and timely escalate to the client help in creating creditability and willingness of a client.

Disappointing project

- Overestimated promises (so not realised);
- Laboured relation with client;
- Improper intern conversations (hear and be heard).

For SPIE in general it can be stated that risks are underestimated. In addition, it is often the case that some activities are already started, despite there is not a contract drawn up. In practice this is done to maintain a good relation with the client, however you take a huge risk doing work that is not agreed in a contract already. For project Noordzeekanaal these extra activities can be found in the column 'Extra opbrengst' in AX. Because of inner agreements within the project team extra activities are accommodated within this column. However, the interviewee do not have any idea if this column

is used in the same way for other projects. Therefore it might be hard to come up with reliable analysis based on former projects.

Recommendations

The initial cost price is most influenced by the calculation process. Risks and possibilities need to be documented and valued, preferably by using a standardised format for all projects, to make the process more efficient and manageable. So, the calculation process is key in achieving positive (financial) results. More general calling and discussing problems is applicable on all phases of an (intended) project. Within SPIE is it important to keep escalating these problems.

In short

The interviewee questions the way in which risks are reported. His presumption is that risks are marked down by sense of the calculator, but cannot be substantiated. The interviewee recommends therefore a more structured way of risk management. Quantification of possibilities and risks should be done by valuing them plus take into account their impact. A list of quantified (€) should become the standard for all tenders. The way in which regarding documents is already available is not known by the interviewee. So, these documents need to be created or made accessible easier. To improve and implement such a process, on regular basis tenders need to be evaluated with concerning staff as a sort of 'Best Practices'.

Finally, the factor of luck plays a particular role in reaching positive financial results in a project. However, it must be said that the factor of luck can be forced by two key aspects: transparency and communication (as well intern as extern).

Interviewee 9

Date + time	30th of April, 16.00h
Location	SPIE Wijhe (Conference call)

Interview report

At the start of the interview the footnote has to be made that the interviewee is only one and a half year employed at SPIE. During this period he is only been active at one project, 'Noordbruggen Amaliabrug en Kogerpolderbrug'. Before his employment, the tender phase was already completed. Therefore he is never involved in a tender phase at SPIE before. However, he knows that SKID (should) offer standardised procedures with respect to cost price calculations. Quite remarkable is the way he received the risk profile of the project during the transmission. The document with risks and possibilities contained no more than four risks and four possibilities written by hand. Although this part of the transmission is quite defective, he claimed to have enough time read in to the project. As a result of that, he took the formal kick-off of the project for his response instead of the tender team. He mentioned it as a benefit that the team was and is still available for questions, but it must be noted that this necessity because not only the risks and possibilities were transmitted deductively. Although the budget of the project is clear, the qualitative assumptions and requirements (EMVI) out of the tender were unclear.

To overcome such unclear transmissions it is of high priority to involve at least the project manager in the tender phase. As an important factor influencing the efficiency he mentions the calculation phase at which key figures are used. The reliability of those key figures is not been a point of discussion, however the frame of reference is discussed, which can be illustrated by the project he manages.

Excellent & Disappointing project

The project can be seen as quite prestigious, but because of the disappointing financial results it is for SPIE a project to learn of for the future. During the calculation phase, the frame of reference is estimated incorrect. As an example, it can be imagined that building a bungalow using key figures of a terraced house will result in underestimations of costs, which is exactly what happened at the project 'Noordbruggen'.

In addition to the incorrect frame of reference, the structure of subcontractor – contractor is mentioned as a disadvantage. The interviewee advises against this structure for projects containing a high risk. Though, he is quite sure that SPIE is nowadays not able to be the main contractor, he proposes to steer on structural organisations like a private company or general partnership (b.v. and v.o.f. in Dutch) for prestigious projects like these.

General recommendations and suggestions

Choices made during the tender phase often turn out to be made under pressure of time or a lack of knowledge. The current capacity and quality of SPIE's staff cannot cope with some very complex contracts. Increased complexity because of environment, contracts, documentation, etc. also requires employing staff with expertise to a particular field. Employing the right people for more complex contracts overcomes the lack of capacity and quality already for a large part. Nearby, 'taking time' in general is something that need to be considered more as an important factor in projects, since the mentality within SPIE is 'the less hours and people, the better'. The technical management is already working hard on elaborating its capacity, with respect to project and site management it occurs to be difficult elaborating the capacity.

With respect to communication and expertise it is essential that these two aspects are during project available at the right time. This means that at least the project management, and depending on the value of the project, the site and technical management are involved during the tender phase. This involvement is of importance to come up with a representative frame of reference and indicate to which extent qualitative requirements and additions are applicable and realistic. Besides, the capacity and expertise of tender teams need to be increased due to recent contracts (for example UAV-GC) and the need of systems engineering. In the other way, the tender team needs to be available for questions about interpretations and documentation during the implementation phase, such that the quality of the work suggested during tender, is maintained and realised.

The interviewee himself was on the basis of his former job used to organise coaching sessions with a project team. During these sessions an extern coach emphasizes what responsibilities each member has and pays attention to attitude and behaviour of individuals and the project group as a whole. In

the end, this sessions contribute to a better cohesions within the team at which everyone openly comes up for his/her responsibilities.

Planning more time for sessions with a client, draw up a plan and subsequent talk again with the client are key in improving the efficiency of projects according to the interviewee, since this will result in better structured cost price calculations and thought out starting points.

Before starting a project, but after winning a tender the following steps should be run through:

1. Talk with client;
2. 'Lean back' and brainstorm;
3. Make actual plan and time schedule;
4. Talk with client;
5. Start with project.

In short

In essence, the point reported above can be summarised into three statements:

- Know how to approach a project;
- Draw up a well thought out organisation;
- Provide agreement on the budget with the tender team (≠ literally copy what is invented during tender).

Interviewee 10

Date + time	2nd of May, 13.00h
Location	SPIE Wijhe (Conference call)

Interview report

As a note, it must be mentioned that the interview with Jaap Bongers was more or less a combination of an interview and a conversation about the progression of the research. On the contrary of other interviews, which were (semi-)structured, this one was unstructured.

Accuracy in the cost price calculations is key in improving the financial efficiency of projects. This can only be realised when more time is reserved for those calculations and when the knowledge is available at the right time about particular costs. For example the offer of a supplier need to run through carefully. What is included and excluded by the supplier of a product need to be clear, such that you know what shortcomings you have or not have. Increasing the accuracy of calculators can be achieved by making them conscious about what they actually calculate, but there also a role for control/tender manager within process. Besides, projects need to go through the management organisation based on their cost price, apart from the trajectory via the board. This means that the managers of each 'as' or the operational manager have a voice in whether or not go on with a tender.

In current projects it often turn out that the calculation process is approached wrong due to several aspects:

- Too fast;
- Lack of logistic aspects;
- Lack of phasing;
- Budgeting of to deliver and purchased activities/products.

Besides, the transmission from as. 1 to as. 2 is too short and little informative for the project team. Therefore it is suggested to introduce a standardised package of transmission documents, at can be thought of:

- Cost price budgeting;
- Risks and possibilities register;
- Description of implementation phase (interpretation from tender team);
- All outgoing and incoming offers.

Excellent & Disappointing project

The interviewee not explicitly mentioned a financial excellent and disappointing project. However, he sketched how most of the successful projects are founded, according to his experience. Financial successful projects all start with cost price calculations which are founded on good relationship with the client. Having a good relationship with a client is the basis of dialogues, and dialogues contribute to good relationship with the client. From these dialogues the scope of a project becomes clear. In addition, you map risks within the scope of the project and put them down in a reasonable way at the client, or by yourself as a contractor. Finally, fluid dialogues with the client provide an offer which is reasonable an beneficial for both parties.

As an example, during a project the construction team was drawn up with both staff members of SPIE as from the client. This team eventually came up with a well-structured scope of the project and finally a fixed price, based on clear risks and opportunities which were resigned to one of the two parties.

In essence, this comes down to investing (more) time in calculating the cost price and 'just' talk with the client. Coherent with a good relationship, you provide yourself as a contractor the opportunity to easily gather additional work during or after project. Besides, confidence of the client will rather give you the opportunity recover or improve eventual mistakes, without damaging the relationship.

A concrete proposition of the interviewee is creating a 'traffic light model'. This model should contain factors such as the available time SPIE have, the capacity available, the client offering a tender and the extent/diversity of expertise in the project.

Interviewee 11

Date + time	3rd of May, 9.00h
Location	SPIE Wijhe

Interview report

The interviewee is during his time as a project manager twice involved during the tender phase. Respectively for the projects 'Rehabilitatie Overijssel' and 'ICAIR'. During the tender phase he was involved in the qualitative part, which contains drawing up a plan of action. As components of this plan of action the possibilities, risks and performances were mapped under his responsibility. Advantageous in the project was the fixed sum form the client in combination with a scope which was not binding. During 'Rehabilitatie Overijssel', a best value (BVP) contract (2.6 Contract types - BVP), the interviewee himself was involved during the tender as a project manager, and a best value consultant took part, which gave the implementation of the project a flying start since these two people knew exactly what should be done.

In more 'classic' situations the following steps can be distinguished:

Steer on calculation/budget → Read in to project → Playing around with available material → Draw up working budget in phases:

- First engineering + remaining;
- Second Execution + remaining;
- Etc.

Phasing of the working budget is of importance so that you can easily look back which phase got out of hand. However, current calculations during the tender phase do not consider all these aspects. On the contrary, they only take into account hourly rates and materials. Pre-work activities, aftercare or for example surcharges for night time work are (barely) considered. In short, it can be said that calculators do consider *activity* but not *time for activity*. With regard to the risk profile the interviewee suggests to more look at similar projects conducted in the past, but does not give further elaboration on this.

One of the factors influencing the financial efficiency of projects according to the interviewee is the interaction between calculation of engineering and the execution of engineering processes. On the one hand, engineering is structural underestimated by calculators. On the other hand, the interviewee proposes a more critical attitude within as.3 of their own work. When a lead engineer instructs an engineer monitoring spent hours is not done at all on intermediate basis. Mainly with respect to the electrical engineering this problem plays an important role.

Excellent project

- Spacious calculated;
- Adequate management between expectations of client versus expectation of SPIE;
- Good time management.

The interviewee could not mention a particular factor of this project that can in general be related to a successful set of projects.

Disappointing project

- Much hired staff;
- Too late start of the project after tender due to uncertainties of team structure and project manager;
- In general underestimated budgeting of calculation;
- Critical client: required a lot of detail for all activities.

The late start in combination with the (very) critical client leaded to a stiff relation which is best represented as distrustful according to the interviewee.

According to the interviewee the factor of starting (too) late with a project after winning a tender can be generalised to a larger set of projects within SPIE. Often it occurs that during the tender phase the capacity and availability of staff is not investigated. As a result of that won tender cannot always be immediately picked up by a project team, or there is no a project team at all.

Recommendations

The interviewee has several recommendations to improve the financial efficiency of projects. First of all, he stated that the always sends as. 1 the right tools (AX-data, work budget) to make an evaluation possible. In his opinion these tools are not picked up because people do not understand them and therefore do not use them. In second, he requires more maturity and responsibility from lead engineers in managing time of engineering tasks, which is reasonable since the manager of as. 3, Robbert de Ridder, introduced a document for transmission of work budgets. Within projects and mainly during tender, it is of importance the required knowledge and right staff is available on the moments required. This helps in planning ahead 'peripheral' matters (pre-work activities, aftercare, surcharges, etc.). Intermediate evaluations of costs and budgeting need to be standardised to anticipate fast on too low budgets, knowledge or communication with the client.

In short

Finally the matters reported above can shortly be summarised in three statements:

1. The calculations made by as. 1 are too limited. Therefore knowledge within as. 1 needs to be elaborated and other staff should be involved during this phase;
2. As. 3, mainly lead engineers, need to take more responsibility for managing the calculated hourly rates and not let engineers 'just' work along;
3. Someone have to be made responsible for afterward calculations, so that they can be evaded any more.

As a final note: the interviewee remarked that prices of job descriptions can often not be related to each other and to specific functions staff members conduct.

Interviewee 12

Date + time	3rd of May, 10.30h
Location	SPIE Wijhe

Interview report

The interviewed project manager is only employed since October last year. Therefore, his image is partly based on impressions rather than experience. However, as project manager he knows at what phases during the tender he wants to be present. At first, involvement in defining the scope is essential in two directions. On the one hand experience of 'executive' staff helps in better structuring and defining the scope. Parallel with that, involvement during the definition of the scope helps the project team keeping within that scope during implementation, because the people responsible were already involved in the tender. Secondly, it is of importance to have a voice in choices about 'rough' components. For example the way the deck of a bridge is transported to location. As mentioned by more interviewees it is his belief that a lot of knowledge is already available within SPIE. However, this knowledge is not shared properly and the right people are not available at the moment of a process.

To map the risk profile of a project more proper and consequent he argues for a 'risk session' as a standard for all above a particular value or complexity. At least the executive site manager and intended project manager should be present, in addition staff pointed out by the tender should be invited to share their point of view. The project manager should be invited on the basis of expertise. Also if a project manager with a lot of expertise is fully booked in the period the concerning project needs to be executed, it can be useful to invite him/her during a 'risk session' so that the initial risks and possibilities can be approached by someone with experience and expertise.

During the tender phase offers of suppliers are not requested and documented as they should. Besides, pressure of time plays a particular role during the tender phase. Due to a lack of time projects are played down. In other words, high valued and/or complex projects are approached as easily and volatile.

During the implementation phase of project a lot of factors influence the financial efficiency. Three important factors that need to be mentioned are:

1. Make a time schedule at the start of a project (right after tender);
2. Complete project team fast and comprehensive.
    a. Mainly draftsman and constructor turn out to be fully booked jobs → more flexibility.

Excellent project

1. Capable team, able to and willing to complement each other;
    a. Clarity about responsibilities and expectations from every team member from PM;
    b. Compliments from extern organisations or 'from above' shared with entire team.
2. Good relation with client;
3. Good relation with suppliers.
    a. Discussed time schedule (detailed, per hour) and one on one dialogues about prices.

In general the interviewee can state that a 'good' team is essential in in achieving good financial results. Besides, it is essential to honour existing commitments with the client, which is the responsibility of the regarding project manager. Transparency, flexibility and collaboration with the client are key in this aspect. Never get out of the way of dialogues coherent with that. Finally, as a

general remark on projects within SPIE the interviewee wishes that intern respondents are appointed for specific tasks on forehand. Investing in overarching management (above the 'assen') will eventually increase efficiency.

Recommendations

Promises from SPIE to the client during tender phase is pointed as a factor influencing the initial cost price most. It often occurs that the tender team makes promises to client that can in fact not be made truth. Therefore the right people and knowledge need to be available during the tender phase, so that promises can be made in a way that SPIE can offer something extra (so that tender are still won) but it won't result into problems or even impossibilities during the implementation of a project. It is up to tender team to ask themselves the following questions:

- What kind of knowledge do we need in tendering this project?
- Do we have this knowledge within the tender team?
- If not, ask required staff members (PM, SM, TM, etc.);
- If not available within SPIE, hire required staff instead of 'just' continue.

The impression of the interviewee is that tender mangers tend to influence the implementation phase of projects too much. In his opinion the tender team/tender manager always needs be available for the concerning project team to answer questions, but it should be limited to answer questions, and not focus on influencing the project. Overarching it is the responsibility of the management to conscious about possibilities and, mainly, impossibilities.

In short

According to the interviewee a lot of the discussed problems can be overcome by a business unit manager that knows what is going on within a location. When this is the case, he can operate as a connection between the location-overarching 'assen'-structure and staff at one location.

Withholding information from project leader to project manager is marked a particular threat in monitoring the course of a project.

C. Processing mentions into categories

The histograms in section 4.1 ‘Categorisation of interview results’ are deduced from the mentioned properties from the interviews in combination with eighteen categories of time and cost overrun for construction projects researched by Ramanathan (2012). Table 21, Table 22 and Table 23 mention the excellent and disappointing projects pointed out by the interviewees and the general improvements suggested by the interviewees. For each of these three tables the properties are given, with underlying factor. The fourth column views the set of categories pointed out by Ramanathan (2012) that best covers the combination of given properties and factors. As can be seen in Table 21 the category number is followed by a plus sign (“+”), since this table is about excellent projects, the properties and factors mentioned are pointed out as positive aspects. In Table 22 and Table 23 the category number is followed by a minus sign (“-“), since these tables are about disappointing projects and suggested improvements. So the aspects mentioned by the interviewees can be understand as negative/to be improved.

Table 21: Categorisation of properties of 'Excellent projects'

Project	Property	Factor	Category
Excellent project 1	Increase of sales volume	Additional work	2. +
	Initial net margin achieved	Financial efficiency	5. +
	"Short lines" with client	Relation with client	11. +
	Low factor of engineering	Low risk	14. +
	Team with motivation and expertise	Team structure	16. +
Excellent project 2	Succesful submission of VTW	Critical attitude	4. +
	Analysis of requirements + evaluation with client by TM	Management involved	8. +
			14. +
			16. +
Excellent project 3		Financial efficiency	3. +
	22% net margin (€70.000)	Knowledge of client	4. +
	Initial calculation quite high	Team structure	5. +
	Excellent production planner	Subcontract	11. +
	Subcontract to other SPIE location		17. +

Project	Property	Factor	Category
Excellent project 4	Permanent team working on contract Location known based on former projects Low risk profile	Team structure Foreknowledge Low risk	2. + 4. + 11. + 12. + 16. +
Excellent project 5	14% net margin (€100.000) Low demanding client Total of six CADO's, favourable for purchase	Financial efficiency Knowledge of client Authority of SPIE Cost price	4. + 9. +
Excellent project 6	Easily scored additional work Wide set of scenarios possible during project	Additional work Knowledge of client Management involved Decision making	4. + 5. + 16. + 17. +
Excellent project 7	Time for risk estimation Critical against client and order	Time management Critical attitude	8. + 17. +
Excellent project 8	Time schedule on basis of seperatly calculated VA's Shift hourly rates between VA's Low margin overall, high profits in additional work Dedicated and skillful team	Time management Financial efficiency Additional work Team structure	2. + 5. + 11. + 13. + 15. + 17. +
Excellent project 9	Good mapping of risks and react on them Good relation with client	Critical attitude Management involved Team structure Relation with client	5. + 11. + 14. + 17. +
Excellent project 10	Ability to signal and anticipate potential risks Conduct what is promised Project management is concerned	Critical attitude Management involved Team structure Relation with client Management involved	5. + 11. + 14. + 17. +

Project	Property	Factor	Category
Excellent project 11	Prestigious project	Authority of SPIE	2. +
	Good relation with client	Brand awareness	4. +
	Reserve time for cost price budgeting	Relation with client	5. +
	Combined team of contractor and client	Time management	14. +
		Team structure	17. +
Excellent project 12	Spacious calculated	Calculation	5. +
	Dialogue about expectations with client	Relation with client	7. +
	Good time management	Time management	14. +
	Capable team, able and willing to complement each other	Team structure	17. +
Excellent project 13	Clarity about responsibilities and expectations	Management involved	1. +
	Good relation with client	Relation with client	8. +
	Good relation with suppliers	Time management	9. +
			11. +
			14. +

Table 22: Categorisation of properties of 'Disappointing projects'

Project	Property	Factor	Category
Disappointing project 1	Underestimation of engineering work	Calculation	3. -
	Stribling client	Relation with client	4. -
	Inefficient execution of work	Team structure	5. -
	Hiring electrical mechanics	Capacity	11. -
		E-engineering	14. -
			17. -
Disappointing project 2	Underestimation of safety engineering	Calculation	5. -
	Unknown structure and availability of staff	Team structure	7. -
	Lack of available staff members	Capacity	11. -
			17. -
Disappointing project 3	Underestimation of electrical engineering	E-engineering	7. -
Disappointing project 4	Shortcomings with respect to capacity, knowledge and skill on E-engineering	Team structure	5. -
		E-engineering	7. -
	Request for delay in first evaluation	Management	8. -
	Underestimation of hourly rates and complexity of work	involved	11. -
		Calculation	17. -

Project	Property	Factor	Category
Disappointing project 5	Underestimation of temporary provisions Too low capacity of engineers (hardware and software)	Calculation Capacity	5. - 7. - 11. -
Disappointing project 6	Project on directory Missed activities in calculation phase (engineering, sub-projects, hiring expertise)	On directory Policy Calculation	2. - 5. - 7. -
Disappointing project 7	Overestimated promises that couldn't be realised	Calculation Relation with client Team structure Management involved	5. - 7. - 8. - 14. - 17. -
Disappointing project 8	Wrong frame of reference during calculation phase Organisational structure as subcontractor in a project with high risk Too fast calculation Aspects not taken into account during calculation Documentation of products to be purchased/delivered	Calculation Management involved Team structure Policy Calculation Time management Calculation Documentation	2. - 3. - 5. - 7. - 17. -
Disappointing project 9	Much hired staff Too late start of the project Underestimation of budgets Critical client	Team structure Capacity Time management Calculation Relation with client	7. - 11. - 14. - 17. -

Table 23: Categorisation of properties of 'General improvements'

Interviewee	Property	Factor	Category
P11	Map spent hours and budgets Division of time + monitoring Let engineers report deviations Map risks and opportunities	(Intermediate) evaluation Time planning Critical attitude Management involved	8. - 17. -

Interviewee	Property	Factor	Category
P3	Control, manage and if required adjust time schedule Subscribe "by-catch"	Time planning Financial efficiency Relation with client	2. - 14. - 17. -
P1	Bet on small (low risk) projects in addition to high valued contracts Permanent teams per client (risk = estrangement of other competencies)	Financial efficiency Team structure	2. - 5. - 11. -
P18	PM more involved in sales and calculation phase Create more entity within teams by standardisation, etc. Electrical engineering is doubtful	Management involved Standardisation E-engineering	2. - 5. - 8. - 11. - 17. -
P16	Create "we" feeling Map competencies of project managers More eleictrical engineers and calculators	Team structure Competencies Capacity	5. - 11. - 17. -
P20	Report 'Leegloop' to evaluate potential efficiencies of projects Conduct less contracts on the basis of directory Be honest in acknowledging problems Less shuffling with hourly rates Involve staff and make concisious of budget as PM	Financial efficiency Documentation (Intermediate) evaluation Policy Transparancy Management involved Team structure	2. - 5. - 8. - 17. -
P6	Explain organisational structure Re-structure organisational structure	Policy Documentation Management involved	5. - 8. -
P25	Map and report risks and possibilities Sessions to come up with 'Best Practices'	Policy Documentation Management involved (Intermediate) evaluation	8. - 17. -

Interviewee	Property	Factor	Category
P17	Involve PM in calculation phase Keep tender team available during project Take time before 'just' starting Increase capacity and quality of staff in line with complexity of projects	Management involved Team structure Time planning Standardisation Capacity Competencies Expertise	5. - 7. - 11. - 17. -
P10	Standardised 'package' of transmission from as. 1 Evaluation on numbers, in addition to 'soft' evaluations Traffic jam model' (eventual "NO" against tenders)	Documentation Management involved (Intermediate) evaluation Standardisation Documentation Policy	8. - 17. -
P5	Calculations of as. 1 are too limited More responsibility of lead engineers in as. 3 Responsibility for afterward calculations Standardise tariffs of staff mebmers	Management involved Team structure Critical attitude Transparancy Policy (Intermediate) evaluation Documentation	1. - 5. - 8. - 11. - 17. -
P9	More involvement of 'executors' in tender Standardised 'risk sessions' Business unit manager as connection between assen and locations	Management involved Team structure (Intermediate) evaluation Standardisation Critical attitude Policy Management involved	5. - 8. - 17. -

C.1. Overview of factors covering all properties

All properties of Table 21, Table 22 and Table 23 can be covered by 26 factors. For each of these factors the total amount per list (excellent projects, disappointing projects and general improvements) is counted (Table 24).

Table 24: Summed factors of accompanying properties per list

Factors summed	Excellent projects	Disappointing projects	General improvements
(Intermediate) evaluation	0	0	6
Additional work	3	0	0
Authority of SPIE	2	0	0
Brand awareness	1	0	0
Calculation	1	10	0
Capacity	0	4	2
Competencies	0	0	2
Cost price	1	0	0
Critical attitude	4	0	3
Decision making	1	0	0
Documentation	0	1	8
E-engineering	0	3	1
Expertise	0	0	1
Financial efficiency	4	0	4
Foreknowledge	1	0	0
Knowledge of client	3	0	0
Low risk	2	0	0
Management involved	6	3	14
Policy	0	2	8
Relation with client	6	3	1
Standardisation	0	0	4
Subcontract	1	0	0
Team structure	8	6	6
Time management	5	2	0
Time planning	0	0	3
Transparancy	0	0	2

C.2. Link to categories of time and cost overruns

The histograms presented in section 4.1 are deduced from Table 25, which summarises the number of mentions per category of time and cost overrun for the three parts distinguished during the interviews.

Table 25: Positive and negative mentions per category of time and cost overrun

Category	Explanation	Excellent projects	Disappointing projects	General improvements
1. Financial	Rapidity of payment, financial situation of contractor	1	0	1
2. Project	Necessary variations of work, kind of project	4	2	3
3. Project Attributes	Relevance and recency of used technology	1	2	0
4. Owner / Client	Realness of requirements, rapidity of giving approvals and making decisions, readiness of project site	6	1	0
5. Contractor	Capability of management, capacity of personnel, realisation of planning and way of constructing	8	7	7
6. Consultant	Quality and rapidity of consultation to contractor	0	0	0
7. Design	Practiceness of design, conformity of design with reality, on time finish of design	1	7	1
8. Coordination	Information flow within project team / company and within the relation client - contractor	3	2	8
9. Material	Quality and quantity of used materials, price and delivery time of materials	2	0	0
10. Plant / Equipments	Availability and quality equipments needed during implementation	0	0	0
11. Labour / Manpower	Capability and availability of manpower	6	4	5
12. Environment	Weather conditions, available utilities at site	1	0	0
13. Contract	Evidence of contract	1	0	0
14. Contractual Relationships	Relation with client, willingness of parties	7	3	0
15. External	Problems with direct surroundings of site, unforeseen site conditions, kickbacks and/or fraud	1	0	0

16. Changes	Conditions on site and mapping of conditions on site, impossibilities that occur during implementation on site	4	0	0
17. Scheduling & Controlling	Capability and availability of planner and management, estimation of time and resources, waiting times for deliveries and approvals	8	5	10
18. Government relations	Obtaining permits, leading building codes	0	0	0

D. Descriptive analysis of financial data

As already stated in the report itself the descriptive analysis is limited to those variables which are obtained relevant on the basis of the interviews and the utility of a particular variable.

D.1. Selection of combined variables

Since there are six 'project property' related variables (Table 26), in potential it is possible to make fifteen pairs of variables (Table 27) that can be described together in relation to the margin. Based on the interview results and the suitability of data some of the pairs can be relevant for the research and are therefore be investigated (section D.2. Indication of relation between variables). These pairs are marked green, the remaining pairs will not be further researched.

Table 26: Project related variables

No.	Property
1	Type of client
2	Project manager
3	Project value
4	Profession
5	Type of work
6	Business unit

Table 27: Possible pairs

Possible pairs	
1	Type of client – Project manager
2	Type of client – Project value
3	Type of client – Profession
4	Type of client – Type of work
5	Type of client – Business unit
6	Project manager – Project value
7	Project manager – Profession
8	Project manager – Type of work
9	Project manager – Business unit
10	Project value – Profession
11	Project value – Type of work
12	Project value – Business unit
13	Profession – Type of work
14	Profession – Business unit
15	Type of work – Business unit

D.2. Indication of relation between variables

For each pair highlighted green in Table 27 Figure 17 up till Figure 21 provide schematisations of the two variables set against the net margin of the project. For the four pairs the colours indicates the interval of project value at which the particular project falls in. For Figure 21 the colour indicates the business unit (Sliedrecht or Wijhe).

From Figure 17 can be derived that the project value of projects for Rijkswaterstaat is relatively high. Furthermore, it seems quite logical that the project value of the three clients Rijkswaterstaat, provinces and municipality is decreasing. The interval of [> €1 million; < €3 million] seems to occur most often at projects for other contractors. It can be declared that other contractors outsource specialisations of high valued projects.

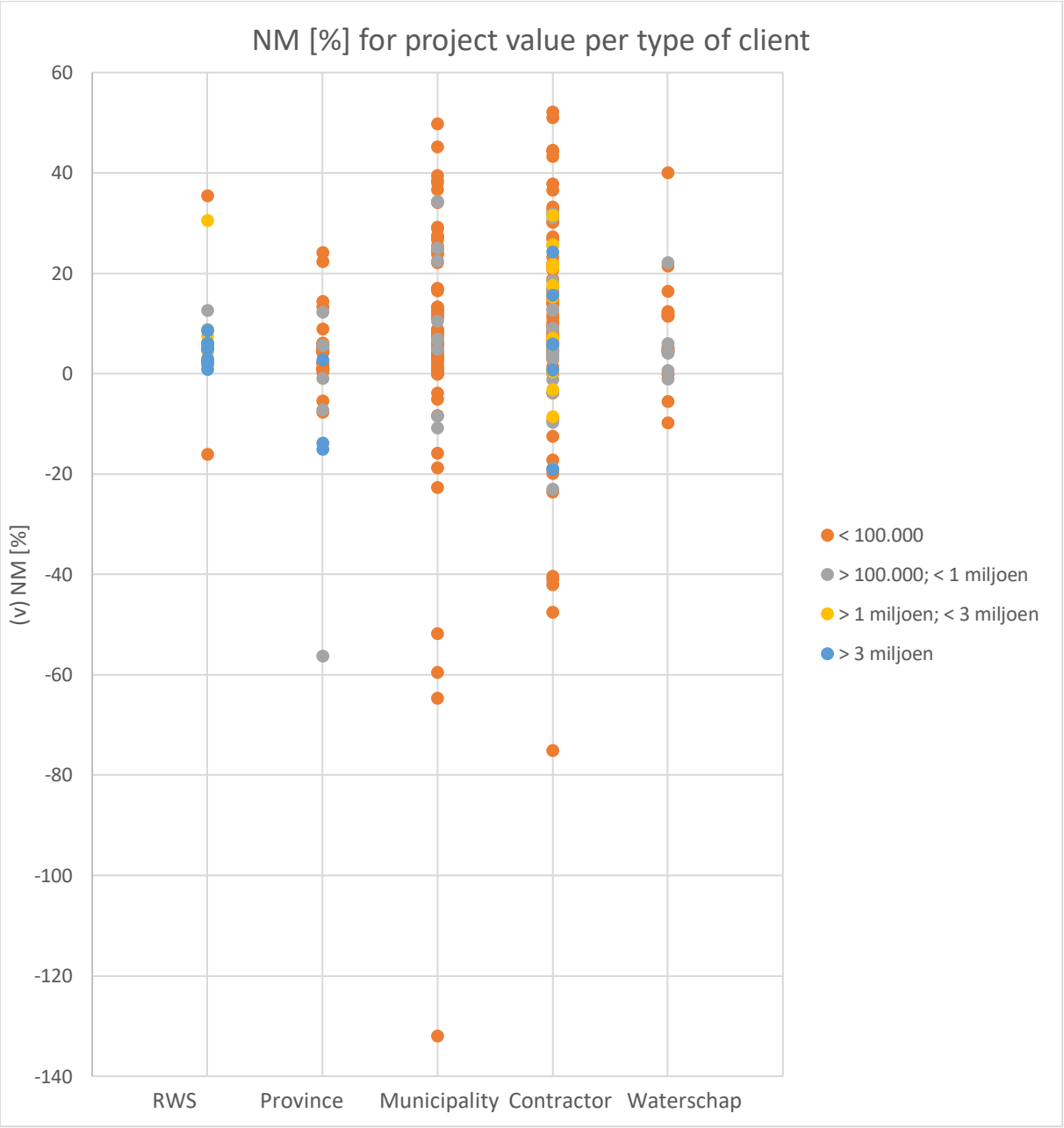

Figure 17:Net margin for project value per type of client

The location of Wijhe is known as a location conducting a lot of maintenance activities, just as corrective or preventive maintenance. The value of this projects is logically low, on the contrary of the location at Sliedrecht, which focuses on new artefacts and multi-year maintenance contracts of high value. (Figure 18)

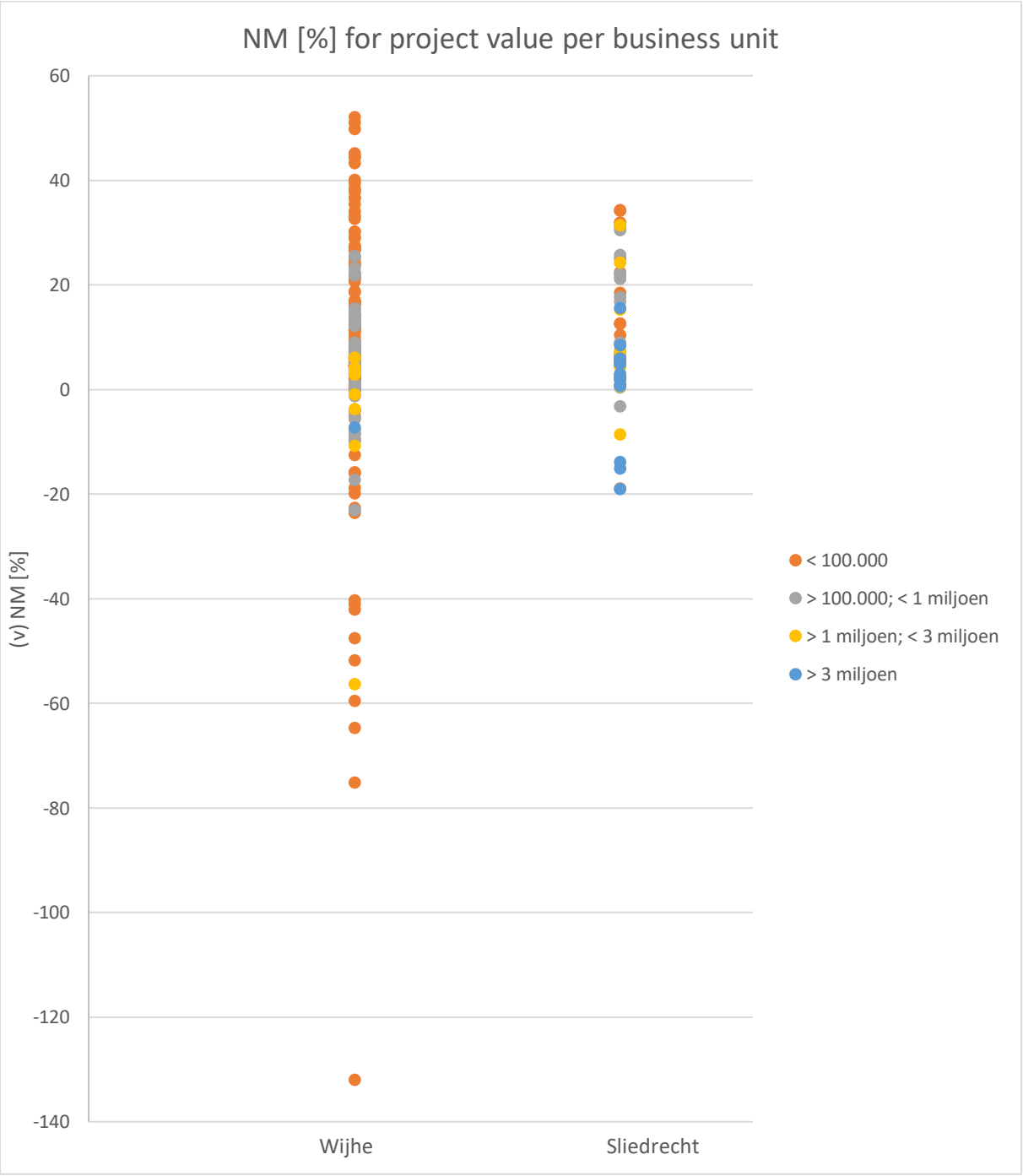

Figure 18: Net margin for project value per business unit

Per project manger the net margin of each project is given in Figure 19. In general the figure shows that, the least projects are conducted by a project manager, the higher the value of projects becomes. In the end all project managers seem to near an average between roughly 0% and 10%.

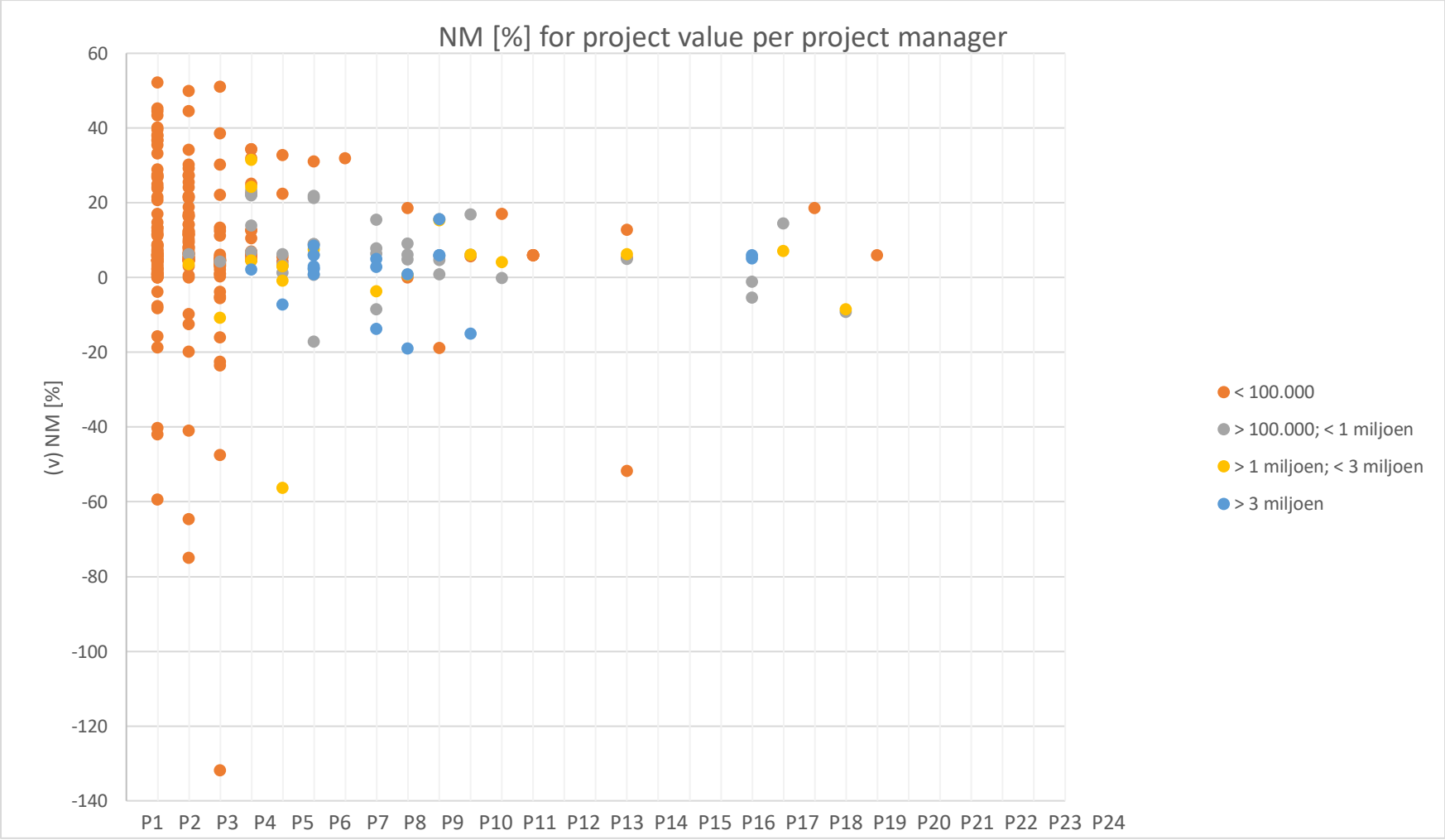

Figure 19: Net margin for project value per project manager

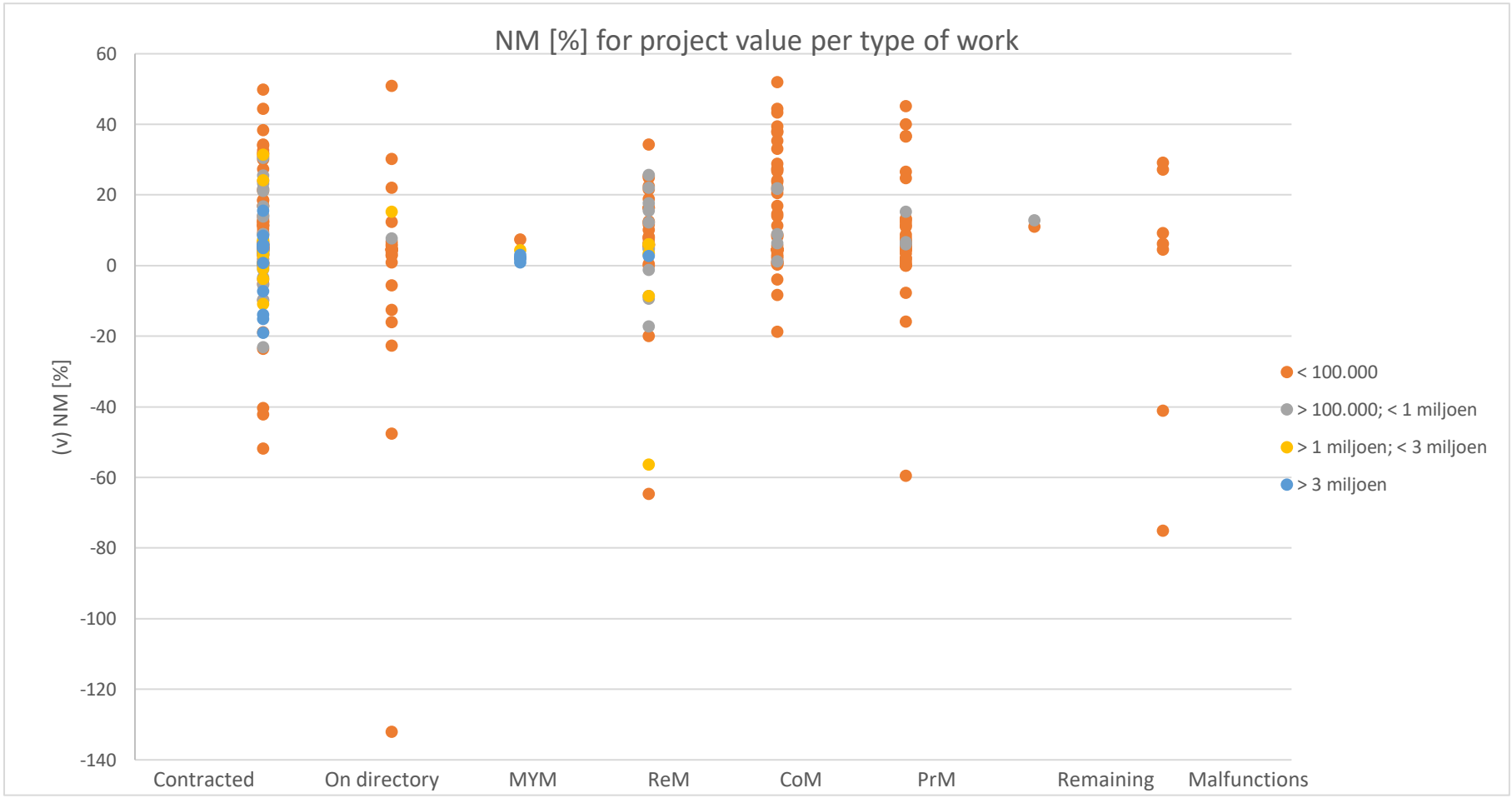

Figure 20: Net margin for project value per type of work

The high density of contracted projects from the location of Sliedrecht (Figure 21) can be declared by the fact that mainly at this location the type of work is not reported properly. As mentioned in section 3.2 a project is assumed as 'contracted' if the real type of work cannot be tracked down.

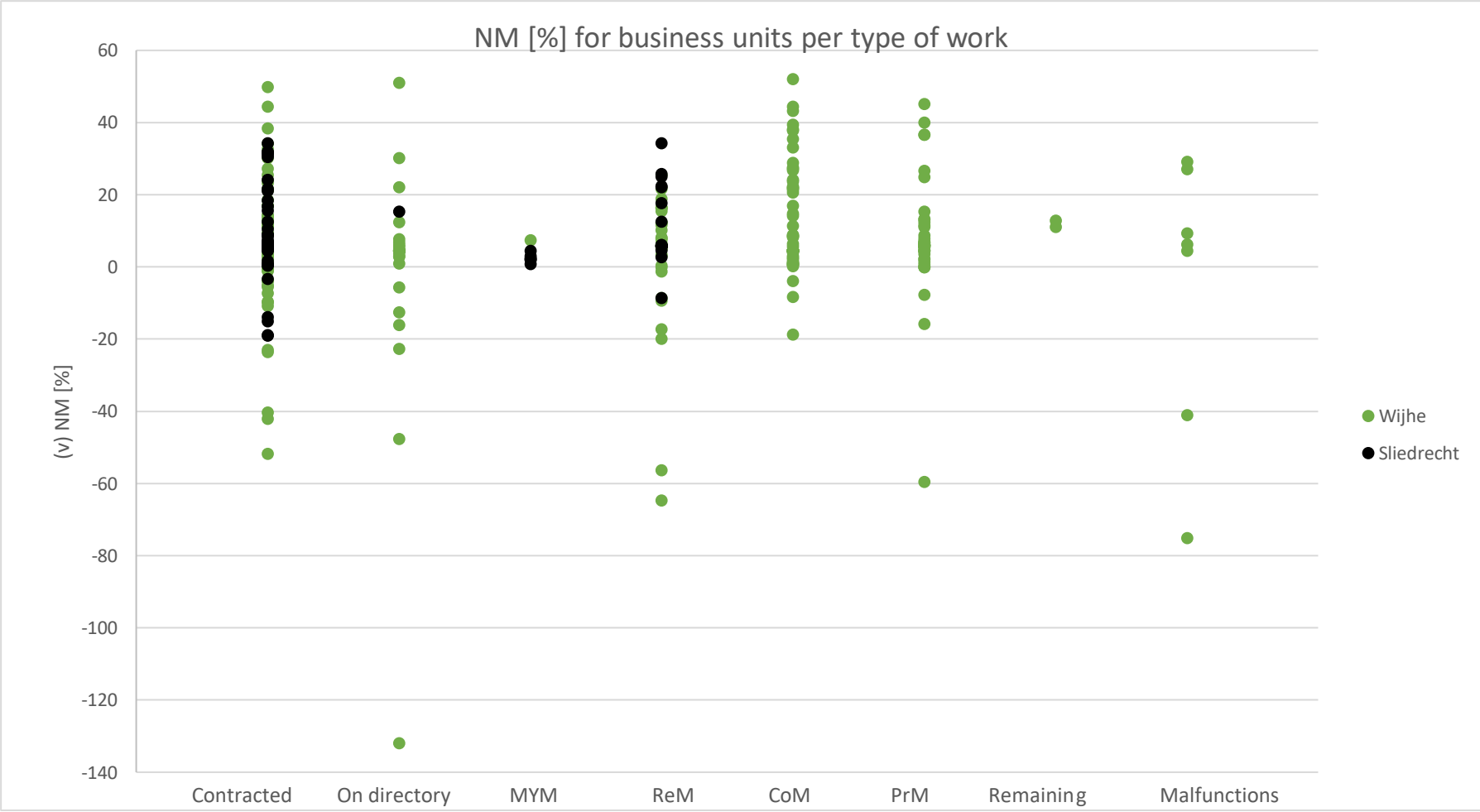

Figure 21: Net margin for business units per type of work

E. Explanation data analysis

For all variables analysed as part of the quantitative data analysis of the financial data a plan of action can be followed according to Figure 22. As can be seen it is of importance to indicate the number of groups per variable. As long as the number is higher than two ANOVA can be used (and in addition of the ANOVA a T-test as part of this process), when the number of groups is two only a T-test can be used.

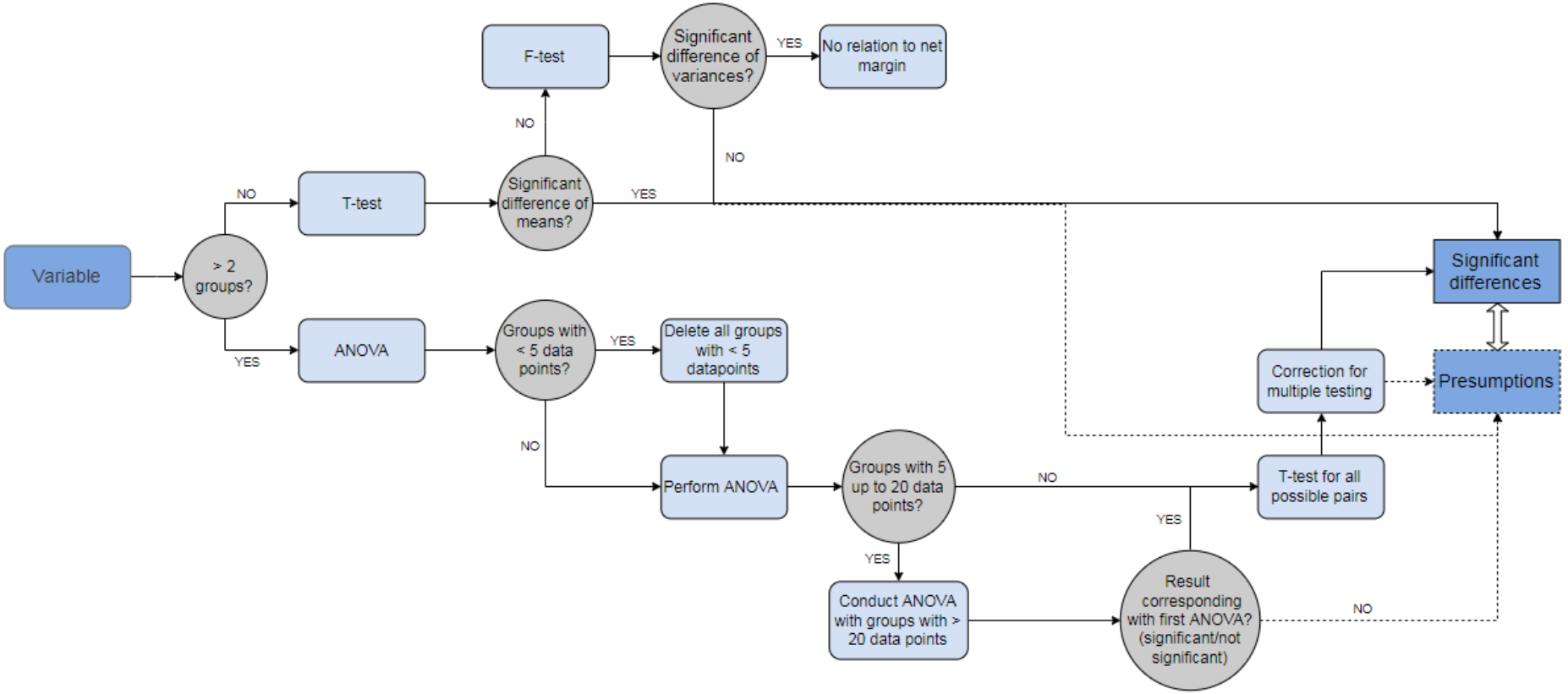

Figure 22: Analysis of variables

F. Statistical analysis of financial data

The appendix provides a detailed elaboration on the results of the data analysis in section 5.2. Appendix F.1. gives the type of test and insight in the amount of datapoints available per group for each variable. The remaining sections each elaborate the analysis of a single variable.

F.1. Conducted tests

In section 3.2 - Data collection it is already mentioned that ANOVA is suited for tests with more than two groups. When only two groups are considered a T-test is the most suitable method. Table 28 overviews the type of test used for each variable. In addition all groups are summed. Since it is declared that the minimum of datapoints is five, and it is highly recommended to only use groups with more than twenty datapoints, it is also mentioned which groups have more than five and more than twenty datapoints. With respect to the ANOVA, the analysis is done twice if there is a difference between the set of groups with more than five and more than twenty datapoints. The groups with less than five datapoints are not considered at all, because of the high unreliability.

Table 28: Overview of variables and datapoints

Variable	Type of test	All groups	Groups with > 5 datapoints	Groups with > 20 datapoints
Prognostication of net margin	T-test	Production [0 – 90%] Production [> 90 – 100%]	Production [0 – 90%] Production [> 90 – 100%]	Production [0 – 90%] Production [> 90 – 100%]
Type of client	ANOVA	Rijkswaterstaat Province Municipality Waterschap Contractor	Rijkswaterstaat Province Municipality Waterschap Contractor	Rijkswaterstaat Province Municipality Waterschap Contractor
Project manager	ANOVA	23 project managers	Eleven project managers	Four project managers
Value of project	ANOVA	< €100.000 > €100.000; < €1 million > €1 million; < €3 million > €3 million	< €100.000 > €100.000; < €1 million > €1 million, < €3 million > €3 million	< €100.000 > €100.000; < €1 million
Profession	ANOVA	Electricity Electrical maintenance Engineering and Installations – Automation & software	Electricity Electrical maintenance Multi-technical maintenance	Electricity

		Mechanical maintenance Multi-technical maintenance		
Business unit	T-test and F-test	Sliedrecht Wijhe	Sliedrecht Wijhe	Sliedrecht Wijhe
Type of work	ANOVA	Contracted work Project on directory Multi-year maintenance Maintenance Corrective maintenance Preventive maintenance Malfunction Remaining	Contracted work Project on directory Multi-year maintenance Maintenance Corrective maintenance Preventive maintenance Malfunction	Contracted work Project on directory Maintenance Corrective maintenance Preventive maintenance

F.2. Prognostication of net margin

In first place the prognostication of projects evaluated. The production of each project [%] is set against the net margin [%] (Figure 23). Evaluating Figure 23 on the eye suggests a potential significant difference between the projects produced less than 90% and projects already produced for more than 90%. To check whether the observation is significant or not a T-test with equal variances is conducted. From Table 29 can be derived that there is a significant difference between projects with a production lower than 90% and projects with a production higher than 90% (Equation 8).

From the T-test can be concluded that there is a significant difference between the financial results prognosticated in the approximate 90% and projects that are (almost) finished.

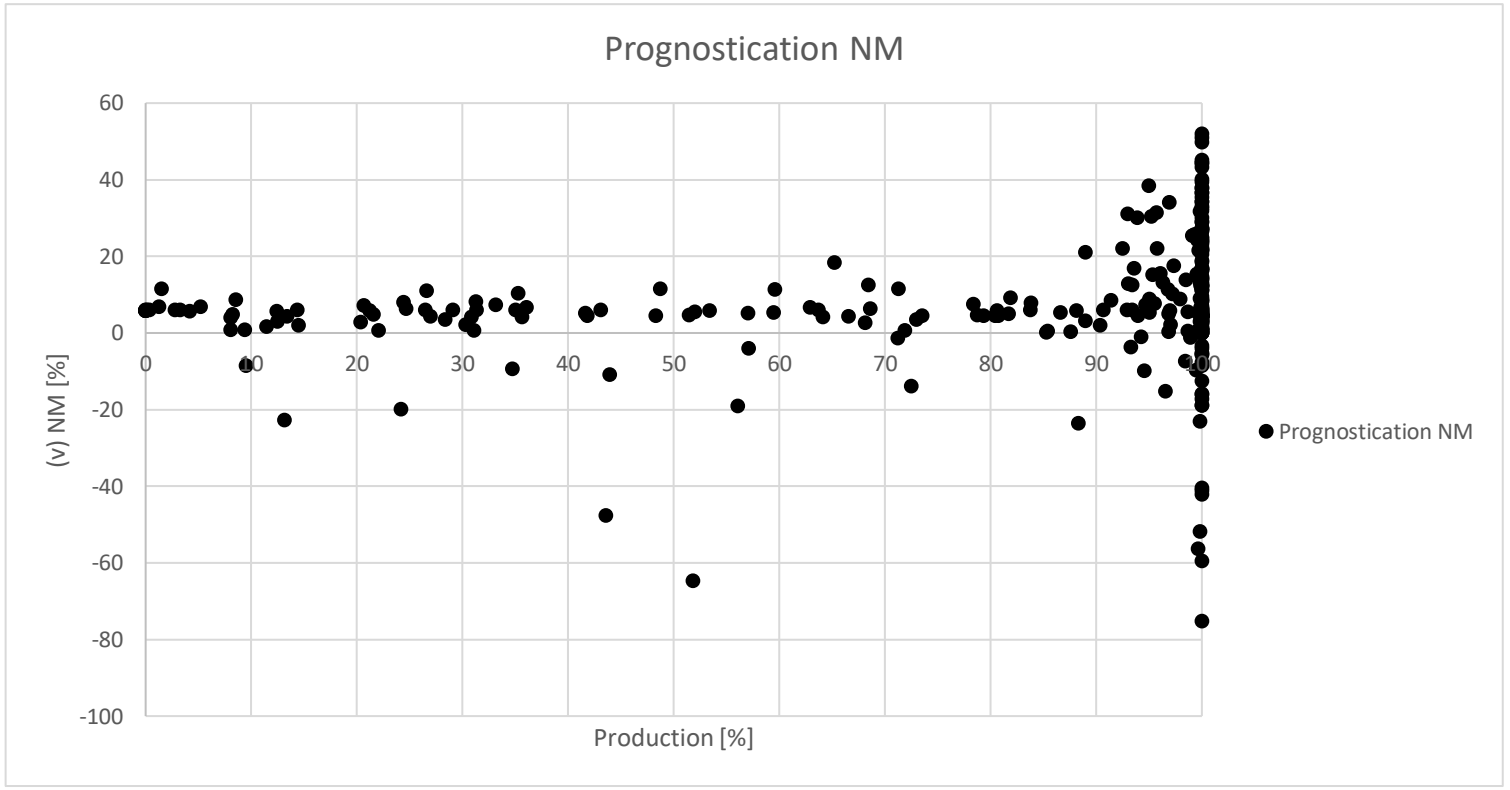

Figure 23: Prognostication of net margin

Table 29: T-test of prognostication of NM

	Production < 90%	Production > 90%
Average	2,7019	8,875630631
Variance	121,5177267	408,964032
No. of observations	100	222
Paired variance	320,0353313	
Estimation of difference between averages	0	
Degrees of freedom	320	
T- statistical data	-2,86547923	

P(T<=t) one-sided	0,002219666
Critical area of T-test: one-sided	2,338057294
P(T<=t) double sided	0,004439331
Critical area of T-test: double sided	2,591280164

Equation 8: T-test result for 'Prognostication of net margin'

$$T_{prognostication} \approx -2{,}87 \leq T_{crit} \approx -1{,}59 \ (CI = 99\%)$$

F.3. Type of client

For all projects the type of client is indicated. There is made distinguish between five types of clients: Rijkswaterstaat, provinces, municipalities, contractors and waterschappen. The one-way ANOVA did not result in a significant difference between at least two groups, neither between more of them (Table 30, Equation 9).

Table 30: ANOVA on 'Type of client'

Summary						
Groups	*No. of datapoints*	*Sum*	*Average*	*Variance*		
Rijkswaterstaat	30	195,37	6,512333333	72,74946678		
Province	38	81,7	2,15	153,6801351		
Municipality	98	682,82	6,96755102	523,0842888		
Contractor	138	202,32	1,466086957	4992,858614		
Waterschap	22	181,95	8,270454545	111,5762141		
Variance analysis						
Source of variance	*Squared sum*	*Degrees of freedom*	*Average squares*	*F*	*P-value*	*Critical area F-test*
Between groups	2464,753351	4	616,1883377	0,26553431	0,899990937	2,399776972
Within groups	744899,8061	321	2320,560144			
Total	747364,5595	325				

Equation 9: No significant difference of 'Type of client'

$$F_{client} \approx 0{,}27 \leq F_{crit} \approx 2{,}40 \ (CI = 95\%)$$

The pairwise T-test for each combination substantiates that there are no significant differences between groups. Since the total of groups is five, there are ten possible pairs. For each pair the T-test resulted in a chance higher than $cf = \frac{0,05}{10} = 0,005$ (Table 31).

Table 31: T-test results for each 'type of client' pair (ranked on value)

Rank	T-test pair	Value
10	Municipality – Waterschap	0,94660828
9	Province – Contractor	0,892763939
8	Rijkswaterstaat – Municipality	0,576674992
7	Rijkswaterstaat – Waterschap	0,524517601
6	Municipality – Contractor	0,387424792
5	Rijkswaterstaat – Contractor	0,31781217
4	Contractor – Waterschap	0,260961838
3	Province – Municipality	0,12050132
2	Province – Waterschap	0,056415923
1	Rijkswaterstaat – Province	0,050151614

Although there are not found significant differences between clients, it is notable that provinces seem to influence the net margin negatively, since the top three of lowest values are all concerned with provinces and the average net margin of provinces is quite low (Table 30). Therefore, the NOT significant presumption can be made that projects commissioned by provinces result in lower net margins.

F.4. Project manager

In total there are 23 different project manager numbers within the financial system. So, in fact there can be distinguished 23 people who are responsible and can be compared with each other. However, some project manager number contain one single project, for example movement to a new location. This kind of 'projects' are not taken into account during the analysis. Besides there are eleven numbers with less than five datapoints and one number with five exactly the same data points which is considered as unreliable. This leaves alone twelve project manager numbers with all more than five datapoints, that are used in the analysis. Since it is recommended only conduct ANOVA on groups with more than five, but preferably more than twenty datapoints (see ANOVA), the analysis is done twice. Once for all project manager numbers with more than five datapoints, and once for all project managers with more than twenty datapoints.

More than five projects

Table 32: ANOVA on 'Project manager' (>5 projects)

Summary						
Groups	*No. of datapoints*	*Sum*	*Average*	*Variance*		
P1	101	956,33	9,468613861	288,8744501		
P2	44	22,1	0,502272727	642,5967203		
P3	71	535,76	7,545915493	347,4217874		
P4	30	459,24	15,308	120,6220234		
P5	14	50,05	3,575	439,8418577		
P6	9	63,28	7,031111111	88,50471111		
P7	7	38,92	5,56	37,80936667		
P8	6	24,32	4,053333333	161,3325067		
P9	5	-32,74	-6,548	138,07157		
P10	6	11,71	1,951666667	76,58021667		
P11	6	27,15	4,525	153,62255		
Variance analysis						
Source of variance	*Sum of squares*	Degrees of freedom	*Average of squares*	*F*	*P-value*	*Critical area F-test*
Between groups	5889,979476	10	588,9979476	1,814249981	0,057789	1,620964494
Within groups	93499,46846	288	324,6509322			
Total	99389,44794	298				

Equation 10: Significant difference of 'Project manager' (>5 projects)

$$F_{PM(>5)} \approx 1{,}81 \geq F_{crit} \approx 1{,}62 (CI = 90\%)$$

More than twenty projects

Table 33: ANOVA on 'Project managers' (>20 projects)

Summary				
Groups	*No. of datapoints*	*Sum*	*Average*	*Variance*
P1	101	956,33	9,468613861	288,8744501
P2	44	22,1	0,502272727	642,5967203
P3	71	535,76	7,545915493	347,4217874
P4	30	459,24	15,308	120,6220234

Variance analysis						
Source of variance	*Sum of squares*	Degrees of freedom	*Average of squares*	*F*	*P-value*	*Critical area F-test*
Between groups	4308,065469	3	1436,021823	4,120595351	0,00711	3,863539073
Within groups	84336,66777	242	348,4986272			
Total	88644,73324	245				

Equation 11: Significant difference of 'Project manager' (>20 projects)

$$F_{PM(>20)} \approx 4{,}12 \geq F_{crit} \approx 3{,}86\ (CI = 99\%)$$

As well the analysis on project managers with more than five projects as the analysis on project managers with more than twenty projects resulted in a F-value indicating that there is a significant difference between at least two groups within the entire set. By further investigation on outstanding (positive or negative) project managers by conducting pairwise T-tests requires a correction factor ($cf = \frac{P}{N} = \frac{0{,}01}{12} \approx 0{,}001$). From Table 34 can be deduced that the T-test pair 'P2-P4' ($\approx 0{,}001$) results in a significant difference of averages when the correction factor is taken into account. The T-test pairs marked green indicate that the test between those two groups can be considered as quite reliable, since both groups contain more than twenty datapoints.

Table 34: T-test results for each 'project manager' pair (ranked on value)

Rank	T-test pair	Value	Rank	T-test pair	Value	Rank	T-test pair	Value
55	P5 – P8	0,950855661	36	P3 – P7	0,542811968	17	P7 – P9	0,180638495
54	P8 – P11	0,949377532	35	P2 – P11	0,537843594	16	P6 – P9	0,165546927
53	P5 – P11	0,901480918	34	P3 – P5	0,518588851	15	P3 – P9	0,159677519
52	P3 – P6	0,894820959	33	P1 – P6	0,505684225	14	P1 – P9	0,141540395
51	P7 – P11	0,857762578	32	P1 – P3	0,491007122	13	P2 – P3	0,115074579
50	P5 – P10	0,809819721	31	P7 – P10	0,419599354	12	P4 – P9	0,098795953
49	P7 – P8	0,798562189	30	P1 – P11	0,388905839	11	P1 – P10	0,096300631
48	P2 – P10	0,784587943	29	P1 – P8	0,358418477	10	P4 – P11	0,090095702
47	P5 – P7	0,747611561	28	P1 – P5	0,329602507	9	P4 – P8	0,085175474
46	P8 – P10	0,746314238	27	P6 – P10	0,30732414	8	P4 – P5	0,065827331
45	P6 – P7	0,712027116	26	P2 – P7	0,264760668	7	P4 – P6	0,041758314
44	P10 – P11	0,687551731	25	P2 – P9	0,24852272	6	P1 – P2	0,035932792
43	P6 – P11	0,68389405	24	P9 – P10	0,227133604	5	P1 – P4	0,029049189
42	P2 – P5	0,65432152	23	P3 – P10	0,214238952	4	P3 – P4	0,010931702
41	P6 – P8	0,635438113	22	P5 – P9	0,209408445	3	P4 – P10	0,010614632

40	P3 – P11	0,60117876	21	P8 – P9	0,202488526	2	P4 – P7	0,005734136
39	P5 – P6	0,596643253	20	P9 – P11	0,196402861	1	P2 – P4	0,001068857
38	P2 – P8	0,591983458	19	P1 – P7	0,195671422			
37	P3 – P8	0,555278377	18	P2 – P6	0,195168711			

The ANOVA in itself statistically demonstrated that the concerned project manager can make a difference in obtaining a desirable net margin. The pairwise T-tests indicated that there is at least one relation (P2 – P4) at which can be said with a reliability of 90% that there is a difference in the net margins obtained by both project managers. Although NOT significant demonstrated, it is remarkable that P4 has nine of its relations with other project managers within the top 10 ranked values. Considering the quite high average in combination with the relatively low variance of this project manager (Table 33) it can be presumed that this project manager is able to achieve higher margins then other project managers.

F.5. Project value

The financial value of a project is of importance for the total sales volume. Besides, higher projects contain higher risk because of the higher value. The projects are divided into four groups, respectively < €100.000, €100.000 - €1 million, €1 million - €3 million and > €3 million. Table 35 gives insight in the descriptive statistics of each group and the variance analysis.

Table 35: ANOVA on 'Project value'

Summary						
Groups	*No. of datapoints*	*Sum*	*Average*	*Variance*		
< €100.000	234	899,08	3,842222222	3148,950439		
€100.000 - €1 million	56	394,89	7,051607143	112,0919156		
€1 million - €3 million	17	33,4	1,964705882	334,834839		
> €3 million	19	16,79	0,883684211	75,52162456		
Variance analysis						
Source of variance	*Sum of squares*	*Degrees of freedom*	*Average squares*	*F*	*P-value*	*Critical area F-test*
Between groups	777,3052168	3	259,1017389	0,11174951	0,953200971	2,632652217
Within groups	746587,2543	322	2318,593957			
Total	747364,5595	325				

Equation 12: No significant difference of 'Project value'

$$F_{value} \approx 0{,}11 \leq F_{crit} \approx 2{,}63 \ (CI = 95\%)$$

Additional test

Because the number of datapoints for projects between one and three million and above three million are below the recommended amount of twenty (ANOVA), the analysis is also done for three groups, respectively < €100.000, €100.000 - €1 million and > €1 million. However, the result presented in Table 36 and Equation 13 shows that there is still a very high chance of coincidence and F-value is not coming even close to F_{crit}.

Table 36: ANOVA on 'Project value' (additional test)

Summary						
Groups	*No. of datapoints*	*Sum*	*Average*	*Variance*		
< €100.000	234	899,08	3,842222222	3148,950439		
€100.000 - €1 million	56	394,89	7,051607143	112,0919156		
> €1 million	36	50,19	1,394166667	192,2066193		
Variance analysis						
Source of variation	*Sum of squares*	*Degrees of freedom*	*Average squares*	*F*	*P-value*	*Critical area F-test*
Between groups	766,8202074	2	383,4101037	0,165874415	0,847224734	3,023689426
Within groups	746597,7393	323	2311,448109			
Total	747364,5595	325				

Equation 13: No significant difference 'Project value' (additional test)

$$F_{value} \approx 0{,}17 \leq F_{crit} \approx 3{,}02 \ (CI = 95\%)$$

Different gradations of financial values of projects did not result in significant differences of net margins between groups, which can be deduced from both the low value of *F* as from the high *P-value* indicating a high chance of coincidence. The descriptive statistics in the summary of Table 35 nevertheless show some information that have to noted. The average of projects with a value between €100.000 and €1 million have clearly higher and the variance relatively low, compared to the other three groups. Furthermore, it seems quite logical that as well the net margin as the variance of projects decrease when their financial value is increasing.

F.6. Profession

Different profession of projects could be logical causations for differences in achieved revenues and net margins. Unfortunately, the dataset contains a lot datapoints from one group (electricity), but the remaining groups are limited to a few. Despite is was not expected to find significant differences because of

a lack of datapoints from the majority of the groups, an ANOVA is conducted (Table 37). As shown in Equation 14 the F-value is not even close to the critical value to consider the result as significant, what could also be expected because of the lack of datapoints.

Table 37: ANOVA on 'Profession'

Summary						
Groups	*No. of datapoints*	*Sum*	*Average*	*Variance*		
Electricity	300	1175,17	3,917233333	2489,338857		
Electrical maintenance	17	55,72	3,277647059	87,99670662		
Multi-technical maintenance	5	48,34	9,668	141,15297		
Variance analysis						
Source of variation	*Sum of squares*	*Degrees of freedom*	*Average squares*	*F*	*P-value*	*Critical value F-test*
Between groups	171,3178505	2	85,65892526	0,036614968	0,964051304	3,024042187
Within groups	746284,8774	319	2339,451026			
Total	746456,1952	321				

Equation 14: No significant difference 'Profession'

$$F_{profession} \approx 0{,}04 \leq F_{crit} \approx 3{,}02\ (CI = 95\%)$$

During the interviews it was often the engineering aspect of electricity components that was mentioned as a problem, which declares the proposition that electrical related projects will score worse with respect to the net margin. Because of that reason it seemed logical to take the profession of projects as a variable. Unfortunately the column 'Profession' is not used adequately, or the column is unnecessary since almost all kind of projects are defined as 'Electricity' projects.

F.7. Business unit

All projects within the division of BS&G are settled at the location of Sliedrecht or Wijhe. In general, it can be said that from the location of Sliedrecht the 'big valued' projects are conducted, which take a lot of time individually. At Wijhe most projects have lower financial values and a lot of these maintenance activities do not take a lot of time. Since the interviews did not result in mentions about positive or negative mentions about specific locations of BS&G it can

be expected that there is no significant difference between both locations. Since there are only two groups that can be distinguished, Sliedrecht and Wijhe, ANOVA is not suited. For the variable 'Business unit' a T-test and F-test (Table 38) are conducted. Equation 15 and Equation 16 provide the comparison between the *T-value* and *F-value* against their critical values.

Table 38: T-test (left) and F-test (right) on 'Business unit'

T-test on 'Business unit'		
Location	*Wijhe*	*Sliedrecht*
Average	3,269254902	7,190140845
Variance	2827,121405	406,0276586
No. of observations	255	71
Estimation of difference in averages	0	
Degrees of freedom	297	
T	-0,956443094	
P(T<=t) one-sided	0,169813144	
Critical area T-test: one-sided	1,650000301	
P(T<=t) double sided	0,339626288	
Critical area T-test: double sided	1,967983525	

F-test on 'Business Unit		
Location	*Wijhe*	*Sliedrecht*
Average	3,269254902	7,190140845
Variance	2827,121405	406,0276586
No. of observations	255	71
Degrees of freedom	254	70
F	6,96287887	
P(F<=f) one-sided	5,65979E-17	
Critical area F-test: one sided	1,393876974	

Equation 15: No significant difference between averages of 'Business unit'

$$T_{BU} \approx -0{,}96 \geq T_{crit,double} \approx -1{,}97 \ (CI = 95\%)$$

Equation 16: Significant difference between variances of 'Business unit'

$$F_{BU} \approx 6{,}96 \geq F_{crit} \approx 1{,}39 \ (CI = 95\%)$$

According to the T-test conducted there is significant relation between the two business units. The T-test focuses on a significant difference between averages of both locations. Therefore, the proposition that there is no significant difference between the net margins of projects when the location is taken as variable. However, the F-test, focusing on the difference of variances shows a significant difference. It can be declared that the variance of projects at Wijhe is much higher, since the number of projects is quite high, but in general the value is quite low. Therefore, it can imagined that there are small that sometimes have huge net margins and sometimes go deeply negative, without influencing the average margin a lot. The number of projects conducted at Sliedrecht is much lower, because of the higher financial value. The margin of single projects is therefore of higher influence on the overall margin and needs to be controlled more per project.

F.8. Type of work

As part of the project name in the financial system, the type of work is recorded. The projects can be divided into seven different groups, respectively contracted projects, projects on directory, corrective, preventive and regular maintenance, multi-year maintenance and malfunctions. As can be seen in Table 39 the last two groups contain less than twenty datapoints. To control whether a significant or not significant difference could be caused by the unreliability due to a lack of datapoints the ANOVA is done twice. Once for all groups, and once only for groups containing more than twenty datapoints (Table 40). Both tests resulted in a an F-value indicating a significant difference between at least two groups (Equation 17 and Equation 18).

More than five projects

Table 39: ANOVA on 'Type of work' (>5 projects)

Summary						
Groups	*No. of datapoints*	*Sum*	*Average*	*Variance*		
Contracted projects	127	893,76	7,037480315	223,6530158		
Corrective maintenance	56	741,21	13,23589286	219,5426465		
Regular maintenance	49	272,6	5,563265306	301,7486141		
Preventive maintenance	45	348,16	7,736888889	242,8698174		
Projects on directory	29	-22,11	-0,762413793	908,1040833		
Multi-year maintenance	7	22,52	3,217142857	4,73112381		
Malfunctions	7	-39,58	-5,654285714	1472,579195		
Variance analysis						
Source of variance	*Sum of squares*	*Degrees of freedom*	*Average squares*	*F*	*P-value*	*Critical area F-test*
Between groups	5270,162584	6	878,3604306	2,757095342	0,012607851	2,12758706
Within groups	99716,10724	313	318,5818123			
Total	104986,2698	319				

Equation 17: Significant difference 'Type of work' (>5 projects)

$$F_{type\_work(>5)} \approx 2{,}76 \geq F_{crit} \approx 2{,}13 \ (CI = 95\%)$$

More than twenty projects

Table 40: ANOVA on 'Type of work' (>20 projects)

Summary				
Groups	*No. of datapoints*	*Sum*	*Average*	*Variance*

Contracted projects	127	893,76	7,037480315	223,6530158		
Corrective maintenance	56	741,21	13,23589286	219,5426465		
Regular maintenance	49	272,6	5,563265306	301,7486141		
Preventive maintenance	45	348,16	7,736888889	242,8698174		
Projects on directory	29	-22,11	-0,762413793	908,1040833		
Variance analysis						
Source of variance	*Sum of squares*	*Degrees of freedom*	*Average squares*	*F*	*P-value*	*Critical area F-test*
Between groups	4023,360772	4	1005,840193	3,332420647	0,010862806	2,40163998
Within groups	90852,24532	301	301,8347021			
Total	94875,60609	305				

Equation 18: Significant difference 'Type of work' (>20 projects)

$$F_{type\_work(>20)} \approx 3{,}33 \geq F_{crit} \approx 2{,}40 \ (CI = 95\%)$$

To investigate which pairwise relations result in a significant difference of means for the variable 'type of work' for all possible pairs a T-test is conducted. The results of all T-test are ranked on value (Table 41). The pairs marked green indicate that the result of this single T-test is reliable, since it is for both of the groups the case that the number of datapoints is more than twenty. The correction factor for multiple testing is taken into account, which is $cf = \frac{P}{N} = \frac{0{,}05}{21} \approx 0{,}002$. When the correction factor is taken into account, from Table 41 can be deduced that only one pair indicate a significant difference (Corrective maintenance – Multi-year maintenance). Comparing the averages of these two (corrective maintenance is 13%, multi-year maintenance 3%) it can be said that the results booked on corrective maintenance are significant better than results booked on multi-year maintenance. Because of the amount of datapoints of multi-year maintenance it must be said that it could be the case that result is not completely reliable.

Table 41: T-test results for each 'type of work' pair (ranked on value)

Rank	T-test pair	Value	Rank	T-test pair	Value
21	Contracted projects – Preventive maintenance	0,805421279	10	Contracted projects – Projects on directory	0,182809665
20	Projects on directory – Malfunctions	0,761182167	9	Preventive maintenance – Projects on directory	0,180784795
19	Regular maintenance – Preventive maintenance	0,722344245	8	Regular maintenance – Projects on directory	0,1379506
18	Contracted projects – Regular maintenance	0,601876396	7	Corrective maintenance – Preventive maintenance	0,079234556
17	Multi-year maintenance – Malfunctions	0,56368097	6	Preventive maintenance – Multi-year maintenance	0,072604209
16	Projects on directory – Multi-year maintenance	0,487259835	5	Corrective maintenance – Projects on directory	0,027310763
15	Regular maintenance – Malfunctions	0,473197737	4	Contracted projects – Multi-year maintenance	0,01739365
14	Contracted projects – Malfunctions	0,416500633	3	Corrective maintenance – Regular maintenance	0,011984471

13	Preventive maintenance – Malfunctions	0,395439599	2	Contracted projects – Corrective maintenance	0,006602576
12	Regular maintenance – Multi-year maintenance	0,373465899	1	Corrective maintenance – Multi-year maintenance	1,7474E-05
11	Corrective maintenance – Malfunctions	0,242753144			

Although it cannot assumed that other pairs have significant differences of results, it can be presumed that corrective maintenance is the best performing type of work. The pair corrective maintenance – malfunctions disregarded, five of the six pairs are in the top seven of lowest values. All these values indicate a probability of less than 8% that the calculated difference is because of coincidence.