Fair competition

How to apply the 'Economically Most Advantageous Tender' (EMAT) award mechanism in the Dutch construction industry

Marco Dreschler

Cover illustration: the pair of scales symbolises the main theme of this thesis; in the award phase the procurer evaluates bids on 'value for money'. The value of a bid is represented by a transparent 'multi-dimensional volume' and the price of that bid is represented by a bag of money.

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Proefschrift

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door

Marco DRESCHLER

civiel ingenieur
geboren te Jayapura, Indonesië

Preface

Dear reader, for you this preface is probably the first glimpse of this thesis; for me however, it is the end of a long and tough journey. Now that I have arrived at the end of this journey, I am immensely pleased with the result, which is presented in the book before you.

When explaining to people what I have been doing in the last five years, I noticed that procurement is a hot item, which is remarkable, since it is also often considered to be a dull topic. Furthermore I noticed that besides the construction industry also other industries are struggling with procurement regulation in general and lowest price based awarding in particular.

As I mentioned, the journey was tough, especially at the beginning. Remember the period just after the parliamentary enquiry into collusion in the Dutch construction industry. Experts from various disciplines were furiously debating the problem, definitions, causes, approaches, solutions and implementations. Consultants, scholars and politicians entered the arena which was traditionally the battleground of procurers, suppliers and subcontractors. So to speak, it was a total chaos.

So it turned out to be difficult to single out thè problem in the Dutch construction industry. Of course there is not one ultimate solution; many matters need to add up in order to have a good procurer-market relationship. But with the identification of the difficulties surrounding the Economically Most Advantageous Tender (EMAT) award mechanism I think I succeeded in finding an aspect which forms a barrier for implementing improvements leading to better products and a better interaction between procurers and suppliers in the Dutch construction industry.

In the title I use the word "fair". To prevent disappointments it has to be said that this title could be slightly misleading, because there is no philosophical debate about the concept of fairness in this thesis. However, the title sums up the main theme of the thesis; a fair evaluation of bids is the leading concept in procurement regulation. Furthermore I believe that a fair evaluation is also the basis for a good procurer-supplier relationship and good market dynamics. This thesis presents some of the ways in which procurers have tried to make their fair evaluation explicit.

Please note that this thesis is written by an engineer and not by a lawyer. As such, some of the wordings will not correspond with the words lawyers use. For instance, in European Guideline 2004/18/EC (which is the basis for the subject of this thesis) the word "criterium" has two meanings. It can be interpreted as "award mechanism" or as one of the criteria that is used in the EMAT award mechanism. In the latter case I would suggest to call those criteria "award criteria". But lawyers have reserved that definition for the first meaning. Now lawyers can accuse me of switching definitions, like defining that from now on blue is green and vice versa. But by looking at how the word criterium is used in other disciplines and in normal speaking language, it seems it were lawyers who switched the meaning in the first place. Since I address a wider audience than just lawyers, I use the more practical definitions.

I owe many thanks to people that have helped me. Without them, this investigation could never have been completed. First of all I want to thank my promoter Hennes de Ridder for providing the possibility for doing this research, for inspiring me and for setting an example. Secondly there is Reza Beheshti, my daily supervisor who navigated me through the difficult parts of doing a PhD research and who always stated his belief that I could finish this project. Bart Luiten from TNO also played an important role in monitoring progress and safeguarding the scientificity of the research. In this regard I also want to thank the other members of the promotion committee. In addition I want to thank professors Monica Chao-Duivis, Jan Telgen and Andre Dorée for their valuable contributions.

During the investigation, the input of several field experts was necessary. Many people generously provided information. I especially want to thank the experts involved at the validation meeting (Appendix H). From those people I especially want to express my gratitude to Siem Roetman and Hugo Crucq for generously sharing their information with me. Without that, the investigation would not have progressed as much as it has done now.

I want to thank my colleagues at the section Design and Construction Processes. Martien Reniers, who has been a roommate for a long time. Edwin Dado for his positive attitude and jokes. Jules Verlaan, for his many jokes and anecdotes. Roommate Ruben Vrijhoef for his excellent sense of humour and encyclopedic knowledge of van Kooten and de Bie quotes. Sandra and Gina for their support. The student assistants for their zeal and creating a good atmosphere. Furthermore I want to thank all the other colleagues I did not mention explicitly. Looking back, I can say I was lucky to be in such a humoristic section; it was great!

I also want to thank the many fellow PhD students I met in the conference circuit and on other occasions. You are like fellow travellers because you all know the

Summary

The research presented in this thesis contains a part of the ongoing effort to improve the situation of the Dutch construction sector.

For at least the last decade, a number of measures known as integrated contracting has been heralded as the solution for many problems in the Dutch construction industry.

One of the main reasons for integrated contracting is to stimulate suppliers adopting innovative solutions. The innovative solutions can lead to bids with a lower price, more value or both. However, not all possibilities of the integrated contracting philosophy are utilised, due to the dominance of the lowest price award mechanism. Effective integrated contracting calls for the application of the Economically Most Advantageous Tender (EMAT) award mechanism, which increases the chance for bids with a better value price ratio.

However, the application of the EMAT award mechanism is not widespread, because it is perceived as more complicated than the traditional lowest price award mechanism. The main barrier for the implementation of EMAT is the lack of information on how to formulate suitable EMAT award mechanisms, leading to the main question of this research:

Which EMAT award mechanisms are suitable for the Dutch construction industry?

The research takes an empirical approach in order answer this question. First, suitability requirements are formulated. Then, information is collected on EMAT award mechanisms that are applied in the procurement practice. The matching of the two leads to an overview of suitable EMAT award mechanism elements that are then combined into a decision tree.

Several EMAT types were encountered during this investigation. In order to analyse these different types, the value price model is developed. The value price model is a graphical representation of a procurement situation.

Two preference systems are distinguished namely a system that bases preference on the highest value price ratio and a system that bases preference on the highest difference between value and price.

The introduction of several constraints in the value price model defines the procurement space. Furthermore, the strategies of 'price minimisation', 'value maximisation' and 'value price optimisation' can be represented in the model. Based on this model, the concept of 'bidding freedom' is introduced. The bidding freedom is the share of the theoretically maximum possible added value compared to the price of the theoretical most expensive competitive bid.

Several requirements determine whether an EMAT award mechanism is suitable or not. Legal requirements are 'non-discrimination', 'proportionality' and 'transparency'. Practical requirements are 'sufficient bidding freedom', 'simplicity and elegance' and the safeguarding of traditional project management requirements.

The properties of twenty-four EMAT award mechanisms that were applied in practice are presented. Four main types are distinguished; the point system (six cases), the price correction system (eleven cases), the ratio system (two cases) and the value maximisation system (one case). Several developments are identified. The average "bidding freedom" is about 30% for cases from the civil sector and about 20% for the commercial sector, amounting to a combined bidding freedom of about 25%. In the civil sector, the most used award criterion is a process quality criterion, i.e. 'quality of the project management plan'. Most used award criterion in the commercial sector is 'functionality of the built object', which is a product quality criterion.

The 'value minus price' system and the 'value price ratio' system are both considered suitable. The design contest system should be discouraged. There is a preference for the price correction system over the point system when one chooses for a 'value minus price' system.

Elements that should not be applied are weighed prices, discrete price-point relationships, discrete performance-money relationships, comparative score determination and price dependant value determination.

Most striking observations were 1) the sudden appearance of ratio systems at the end of 2007, 2) the conclusion that procurement practice applies EMAT elements or systems that should be discouraged, and 3) the observation that the choice between procurement profit and profitability is not clear.

Based on this research, procurers are recommended to use the developed EMAT award mechanism decision tree and to use the value price model to present results. Furthermore it will be rewarding for them to keep the EMAT award mechanism as simple as possible and to take eventual budgetary consequences of EMAT into account. Also, procurers are recommended to use curved

performance-money relationships when appropriate and to manage knowledge. Finally, it is recommended that in the phases preceding the award phase enough design freedom is left, in order to keep awarding based on EMAT useful.

Traditional construction companies operating in markets with integrated contracts are recommended to develop themselves towards integrated suppliers in order to remain competitive.

Recommended topics for further investigation are the influence of the application of EMAT on the success of projects and on the reliability of bids. Furthermore it can be worthwhile to investigate whether the award criteria can also be used in other phases of the construction lifecycle. Finally the possibilities of streamlining and objectifying the award phase by the use of advanced ICT applications are interesting topics for further investigation.

The policy of several Dutch governmental agencies to apply integrated contracting promises a bright future for the EMAT award mechanism.

Dutch summary (samenvatting)

Het in dit proefschrift gepresenteerde onderzoek maakt deel uit van de lopende inspanningen om de situatie van de Nederlandse bouw te verbeteren.

Al meer dan tien jaar wordt het "geïntegreerd contracteren" uitgedragen als de oplossing voor vele problemen in de Nederlandse bouw.

Eén van de voornaamste redenen voor het geïntegreerd contracteren is het stimuleren van innovatieve oplossingen. De innovatieve oplossingen kunnen tot aanbiedingen leiden met een lagere prijs, meer waarde, of beide. Door de dominantie van het laagste prijs gunningsmechanisme wordt een groot gedeelte van deze mogelijkheden echter niet benut. Voor effectief geïntegreerd contracteren is toepassing van het gunningscriterium Economisch Meest Voordelige Aanbieding (EMVA) nodig.

De toepassing van het EMVA gunningsmechanisme is niet wijdverspreid omdat het als moeilijker wordt ervaren dan het traditionele gunnen op de laagste prijs. De belangrijkste barrière voor de toepassing van EMVA is het gebrek aan betrouwbare informatie over hoe geschikte EMVA gunningsmechanismen te formuleren, wat tot de hoofdvraag van dit onderzoek leidt:

Welke EMVA gunningsmechanismen zijn geschikt voor de Nederlandse bouwsector?

Om deze hoofdvraag te beantwoorden is er voor een empirisch benadering gekozen. Eerst worden er geschiktheideisen geformuleerd. Dan worden de relevante projectgegevens van in de praktijk toegepaste EMVA gunningsmechanismen verzameld. De combinatie van beide leidt tot een overzicht van geschikte EMVA gunningsmechanisme elementen die vervolgens gecombineerd worden in de vorm van een beslisboom.

Gedurende het onderzoek zijn er verschillende EMVA types aangetroffen. Om deze EMVA types te kunnen vergelijken is het waarde prijs model ontwikkeld. Het waarde prijs model is een grafische weergave van een aanbestedingssituatie.

Er zijn twee voorkeurssystemen onderscheiden; een systeem waarbij de voorkeur gebaseerd wordt op de hoogste waarde prijs verhouding, het zogenaamde

ratiosysteem, of een systeem waarbij de voorkeur gebaseerd wordt op het hoogste verschil tussen waarde en prijs.

Het opnemen van verschillende randvoorwaarden in het waarde prijs model definieert de aanbestedingsruimte. Tevens kunnen de strategieën 'prijs minimalisatie', 'waarde maximalisatie' en 'waarde prijs optimalisatie' in het model weergegeven worden. Verder kan met behulp van het model het begrip 'biedingsvrijheid' geïllustreerd worden. Biedingsvrijheid is het aandeel van de 'theoretisch maximale toegevoegde waarde' ten opzichte van de prijs van de 'duurste en toch nog concurrerende aanbieding'.

Verschillende vereisten bepalen of een EMVA gunningsmechanisme geschikt is of niet. Wettelijke vereisten die onderscheiden worden zijn 'non-discriminatie', 'proportionaliteit' and 'transparantie'. Praktische vereisten die onderscheiden worden zijn 'voldoende biedingsvrijheid', 'eenvoud en elegantie' en het waarborgen van traditionele projectmanagementvereisten.

De eigenschappen van vierentwintig in de praktijk toegepaste EMVA gunningsmechanismen worden weergegeven. Er worden vier hoofdtypen onderscheiden; het puntensysteem (zes cases), het prijscorrectie systeem (elf cases), het ratio systeem (twee cases) en het waarde maximalisatie systeem (één case). Er worden verschillende trends waargenomen. De gemiddelde biedingsvrijheid is ongeveer 30% voor civiele projecten en ongeveer 20% voor utiliteitsbouw projecten, hetgeen tot een gemiddelde biedingsvrijheid van 25% leidt. Het meest gebruikte gunningscriterium in de civiele sector is 'kwaliteit van het projectmanagement plan', wat een proceskwaliteitscriterium is. Het meest gebruikte gunningscriterium in de utiliteitsbouwsector is 'functionaliteit van het gebouwde object', een productkwaliteitscriterium.

Zowel het 'waarde min prijs' systeem als het 'waarde prijs ratio' systeem worden geschikt geacht. Het ontwerpwedstrijdsysteem zou ontmoedigd moeten worden. Als men voor een 'waarde min prijs' systeem kiest kan men beter voor de uitwerking door middel van een prijscorrectie systeem kiezen dan voor de uitwerking door middel van een puntensysteem.

Elementen die niet toegepast zouden moeten worden zijn gewogen prijzen, discrete prijs-punt koppelingen, discrete prestatie-geld koppelingen, prestatiebepaling door middel van onderling vergelijken en prijs afhankelijke waardebepaling.

Meest opvallende observaties waren 1) de plotselinge waarnemingen van ratio systemen eind 2007, 2) de constatering dat er in de praktijk van het aanbesteden elementen toegepast worden die eigenlijk ontmoedigd zouden moeten worden en

3) de constatering dat het niet duidelijk is of 'aanbestedingsvoordeel' of 'aanbestedingswinstgevendheid' gekozen zou moeten worden.

Het wordt aanbesteders aanbevolen om de in dit onderzoek ontwikkelde EMVA beslisboom te gebruiken voor het formuleren van EMVA gunningsmechanismen. Om de resultaten van EMVA uitvragen te visualiseren wordt het aanbevolen het ontwikkelde waarde prijs model te gebruiken. Verder strekt het tot de aanbeveling het EMVA gunningsmechanisme zo eenvoudig mogelijk te houden en om rekening te houden met de budgettaire consequenties die gunnen op EMVA kan hebben. Tevens wordt het aanbesteders aanbevolen om met gekromde prestatie-geld koppelingen te werken (indien van toepassing) en om kennis betreffende de EMVA gunningen te managen. Tenslotte wordt aanbevolen in de fasen voorafgaand aan de gunningsfase voldoende ontwerpvrijheid over te houden om gunnen op EMVA zinvol te laten zijn.

Het wordt traditionele bouwbedrijven die actief zijn op de markt van geïntegreerde contracten aanbevolen zichzelf te ontwikkelen tot geïntegreerde aanbieders om concurrerend te blijven.

Aanbevolen onderwerpen voor vervolgonderzoek zijn de invloed van de toepassing van EMVA op project succes en op de betrouwbaarheid van biedingen. Verder kan het de moeite waard zijn te onderzoeken of de gunningscriteria ook in andere fasen van de project levenscyclus dan alleen de gunningsfase gebruikt kunnen worden. Tenslotte kunnen de mogelijkheden om de gunningsfase te stroomlijnen en te objectiveren door de toepassing van geavanceerde ICT toepassingen interessant zijn voor vervolgonderzoek.

Het beleid van de Nederlandse overheid om steeds meer geïntegreerd te contracteren belooft een mooie toekomst voor het EMVA gunningsmechanisme.

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1 Introduction

One of the greatest pains to human nature is the pain of a new idea - Walter Bagehot, English economist & journalist (1826 - 1877)

For at least the last decade (EZ et al. 1998) a series of measures known as integrated contracting has been heralded as the solution for many problems in the Dutch construction industry. Effective integrated contracting calls for the application of the Economically Most Advantageous Tender (EMAT) award mechanism. However, the application of the EMAT award mechanism is not widespread, because it is perceived as more complicated than the traditional lowest price award mechanism.

1.1   *Background of the investigation*

The problems caused by traditional procurement
The continuous and monotonous application of the lowest price award mechanism in the Dutch construction industry has created a sector that is unhealthy from an economical point of view. In a research by the ARTB (2002:7) the majority of the involved parties stated that traditional procurement practices make an integrated approach and the accompanying efficiencies impossible. Dorée (2004, 2005) questioned the effects of too much price based competition. He argues that the emphasis on price competition creates an environment in which sustainable business behaviour is not empowered. In order to get projects, suppliers have no other choice than to lower their prices to unrealistic low levels. In such a situation it is more the rule rather than exception that the most opportunistic and untrustworthy supplier gets the contract. Priemus (2004:307) states that irregularities have been provoked by the structure of the building industry and government policy on competitive tendering. The parliamentary enquiry committee for the construction industry states that in a lowest price procurement suppliers will follow a strategy of interpreting the required product as limited as possible Tweede Kamer (2003b:122-123).

The promises of integrated contracting
The term 'integrated contracting' was coined to indicate a way of contracting that is different from traditional procurement. The term integrated contracting is also known as innovative procurement (EZ et al. 1998, EZ 1999, ARTB 2002:68, Tweede Kamer 2003a:18). Key element of integrated contracting is that the contractors are responsible for more design work than with traditional procurement. That provides a more suitable allocation of responsibilities between procurers and suppliers, allowing both parties to focus on their core responsibilities. Public clients should interfere less in the details of the design- and construction processes and should enable and empower contractors to come up with their own solutions. In that way, the contractors would develop themselves towards responsibility-taking counterparts, leading to more reliable and better bids.

The idea that public clients should give contractors more design freedom in order to integrate the phases of design and construction has been high on the agenda for quite some time now. A considerable body of opinion within the construction industry suggests that the traditional separation of the design and production functions within the construction process has been primarily responsible for many 'Value for Money' related problems Griffith & Sidwell (1995:1). They state that integration between project phases is necessary and even vital. In several Dutch policy documents (EZ et al. 1998, EZ 1999) it is stated that by applying integrated contracting, the market is allowed to organise and cluster itself in more efficient ways, resulting in projects with a higher 'Value for

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Money' ratio. All of these developments would increase the competitive capacity of the Dutch construction industry. Public clients embraced this vision and took measures to implement the suggested changes.

Collusion in the Dutch construction industry
In the year 2001 a former employee of the construction company Koop Tjuchem, publicly announced (Bos 2001) that, despite stricter regulation, illegal activities such as bid rigging, division of the market and even the bribing of government officials were still going on. As evidence, he presented an elaborate 'shadow bookkeeping account' in which a substantial part of the suppliers in the Dutch construction industry was involved. The Dutch public reacted furiously by this potential misuse of tax money and public trust in the Dutch construction industry was severely damaged. A parliamentary enquiry (Tweede Kamer 2003a) was conducted and many lawsuits followed. This severely disturbed the relationships between public authorities and suppliers.

Renewed efforts
The uncovering of the collusion prompted extra efforts to improve the Dutch construction industry. Some argued that regulation and supervision should be stricter and that penalties for economic offences should be higher (Tweede Kamer 2003a:302-303). However, construction industry researchers warned that these measures could be counterproductive and would paralyse the industry even more (AVBB 2003:6-7). After a thorough parliamentary enquiry the research programmes "RegieRaad Bouw" and the more operational "PSIBouw" (Process and System Innovation in Construction) were started. These agencies targeted problem aspects such as culture, integrity, trustworthiness or the lagging use of Information and Communication Technology (PSIB 2003, PSIB 2006b, PSIB 2006c, EIB 2006, Pol & Straathof 2005). Besides these initiatives the theme "integrated contracting" remained high on the priority list (EZ 2003, PSIB 2005a, PSIB 2005b, PSIB 2006b, RRB 2005, RRB 2006a, RWS 2004a, RWS 2004b).

The "het nieuwe bouwen" report
The "het nieuwe bouwen" (which roughly translates as "a new construction industry") report (Ridder et al. 2002) was one of the exponents advocating the philosophy of integrated contracting. It gained a lot of momentum in the Dutch construction research community, as was shown for instance at the Revaluing Construction conference that was organised in 2005 in Rotterdam (CIB 2005). In order to improve performance in the Dutch construction industry, the report introduced the so-called dynamic steering principle, in which the value-cost balance of a construction object is maintained over the product lifespan by a stakeholder alliance. One of the main distinguishing elements of the "het nieuwe bouwen" report is the more or less implicit plea for more design freedom for suppliers. At each moment of a product lifespan, suppliers would be allowed to propose design changes if these would improve the value price ratio.

Quick scan into value quantification methods

In order to make the "het nieuwe bouwen" philosophy operational, the central concept of value needed to be quantified. The quantification needed to be acceptable to all parties involved and would have to be suitable for all the phases of the product lifespan. A "quick scan" was conducted in order to make an overview of available value quantification methods, to define the concept of value and to establish a suitable strategy for follow-up research. Several types of definitions for the concept of value were encountered (Dreschler 2005, Dreschler et al. 2005, PSIB 2006a). It became clear that before one uses the concept of value, one should be aware of the differing definitions of the concept in order to prevent communication problems. Furthermore, the subjective nature of value seemed to be conflicting with the ambition to formulate some sort of universal value framework that would apply for all phases of a product lifespan and would be acceptable for all involved parties. It was concluded that an artificial value framework would be too 'technocratic' to facilitate breakthroughs in negotiations between stakeholders. "Integrated contracting" was identified as the right context for the concept of value; bids should be no longer assessed on the lowest price only but on their 'value' as well. It became clear that the Economically Most Advantageous Tender (EMAT) award mechanism was an essential item for integrated contracting and that more knowledge of EMAT was needed. Analysing applied EMAT award mechanisms was identified as a suitable research strategy for finding out how value was quantified in practice.

Focus on the EMAT award mechanism

During the quick scan the application of the EMAT award mechanism turned out to be crucial for integrated contracting. ARTB (2002:8) states that procurers should specify "functionally". VNG (2003:26) states that in order to specify functionally, the EMAT award criterion is a prerequisite. The parliamentary enquiry committee for the construction industry recommended that the EMAT award mechanism should be applied in case of complex projects. Furthermore it stated that the procurement function needed large improvements (Tweede Kamer 2003a:301). In the mean time it appeared that procurers still had difficulty applying the EMAT award mechanism. A research into government procurements (PWC 2002:35) stated that EMAT was applied, but often not 'in the spirit' of the mechanism. (RRB 2005) clearly states that the EMAT award mechanism should be applied more often, but that there are practical barriers. On the one hand that seemed strange, because the knowledge of techniques related to EMAT, such as Multi Criteria Evaluation (MCE), Operations Research (OR), value management and requirement elicitation was well developed (see section 2.1.3). On the other hand it seemed understandable because formulating an EMAT award mechanism is less straightforward than simply selecting the bid with the lowest price.

1.2   Problem statement

Integrated contracting in general (CROW 2004) and the EMAT award mechanism specifically (PSIB 2006a) have already been applied in several projects. Although some of these projects have proven to be successful, the majority of procurers in the Dutch construction industry is still reluctant to apply the EMAT award mechanism in their procurement procedures. Their reluctance can be explained by the initial extra difficulties and uncertainties of the EMAT award mechanism. It is obvious that the EMAT award mechanism is more complicated and thus more time consuming to formulate than simply using the lowest price award mechanism. Furthermore, EMAT procurements had to deal with lawsuits (Cobouw 2005, Rechtbank 2005) and problematic execution of the projects. These negative tendencies lead to the following problem statement;

As a result of not knowing which EMAT award mechanisms are suitable for the Dutch construction industry, further implementation of integrated contracting with its associated benefits is threatened.

Increasing the knowledge of which EMAT award mechanisms are suitable for the Dutch construction industry therefore becomes the main goal of this research.

Scientific relevance of the problem statement
While the application of the EMAT award mechanism seems very promising, literature does not provide much information on how to implement it in the construction industry. Successful implementations (PSIB 2006a) showed the use of Multi Criteria Evaluation (MCE) techniques, the knowledge of which has been extensively developed, but the specific problem for procurers is how to express product qualities in monetary terms. However, the literature does not provide enough information about how to apply knowledge from the theoretical realm of MCE to the practical realm of procurement. The AWT (2000:66) states that 1) the theme construction process integration is of major interest, 2) procurement practice has a major impact on successful integration and 3) knowledge on that area exists, but that the application of that knowledge is lacking. Construction innovation literature provides several views on the needed developments in the Dutch construction industry. But often these views are confusing to the average construction industry practitioner, because the same terminology is used to imply different developments, e.g. "innovative procurement". On other occasions, different terminologies are used to indicate the same development, e.g. "integrated contracting". This investigation creates a vocabulary which will enable practitioners to communicate more effectively about integrated contracting and associated concepts, helping the efforts to improve the sector.

Societal relevance of the problem statement
As shown in recent publications (Heijbrock 2006, Heijbrock 2007, Koenen 2008a, Heijbrock 2008) the problem of lowest price selection is persistent. The implementation of integrated contracting is not only beneficial for procurers and suppliers and their relationship, but for the entire Dutch society as well. Under traditional procurement, a lot of effort, time and money go into resolving conflicts and solving quality problems. A troubled relationship between public clients and suppliers leads to a waste of taxpayers' money and other societal problems like extra hindrance due to projects taking longer than strictly necessary. De Ridder et al. (2002:25) estimated the room for improvement to be about 20% of the entire turnover. This estimation is based on, amongst others, reports by SBR and Latham. So the reduction of these problems means a large contribution to the Dutch society. In addition, integrated contracting improves the position of Dutch suppliers on a European and international level, which is good for the Dutch economy. Because suppliers are empowered to develop themselves towards integrated, responsibility taking, as well as being innovative and mature counterparts, they become more competitive. An integrated production process as a prerequisite for becoming or remaining competitive is described in sources such as STT (1999), ARTB (2002), EZ (2003) and Deloitte (2006:25).

1.3   Research questions

Based on the problem statement from the previous section, the main question for this investigation is:

> *Which EMAT award mechanisms are suitable for the Dutch construction industry?*

As shown in Table 1, this main question is broken down into several key questions. Furthermore, several background questions are formulated in order to validate the problem statement and to explore the central concepts related to the main question. The column "section" of Table 1 indicates in which section the research question will be answered.

Table 1   Overview of the research questions

Research question		Section
Background questions		
BQ 1	What is an EMAT award mechanism?	2.1
BQ 2	What is the context of the EMAT award mechanism?	2.2
BQ 3	Why should the EMAT award mechanism be implemented?	2.3
BQ 4	Why is the current application of EMAT problematic?	2.4
BQ 5	How can the EMAT award mechanism be modelled?	3
Main question + sub questions		
KQ 1	Which requirements determine whether an EMAT award mechanism is suitable or not?	4
KQ 2	Which EMAT award mechanisms are used in practice?	5
KQ 3	Which developments can be distinguished in EMAT?	5
KQ 4	Which EMAT award mechanism elements are suitable?	6
MQ	Which EMAT award mechanisms are suitable for the Dutch construction industry?	6
Legend: MQ = Main question, BQ = Background question, KQ = Key question.		

1.4   Organisation of the research

The analysis of applied EMAT award mechanisms is identified as the most appropriate strategy for answering the research questions of this investigation. This section describes how this approach is organised.

Research approach
The approach of analysing applied EMAT award mechanisms is necessary since literature does not provide many clues about how to apply the EMAT award mechanism. Furthermore it is an effective approach because procurers are required to define explicitly and transparently how they are going to evaluate the bids of suppliers in their procurement documents, which provides a very good source of information. Not only because the information is explicit, transparent and not subject to change anymore, but also because it provides qualitative

information about how product features are compared with price as well as quantitative information about the influence of the qualities in the award decision. Another reason to choose this approach is because it utilises the considerations that practitioners had about formulating an EMAT award mechanism. Finally, the acceptance of recommendations based on real life EMAT award mechanisms that have proven to deal with procurement regulation as well as with other practical considerations, is likely to be much higher than the acceptance of unproven theory.

Not all implementations of EMAT are suitable, where "suitable" can be defined as legally advisable and practical (Figure 1).
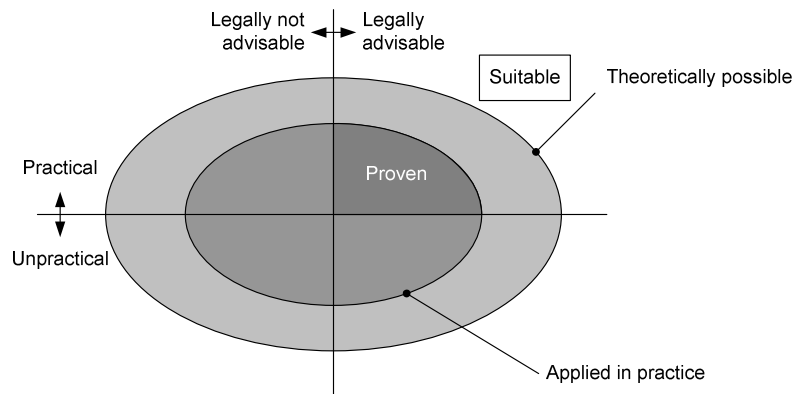
Figure 1   Categorisation of EMAT award mechanisms

The largest circle in Figure 1 represents the collection of all theoretically possible EMAT award mechanisms. Only a part of all these possibilities has been applied in practice, as shown by the smaller circle. Both collections are crossed by two straight lines which represent requirements. The horizontal line represents the requirement that EMAT award mechanisms should be practical; mechanisms above the line are practical, mechanisms below the line are not. The vertical line represents the requirement that EMAT award mechanisms should be advisable from a legal point of view; mechanisms at the right side of that line are advisable, mechanisms at the left side are not. This leaves a quadrant of "suitable" mechanisms. Some of these suitable mechanisms only exist in theory, while others have actually been "proven" by practice.

The approach of this research is therefore to find as many suitable EMAT award mechanisms as possible by studying already applied EMAT award mechanisms.

Scope of the research
In order to keep the research manageable, the following boundary conditions for cases have been set:
- EU regulation must apply, so only public works above a certain threshold.
- The EMAT award mechanism must have been applied in the Dutch construction industry (civil engineering or commercial sector).
- The EMAT award mechanism must have been applied in the year 2000 or later.
- Only "Works" (see glossary), that excludes services such as design work by architects.

Research roadmap
Section 2 validates the problem statement. Furthermore it elaborates the concepts related to EMAT award mechanisms, which answers background questions one through four. The value price model is introduced in section 3, which answers the fifth background question. In order to answer the main question, which requires finding out which EMAT award mechanisms are suitable, applied EMAT award mechanisms will be confronted with suitability criteria.

To do that, first the suitability criteria will be elaborated in section 4, answering the first key question.

Section 5 presents the EMAT award mechanisms that were applied in practice, which answers the second key question.

The third key question is answered in section 5.5 by correlating several parameters in order to see which developments can be distinguished.

The fourth key question is answered in section 6, where all available configuration options from the EMAT award mechanisms are tested with the suitability criteria, leading to an overview of all suitable EMAT configuration options. The considerations for choosing between the options are also mentioned in section 6. The suitable options are grouped into an EMAT configuration tree, which forms the answer to the main question "which EMAT award mechanisms are suitable for the Dutch construction industry?"

The results are validated by presenting them to several procurement specialists and incorporating their feedback.

The conclusions and recommendations of this thesis are presented in section 7.

Figure 2 represents the structure of this thesis, which also forms the roadmap for the research.
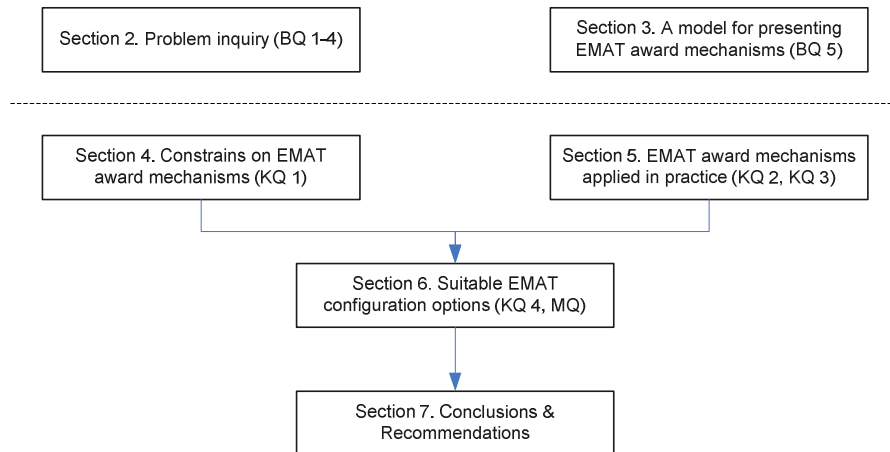
Figure 2   Research roadmap

At the start of each new section the research roadmap will be used to indicate the position of that section in the total research.

2 Problem inquiry

We can have facts without thinking but we cannot have thinking without facts - John Dewey, US educator, pragmatist philosopher & psychologist (1859 - 1952)

| Section 2. Problem inquiry (BQ 1-4) | | Section 3. A model for presenting EMAT award mechanisms (BQ 5) |

| Section 4. Constrains on EMAT award mechanisms (KQ 1) | | Section 5. EMAT award mechanisms applied in practice (KQ 2, KQ 3) |

Section 6. Suitable EMAT configuration options (KQ 4, MQ)

Section 7. Conclusions & Recommendations
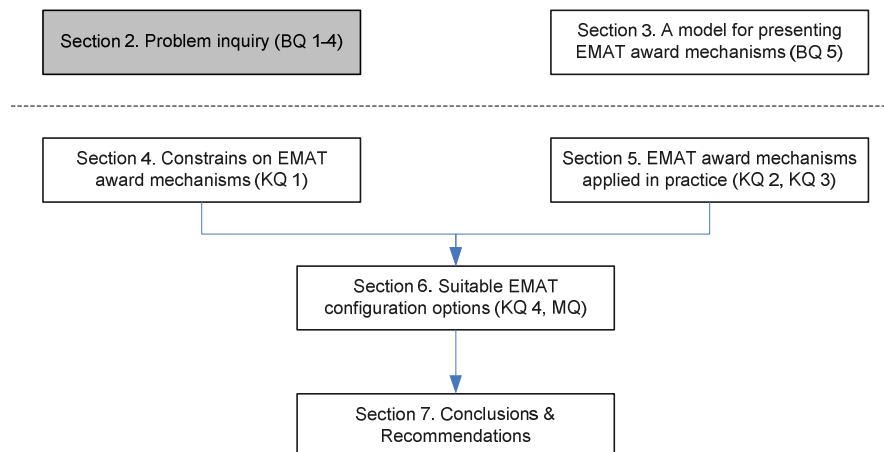
This section answers the first four background questions. Section 2.1 introduces the EMAT award mechanism and other related concepts. The context in which the EMAT award mechanism is used is introduced in section 2.2. Section 2.3 presents the reasons for applying the EMAT award mechanism and section 2.4 investigates why the current application of the EMAT award mechanism is problematic.

2.1 The EMAT award mechanism

This section presents the answer to the first background question "what is an EMAT award mechanism?" by displaying the original definition of the EMAT award mechanism, by describing the main implementations as encountered in literature and finally by a short review of literature about Multi Criteria Evaluation techniques.

2.1.1 Definition of the EMAT award mechanism

The EMAT award mechanism is defined in article 53.1 of Directive 2004/18/EC (European Parliament 2004). According to the Directive, procurers have two possibilities for awarding contracts:

> *"Without prejudice to national laws, regulations or administrative provisions concerning the remuneration of certain services, the criteria on which the contracting authorities shall base the award of public contracts shall be either:*
>
> *(a) when the award is made to the Tender Most Economically Advantageous from the point of view of the contracting authority, various criteria linked to the subject-matter of the public contract in question, for example, quality, price, technical merit, aesthetic and functional characteristics, environmental characteristics, running costs, cost-effectiveness, after-sales service and technical assistance, delivery date and delivery period or period of completion, or*
>
> *(b) the lowest price only."*

Please note that in the article, the word 'criteria' has two different meanings. In the introduction of article 53.1 'criteria' is used in the sense of 'award mechanism'. Under (a) 'criteria' is used in the sense of 'product dimensions'. This thesis will only use the second notion.

The essence of an award mechanism is to grade the bids of suppliers and to select the best bid, as illustrated in Figure 3.
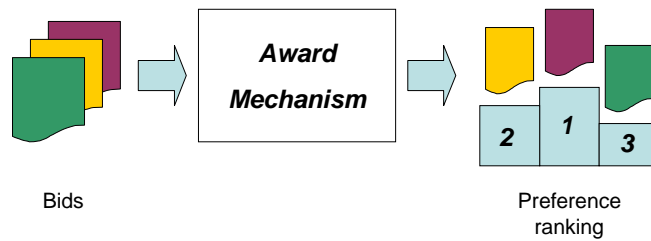
Figure 3   An award mechanism grades the bids

The difference between award mechanisms (a) and (b) is described in Figure 4 and Figure 5. The former describes the lowest price award mechanism, while the latter describes the Economically Most Advantageous Tender (EMAT) award mechanism.
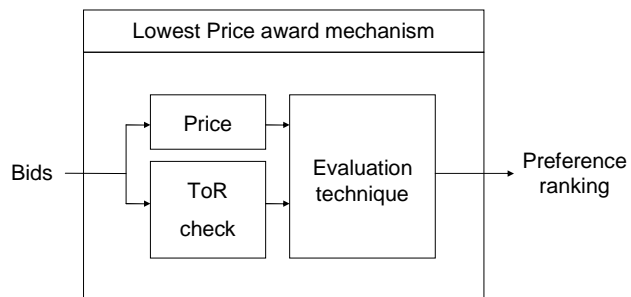
Figure 4   The lowest price award mechanism

The evaluation technique in the lowest price award mechanism simply consists of rejecting bids that do not comply with the Terms of Reference (ToR) and selecting the cheapest bid.
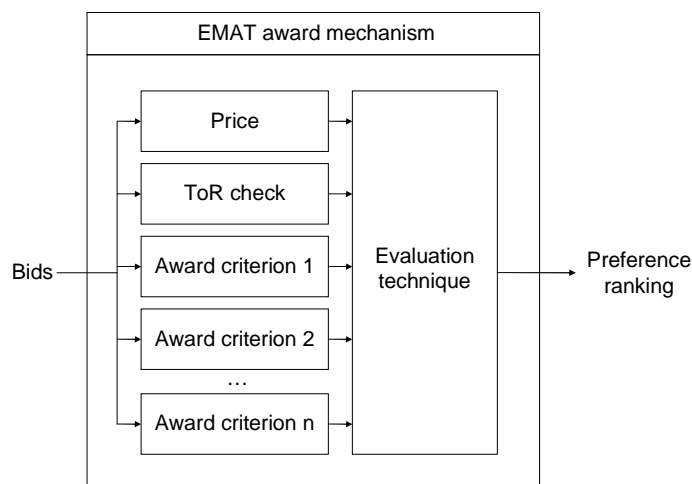
Figure 5   The EMAT award mechanism

Besides price and conformance with the Terms of Reference, the EMAT award
mechanism also takes other criteria into account. These other criteria, hereby
defined as award criteria, are used to establish the partial performances of each
bid. The evaluation technique combines the performance and price information
into a preference ranking. Generally, the evaluation technique uses some
mathematical formula.

2.1.2   Types of EMAT award mechanisms

Article 53.2 of Directive 2004/18/EC (European Parliament 2004) provides a
framework for applying the EMAT award mechanism:

> *"...the contracting authority shall specify in the contract notice
> or in the contract documents or, in the case of a competitive
> dialogue, in the descriptive document, the relative weighting
> which it gives to each of the criteria chosen to determine the most
> economically advantageous tender.*
> *Those weightings can be expressed by providing for a range with
> an appropriate maximum spread.*
> *Where, in the opinion of the contracting authority, weighting is
> not possible for demonstrable reasons, the contracting authority
> shall indicate in the contract notice or contract documents or, in
> the case of a competitive dialogue, in the descriptive document,
> the criteria in descending order of importance."*

Most obvious way to formulate a mechanism that fits within this framework is to apply some Multi Criteria Evaluation (MCE) technique, see section 2.1.3. The difficulty then is how to combine price information with qualitative criteria in such a way that it satisfies the legal criteria of transparency ("objectivity" of criteria), proportionality (balance the weighting criteria in such a way that the value that is attached to performance remains "economically realistic") and equal treatment (not making distinctions on criteria on which distinction is not allowed).

Scientific literature (the journals Construction Management & Economics, Building Research & Information and several others) did not provide much information about applications of the EMAT award criterium.

Doornbos (2005) presented three main EMAT forms: a point system, a price correction system and a ratio system. The point system expresses both the price and the quality of the bids in points and then the bid with the best combined score wins. According to Doornbos, the point system was the most used type at the time. The price correction system rewards extra performance of bids with an added value, which may be subtracted from the price. The bid with the lowest corrected price wins. The ratio system expresses the total value of a bid in a number, which is divided by the price. The bid with the highest ratio wins. According to Doornbos there was no preference for either of these systems.

The usage of point systems was confirmed by the project "quick scan into value quantification methods" (PSIB 2006a). That project did not encounter the price correction mechanism. The use of the price correction mechanism was confirmed by Rijkswaterstaat (RWS 2005b), the Dutch government agency for procuring public works and water management projects. RWS (2005b) prescribed the use of the price correction mechanism, due to known limitations of the point system. No literature was found about the ratio type being applied in practice, but there were publications promoting this EMAT form (Ridder et al. 2002, Staveren 2005).

A special type of the EMAT award mechanism is the one in which the price is fixed and given in advance to the suppliers; bids are allowed to vary on several other product dimensions. This type is called a design contest (MINFIN 2004:9). From a legal point of view the design contest is also an EMAT award mechanism, so it is the fourth main EMAT type.

2.1.3   *Multi Criteria Evaluation techniques*
Returning element in each EMAT award mechanism is the use of Multi Criteria Evaluation (MCE) techniques. MCE techniques originate from the domain of policy analysis. Voogd (1982:18) characterises MCE techniques as methods that can serve to inventory, classify, analyse and conveniently arrange the available

information concerning choice-possibilities. They all use a number of explicitly formulated criteria that are not expressed in one single unit, as is the case in Cost-Benefit Analysis (CBA), but in a variety of units which reflect as good as possible the nature of the criteria concerned. The performance of the choice-possibilities on the criteria will determine the choice; assuming there is a method for aggregating the performances on the criteria.

Although the CBA is also able to combine a variety of units, other literature (Wee & Dijst 2002:247) also distinguishes MCEs from CBAs. Van der Heijden and Mol (1990:11) also separate the monetary methods (CBA) from the non-monetary methods. As non-monetary methods he distinguishes the matrix summary method and the MCE techniques. They describe the MCE type of techniques as methods that aggregate the effects (characteristics) of choice-possibilities by standardisation procedures and explicit prioritisation (weighing).

Van der Heijden and Mol (1990) distinguish qualitative MCEs (that only use qualitative criteria), quantitative MCEs (that only use quantitative criteria) and mixed MCEs (that use both types of criteria). Earlier van der Heijden (1986:182) distinguished the interactive goal-programming approach, the mixed ordinal analysis and the geometric scaling approach as suitable techniques for evaluating choice-possibilities with a partially quantitative and partially qualitative character.

However, these methods had their disadvantages, so he introduced the subtracted summation technique, the subtracted shifted interval technique and the additive interval technique. Drawback of these latter three methods is that they depend highly on mathematics and that the feeling with the original problem is partially lost.

There is much information available concerning CBAs. The result of a large research program aimed at the economical effects of infrastructure, which was conducted by several cooperating Dutch ministries, provides an extensive and thorough source of information concerning CBAs. EZ et al. (2000a:II) deem the application of CBA essential before any large infrastructure project. They (EZ et al. 2000b:25) state that in a so-called societal CBA the go/no go decision of a project should be determined on the basis of the effects the project has on the wellbeing of all people in that society.

Criticism of the CBA is (amongst others) that 'proxies' need to be applied in order to express certain effects into monetary terms and that there is no general consensus on the underpinning of these proxies (Koppenjan & Ham 2002:312). Drawback of MCEs is that although they are able to express the level of functionality of certain alternatives, the price that should be paid for that functionality is not clear. If price is one of the criteria, everything then depends

on the way the weighing factors are determined. Van Wee & Dijst (2002:257) seem to prefer MCEs above CBAs, mainly because criteria from the environmental and social domain are more difficult to express in monetary terms. However, they also suggest combining the methods.

There are many MCE techniques. The "Afwegingsmethodieken" (evaluation methods) report (KC BPI 2004), which was a starting point for this PhD research, made an inventory of thirty-three methods for evaluating choice-possibilities on more than the lowest price only. It distinguishes seven evaluation methods, four matrix summary methods, eleven multi criteria methods including Saaty's (1980) well-known Analytical Hierarchy Process, four monetary methods, four forecasting methods and three environmental methods.

An inventory done by the CIB (Porkka & Huovila 2004) distinguishes Saaty's Analytical Hierarchy Process as the foremost multi criteria decision making technique. The inventory also included requirement analysis techniques and other tools for performance based building.

Horstmeier (2002:11-1) describes the most basic MCE; the weighed summation technique. It uses criteria, weighing factors, sub-criteria and sub weighing factors in order to combine several functionalities. (Beheshti 1999) describes many techniques (including the ones of Van der Heijden and Horstmeier), not only for evaluating and assessing alternatives, but for generating them as well. De Boer (1998) distinguishes six groups of methods for selecting suppliers, see Table 2.

Table 2   Inventory of multi criteria supplier selection methods by De Boer

Methods	Description
Categorical model Neural Networks	Methods with implicit decision rules
Cost ratio / Financial Analysis Total Cost of Ownership Decision Analysis	Methods that strictly include quantitative (financial) criteria
Linear weighting Weighted product method (including Multi-Attribute Utility Theory and Analytic Hierarchy Process)	Methods that employ compensatory decision rules
Mathematical programming	Methods that use quantitative criteria and relate supplier selection to order-volume decisions
Cluster Analysis Data Envelopment Analysis	Methods that use quantitative criteria to sort suppliers
Interpretive Structural Modelling	Analyses supplier selection criteria

Another science area concerned with combining performances on several criteria is the well-developed discipline of Operations Research (also known as linear programming), as for instance described by Winston (1991).

Ho et al. (2009) reviewed 78 multi-criteria decision making articles that appeared in international operations research and supply chain management journals from 2000 to 2008. They identified several techniques for supplier selection. The most used individual approaches were 'data envelopment analysis' (DEA), 'mathematical programming' and the 'analytic hierarchy process' (AHP). They also encountered several approaches that combined techniques, the main one being integrated AHP approaches.

Mietinnen (2009) shows there are at least seven societies, forty journals and more than thirty conferences in 2009 alone on the area of multiple criteria decision making. This leads to the conclusion that the knowledge on MCE techniques is abundant and well-developed, but apparently, given the number of research conferences on the subject, there are still many questions which need further investigation.

2.2   The context of the EMAT award mechanism

This section presents the answer to the second background question "what is the context of the EMAT award mechanism?" by describing the procurement procedures it plays a role in, along with the relevant procurement regulation.

The EMAT award mechanism plays a role in the award phase. The award phase plays a role in several procurement procedures.

Pijnacker Hordijk et al. (2004) define procurement as the act of purchasing goods or services from an outside body by the government with a specified contract and a specified award procedure. In this definition, the government comprises traditional state authorities (state and regional), bodies governed by public law and associations of these first two bodies.

So in contrast with associated concepts as acquisition, buying or purchasing (see appendix F.1), procurement is always 'public'. Based on the problem statement, this thesis defines procurement as "the regulated search and selection process on the supplier market that a public client undertakes in order to fulfil its construction need".

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2.2.1 *European procurement regulation*

At this moment, the context of the procurement procedures is formed by Directive 2004/18/EC (European Parliament 2004). Section 2.2.2 describes several procurement procedures. In some of those procedures, the award phase is preceded by a selection phase, see section 2.2.3. During the selection phase several suppliers are selected (which needs a focus on supplier properties), while during the award phase tenders are selected, which needs a focus on properties of the proposal. The Directive is the result of the unification of several loose guidelines on the area of works, supplies and services into one guideline. Table 3 provides the details of this development.

Table 3   The operative European Directives

Old European Directives	The operative European Directives
Directive 93/37/EEC of 14 June 1993 concerning the coordination of procedures for the award of public works contracts (i.e. construction of infrastructure, bridges, schools, service buildings, etc.)	"Classical sector": **Directive 2004/18/EC** of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts
Directive 93/36/EEC of 14 June 1993 coordinating procedures for the award of public supply contracts (i.e. supply of vehicles, hard- en software, radar installations, medical equipment, etc.)	
Directive 92/50/EEC of 18 June 1992 relating to the coordination of procedures for the award of public service contracts (i.e. financial, courses and training, insurance, advertisement, communication, transportation, etc.)	
Directive 93/38/EEC of 14 June 1993 coordinating the procurement procedures of entities operating in the water, energy, transport and telecommunications sectors	"Utilities sector": **Directive 2004/17/EC** of the European Parliament and of the Council of 31 March 2004 coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors

There is a distinction between a "classical sector" and a "utilities sector", because for the latter, a less strict market regulation applies.

The Directive consists of 51 considerations, 84 articles and 12 annexes. Appendix D presents the structure of the articles. Section 2.2.4 describes how the Directive is implemented in the Dutch regulation.

On the internet, a lot of information concerning procurement regulation can be found. The following portals have been identified as complete and authoritative:

http://eur-lex.europa.eu/en/index.htm, www.aanbestedingskalender.nl, http://www.ovia.nl/ and www.pianoo.nl. Around 2006 the OVIA portal was changed into the PIANOo portal.

2.2.2   Procurement procedures

Articles 28-34 of the Directive define the procurement procedures. In article 28, the Directive states that contracting authorities shall apply their national procedures, adjusted for the purposes of the Directive. They shall award their public contracts by applying the *open* or *restricted procedure*. Only in specific cases and circumstances, contracting authorities may apply a *competitive dialogue*, *a negotiated procedure* or *other procedures*.

The open procedure
As stated in article 28 of the Directive, member states have to apply their own national implementation of the open procedure. That implementation has to align with the purpose of the Directive. The Dutch implementation (VROM 2005) describes the open procedure as follows (translated and shortened):

Article 2.1 ARW 2005: The open procurement procedure ("openbare procedure" in Dutch) is a procurement that is made known generally/publicly, and in which all suppliers are allowed to tender. Before the award of the contract, the procurer can arrange an electronic sale by auction, if precise specifications for the task are established.

The description of the open procedure in article 2.1 is the same for the European and the national procedure, but there are differences in the succeeding articles. The requirements of a European procedure are more intensive than the Dutch procedure, for instance on the area of announcing the works. Section 2.2.5 indicates the threshold values for when the procurement procedure becomes European.

The restricted procedure
As stated in article 28 of the Directive, member states have to apply their own national implementation of the restricted procedure. That implementation has to align with the purpose of the Directive. The Dutch implementation (VROM 2005) describes the restricted procedure as follows (translated):

Article 3.1 ARW 2005: The restricted procurement procedure ("niet-openbare procedure" or "procedure met voorafgaande selectie" in Dutch) is a procurement that is made public and wherein all suppliers are allowed to request to be invited. From these requests, the procurer selects and invites the most suitable suppliers to tender. Only the selected suppliers are allowed to tender. The procurer can limit the number of suppliers that will be invited to tender. This number needs to

be large enough to ensure effective competition and needs to be at least three (in the case of a national procedure) or five (in the case of a European procedure), provided there are enough suitable candidates. Section 2.2.5 describes the threshold values for when a procurement procedure should be European.

The competitive dialogue
In article 29, the Directive states that the competitive dialogue may be applied in the case of particularly complex contracts. Curiously enough, the article does not provide any guideline for establishing the complexity of contracts. It does state that the most economically advantageous tender award mechanism shall be the sole basis of awarding the contract for the competitive dialogue procedure. There are many sources in which the subject of the competitive dialogue is elaborated, see for instance Papenhuizen (2007).

The negotiated procedure
Article 30 describes the cases justifying use of the negotiated procedure *with* prior publication of a contract notice, article 31 *without*.

Cases justifying the use of the negotiated procedure are summarised as follows:
- Specifications cannot be drawn up with sufficient precision to permit open/restricted procedures;
- Research and development projects;
- Overall pricing is not possible due to nature of works or risks;
- Failure of open/restricted procedures.

See Appendix D for a more detailed overview.

Other procedures
The Directive also distinguishes less mainstream procurement forms:
- Article 32: Framework agreements;
- Article 33: Dynamic purchasing systems;
- Article 34: Public works contracts: particular rules on subsidised housing schemes;
- Title III: Rules on public works concessions;
- Title IV: Rules governing design contests.

The Dutch ARW also distinguishes the so-called "informal" procedure, which is not allowed for European projects. Throughout the Directive, even more specific situations and their corresponding procedures are mentioned.

2.2.3 *European regulation on the selection of suppliers*

Articles 45-52 of the Directive arrange the selection phase. The Directive defines a strict separation between the choice of the provider and the choice of the tender. Because of that, we speak of a selection phase and an award phase.

For all procedures, suppliers should first be checked on the *minimum standards*. Noncompliance to these standards will provide ground for exclusion. Besides checking on minimum standards, the restricted procedure, the competitive dialogue and negotiated procedures make use of *selection criteria* as well. The open procedure does not use selection criteria.

Article 44 states that requirements posed in the selection criteria must be related and proportionate to the subject matter of the contract. Furthermore they need to be "objective" (transparent), non-discriminatory and once they are published, they cannot be altered anymore. According to Pijnacker Hordijk et al. (2004), there is a lot of jurisprudence on these topics.

Minimum standards

According to article 45 of the Directive, procurers *must* exclude providers in case of:
- Membership of a criminal organisation;
- Bribery;
- Fraudulent behaviour;
- Money laundering.

Procurers *may* exclude providers in case of:
- Bankruptcy;
- Conviction for misconduct or professional fault;
- Not having paid taxes etc.;
- False statements.

According to article 46 of the Directive, procurers must also check on the suitability of suppliers to pursue the professional activity. Suppliers must give evidence of their enrolment in one of the professional or trade registers, provide a declaration on oath, or provide a certificate as described in annexes of the Directive. In procedures for the award of public service contracts, insofar as candidates or tenderers have to possess a particular authorisation or to be members of a particular organisation in order to be able to perform in their country of origin the service concerned, the contracting authority may require them to prove that they hold such authorisation or membership.

Selection criteria
Article 47 gives examples of criteria for suppliers to prove their economic and financial standing. Procurers can choose which selection criteria they define, as long as they disclose them in advance, accompanied with an evaluation methodology.

Article 48 gives examples of selection criteria on the area of technical and/or professional ability:
- List of educational/professional qualifications;
- A list of works carried out over the last 5 years;
- Statement of tools, plant and technical equipment available for work;
- Average manpower;
- Statement of technicians and services.

The Directive (article 48.6) limits the extent of the evidence that suppliers must provide in order to prove they meet the selection criteria.

Past performance
Procurers can incorporate the past performance of suppliers in their selection criteria. Past performance can be a statement that the supplier has properly completed relevant projects.

2.2.4   Dutch implementation of EU regulation
The Dutch construction procurement regulation is based on the European Directives. As shown in appendix section E.3, which provides a historical overview of regulation developments, this has not always been the case.

For several types of projects a threshold value has been established, see section 2.2.5. Contracts with an estimated value lower than the threshold will have to comply with national procurement regulation. Contracts with an estimated value higher than the threshold will have to comply with European procurement regulation.

The Dutch implementation of Directive 2004/18/EC (European Parliament, 2004b), the Directive for the "classical sector" is the so-called BAO (Staatsblad 2005 408), which stands for "Besluit Aanbestedingsregels voor Overheidsopdrachten" (directive procurement regulation for public contracts). In the BAO the procedure around EMAT is mentioned in article 54.

Compared to the old situation, the BAO has some new elements, including:
- More flexibility as a result of new procurement procedures such as the competitive dialogue and framework agreements;

- Modernisation; as a result of the introduction of the possibility to procure in an electronic way the procedures can be shortened;
- Simplification; Directives are combined and a simpler system for threshold values is introduced;
- Clarification; the possibilities for including environmental- and social criteria in the procurement procedures have been clarified.

The BAO is the basis for the procurement regulation in the document "ARW 2005 - Aanbestedingsreglement Werken 2005" (VROM 2005).

The Dutch implementation of Directive 2004/17/EC (European Parliament, 2004a), the Directive for the "utilities sector" is the so-called BASS (Staatsblad 2005 409), which stands for "Besluit Aanbestedingen Speciale Sectoren" (directive procurement regulation for public contracts in the utilities sector). The BASS is the basis for the procurement regulation in the document "ARN - Aanbestedingsreglement Nutssectoren 2006" (ProRail 2006).

Readers that are interested in details about the Dutch regulation are redirected to section 4 of the publication "Aanbestedingsregels moeten innovatie bouw stimuleren" (RRB 2005); it contains some very illustrative pictures. Even more considerations can be found in the so-called key-publication "Beter aanbesteden in de bouw" (RRB 2006a, RRB 2006b)

Market consultation
Market consultation happens before a formal procurement procedure. In order to comply with procurement regulation it is not allowed to ask financial information during the market consultation. That would jeopardise the open market principle and the governmental duty to treat all market parties as equals.

Papenhuizen (2007) indicates that regulation allows procurers to have a "technical dialogue" with suppliers or to ask/get advice from them during the project specification phase, provided that the principle of effective competition is ensured. So although regulation imposes few limitations on the use of a market consultation, care has to be taken that effective competition is ensured.

2.2.5 Threshold values
Article 7 of the Directive (European Parliament 2004) mentions the threshold values for public contracts. Contracts with an estimated value that is higher than the threshold will have to comply with European regulation. Contracts below the threshold have to comply with the national regulation, which is less restricted. The threshold values are updated yearly. The current threshold values are mentioned in Table 4 and Table 5, in Euros (excluding VAT).

Table 4   Threshold values public contracts 2008-2009

	Central Government	Decentralised Government
Works	€ 5,150,000	€ 5,150,000
Services	€ 133,000 *	€ 206,000
Supplies	€ 133,000	€ 206,000

* For certain exceptions the threshold value is € 206,000.

Table 5   Threshold values utilities sectors 2008-2009

	Utilities sector
Works	€ 5,150,000
Services	€ 412,000
Supplies	€ 412,000

2.3   Reasons for applying the EMAT award mechanism

This section presents the answer to the third background question "why should the EMAT award mechanism be implemented?" by stating the reasons for applying the EMAT award mechanism. The EMAT award mechanism is essential in the application of integrated contracting; a lacking implementation of the EMAT award mechanism is a major hurdle for the implementation of integrated contracting. But why would one want to implement integrated contracting? Reasons for implementing it are described in section 2.3.6. Before that, section 2.3.5 describes the concept of integrated contracting and in contrast, section 2.3.4 presents the characteristics of the so-called traditional procurement. In order to correctly describe these two main procurement philosophies, first some basic characteristics of the construction industry are presented in sections 2.3.1, 2.3.2 and 2.3.3.

2.3.1   Description of the construction industry

A short overview of Dutch construction industry can be found in Appendix D. The appendix highlights financial figures, types of clients and a historical overview of developments in procurement regulation.

The typology of Botter (Boer & Krabbendam 1993) will be used to describe the construction industry. The typology provides a framework to position the construction industry and describe characteristics and peculiarities in regard with other industries. Or, to be more precise, it gives an idea of the position of

different types of players in the construction industry supply chain. The typology of Botter is based on the work of Mintzberg, Woodward, Harvey and Hill. A translated and slightly adapted version of the typology is shown in Table 6.

The horizontal dimension of Table 6 indicates the number of times a product is reproduced. The "construction industry" as a whole cannot be placed in one cell of this typology, because the construction industry actually consists of several disciplines.

The discipline most relevant for this thesis is that of the main contractors. Their products typically reside at column 4, since the number of produced units is almost always one for the utility and civil sector. Note that although their end-products are almost always unique, the main lay-outs, components and sub products are not.

Table 6   Botter's typology of industrial enterprises (Boer & Krabbendam 1993)

Size of the fabrication series	Large			Small
Complexity of the product	*1. Mass/stream production*	*2. Long-lasting fabrication series*	*3. Average sized serial production*	*4. Small series and one piece production*
Small *1. Materials*	11: Chemicals, Metals, Beer, Paper, Glass	12: Drinks, Meat	13: Microchips, Vitamins	14: Sample products
2. Simple products	21: Rolled products	22: Metal parts, Synthetic materials	23: Small turnover from assortment	24: Special orders, Prototypes
3. Assembled products	31: Cars	32: Engines, TV's	33: Furniture, cables	34: Special tools
Large *4. Installations*	41: -	42: Airplanes	43: Office computer systems	44: Telecommuni-cation systems

Suppliers of installations and complex components like integrated floor systems can be positioned in the columns two or three, since they have larger production series. Using that argument, the main part of the housing industry also does not belong in the fourth column.

There are a lot of suppliers in the construction industry that belong in the second column: producers of piles, columns, facades, prefab elements etc. Also the first column is well represented with suppliers of products such as screws, nails and bricks. There are also suppliers of materials such as asphalt, concrete, sand and

gravel, but these often actually do not fit in the first column, because all of these products have a lot of parameters that are customised to project needs, so the production series are actually quite small. They are positioned in column two, three or even one, depending on the number of times a certain mixture is required.

The vertical dimension of Table 6 indicates the complexity of the produced product, or the degree of assembly of the product. Globally four types of product complexity are distinguished. These are illustrated in Figure 6. This dimension is relevant because it is an indication of the logistics involved in the production process.
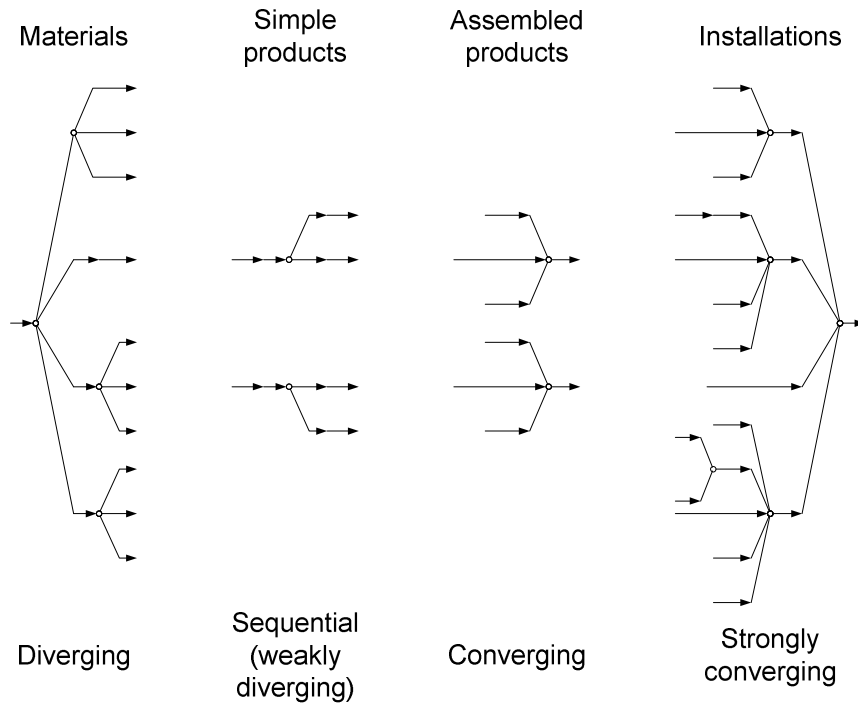
Figure 6   Product complexity (Boer & Krabbendam 1993)

A diverging production process requires a different lay-out, planning and storage management than a converging production process. It is clear that main contractors belong in the most right hand side column, and that suppliers of materials such as sand, cement, steel and gravel belong in the first column.

2.3.2   *Typical process phases in Dutch construction projects*

There are several possibilities for phasing the construction project development process. One could for instance use the British phasing by the Royal Institute of British Architects (RIBA) or by the Office of Government Commerce (OGC 2006). Another authoritative source could be the FIDIC, an international federation of consulting engineers. But, keeping the problem situation in mind, it is wiser to adhere to Dutch phasing systems. Dutch authoritative sources are the CROW, the Dutch centre for regulation and research in civil engineering, the ONRI, the Dutch association of consulting engineers, BNA, an association for Dutch architects or the SBR, a foundation for construction research. Their phasing systems (CROW 1997, ONRI 1998, BNA 2005, SBR 2006) show many similarities with the international phasing systems. The following phasing is derived from above mentioned phasing systems:

Phase 1.   Initiative, orientation;
Phase 2.   Research, feasibility study;
Phase 3.   Definition, establishing Program of Requirements, Conceptual design;
Phase 4.   Preliminary design, tender design;
Phase 5.   Detail design;
Phase 6.   Works preparation;
Phase 7.   Construction + supervision, installation;
Phase 8.   Testing;
Phase 9.   Operation; use and maintenance;
Phase 10. Demolition or reuse.

This phasing connects with current practices in the Dutch construction industry and is suitable for describing several possibilities for dividing the construction project development tasks, with all kinds of organisation forms and contracts as a result.

The procurement phase is excluded from this list, as the moment of procurement differs for each task allocation type. The next section describes these moments of procurement in more detail.

2.3.3   *Contract/Organisation forms*

In the construction project development process, there are many possibilities for dividing the tasks between procurer and supplier. The most used and thus most important task allocation types in the Dutch construction industry are (Ridder & Noppen 2008):

1. Traditional (Bid-Build);
2. Design Team;
3. Design-Build;

4. Partnering and Alliances;
5. BOT (Build-Operate-Transfer).

These types of task allocations are mentioned on an increasing scale of amount of procured activities. Number 5 could actually be seen as a subtype of category number 4. The properties of these five main task allocation types are described into more detail by De Ridder & Noppen (2008). Appendix G presents the considerations that play a role when formulating a procurement strategy.

2.3.4   Traditional procurement

The procurement that takes place under the 'Bid-Build' task allocation type with accompanying organisation and contract forms is known as traditional procurement. The 'Bid-Build' task allocation is still the most used type in the Dutch construction industry. This model has a long history and there is a lot of experience with it. Because of that, a lot of factors are highly standardised.

The product specifications are written with the aid of a standard system, e.g. RAW (Dutch specification system for the civil sector of the construction industry) or STABU (Dutch specification system for the residential and commercial sectors of the construction industry). The resulting product description is very detailed.

The contract stipulations are highly standardised as well. The contractual obligations (technical and administrative conditions) are derived from the so-called UAV model (uniform administrative conditions for the execution of works). In an international context the use of one of the FIDIC standard contracts is common.

The task allocation between procurer and contractor is also very clear. There is a strict organisational separation between the design- and construction phase, and the relative large involvement of the procurer during the construction stage. The procurer is responsible for the design and for the provision of the tender package. The procurer (or his engineer) supervises the works during construction (Dorée 2001) The contractor 'designs' the method of construction (works preparation), makes a planning schedule for the works and executes the works in accordance with the UAV. This process is depicted in Figure 7.
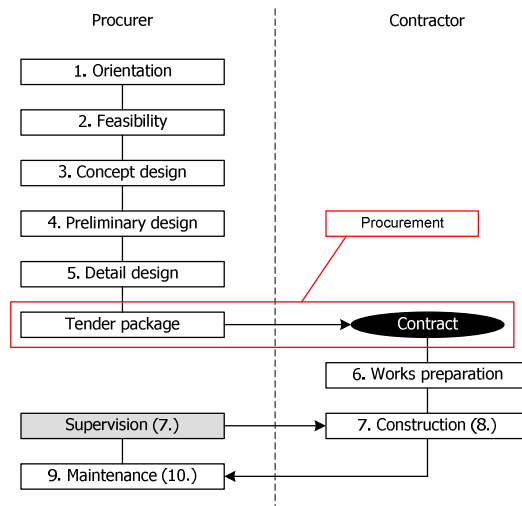
Figure 7   Bid-Build task allocation (CROW 1997)

The award mechanism
As indicated in Figure 7, procurement takes place after the phase of detail design. Contract award is usually based on the lowest price. Awarding based on the Economically Most Advantageous Tender (EMAT) would not make much sense, since the design is fully specified and there is no room for design optimisations. However, sometimes the "traditional way of working" is combined with an EMAT award mechanism. The room for optimisations then is at the execution process. For instance a project that could be called very traditional on all accounts still used EMAT as award mechanism. The project, a bridge renovation project, took "societal costs" caused by traffic hindrance into account (RWS 2001). Another project (RWS 2004b) took into account the quality of the work plan, the level of 'sustainability' elements in the work plan and the degree of product- and process innovations in the work plan. In the latter case, a specification of how the work plan aspects were taken into account was missing. In both cases, the share of these "optimisations" is too low to cause any distinguishing effects in the final bids.

Advantages of traditional procurement for procurers
(Ridder & Noppen 2008, ARTB 2002, SBR 2006, Griffith & Sidwell 1995)
- The detailed and standard clauses hardly give any reasons for discussion;
- The parties clearly know their position, tasks, authorities and responsibilities;
- It offers good checking possibilities;
- Low transaction costs as a result of experience with the procurement form.

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Disadvantages of traditional procurement for procurers
(Ridder & Noppen 2008, ARTB 2002, SBR 2006, Griffith & Sidwell 1995)
- Detailed product description necessary;
- All requirements need to be checked;
- Less suitable for change;
- As a consequence of the sequential character of the activities, the strict separation of design and construction stages causes a 'slowdown' effect on the building process;
- The expertise of the contractor can only be used in the construction / execution stage;
- There is a high chance of additional work as a result of the inadequate 'tuning' of design and construction;
- As a result of the fierce price competition, in practice the quality prescribed in the Terms of Reference becomes the "upper limit" for suppliers, while the procurer sees it as a "lower limit";
- There is a high chance of cost overruns as a result of strategic behaviour of contractors during the tendering phase;
- The level of collaboration between the contract parties is low; the method of tendering causes an adversary culture/contract;
- High chance of unacceptably high costs of additional work; that can lead to serious conflicts between the procurer and the contractor;
- Eventually, as a result of the skewed distribution of responsibilities, contractors become passive and opportunistic.

2.3.5 *Integrated contracting*

The term "integrated contracting" is used to indicate procurements that take place under all the task allocation types other than the 'Bid-Build' task allocation. The term is used to emphasise the difference with traditional procurement. Because one or more process phases (see section 2.3.2) are contractually combined with the construction phase, these types of task allocations are also known as integrated contracts.

The 'Design-Build' task allocation type is most representative for the philosophy of vertical integration (see section 2.3.6) behind integrated contracting; integrated contracting is all about bidding freedom for the suppliers, because it enables product differentiation as well as standardisation of supplier production processes.

In a Design-Build procurement (in the Netherlands known as Design & Construct), the contractor both designs and builds the works. The product specification is less detailed. According to RWS (2005a) ideally, the design is specified functionally. That means prescribing a required behaviour rather than a required solution. This leaves open the possibility for several solutions. In

practice this concept is often used to indicate a procurement which has considerable freedom of design for the supplier, which is erroneous, because even a bolt can be specified functionally. On the other hand a very precise requirement - note the difference between requirement and specification - can still leave open many possibilities, for instance the requirement that the product must have a certain colour. Another point of criticism towards 'specifying functionally' is that it is difficult to implement in the procurement phase, because the check whether a design proposal complies with the functionally specified Program of Requirements is more difficult and not unambiguous (RWS 2002b), which creates problems on the area of the legally required equal treatment principle. Specifying functionally is interwoven with the Systems Engineering working method; see (RWS 2005a) and (RWS et al. 2007) for more information on that subject.

The contract stipulations are usually derived from the UAVgc, the Dutch uniform administrative conditions for integrated contracts. Next to that the RVOI (ONRI 1998) and the DNR (BNA 2007), Dutch client-consultant services agreement models, are often used.

An essential feature of the Design-Build task allocation is that, theoretically, the activities in the design- and construction phase are the responsibility of one contract party. In most cases a construction company, but not necessarily always, since also an architect, engineering firm, installations company, project management bureau or other type of company could take up the responsibility as main-contractor. The procurer's involvement will mainly concern the definition of his main requirements. Usually, the procurer will require process safeguarding measures such as a quality assurance system. There is no traditional form of supervision during the construction phase from the side of the procurer, although the contractor shall allow him a general authorisation for inspection, to ensure contract compliance. As indicated in Figure 8, procurement takes place after the concept design phase. To summarise, the involvement of the procurer in the total building process is much less. In the mean while, the contractor becomes much more involved, and sooner, in the whole process (Ridder & Noppen 2008).
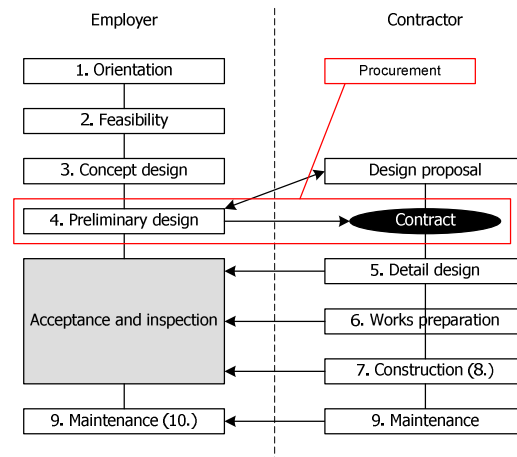
Figure 8   Design-Build task allocation (CROW 1997)

The award mechanism
From an equal treatment point of view, award can not be based on the lowest price. Because the design is not fixed into detail yet, prices cannot be compared, because the offered products are not the same. That means that award can only be based on EMAT. However, this is not entirely true. In the case of functionally specified contracts, it is possible that the performance of bids is fixed. In that case there is some design freedom for suppliers, while lowest price selection is still possible.

Advantages of integrated contracting for the procurer
(Ridder & Noppen 2008, ARTB 2002, SBR 2006, Griffith & Sidwell 1995)
- Fewer possibilities for suppliers to compare bids and make price-agreements;
- Clarity; having a better view of the (financial) possibilities. One would expect that the cost estimation of an integrated supplier is more accurate than the one drafted by the design department. That also applies for the time estimates;
- Better bids as a result of mobilising supplier knowledge/creativity and rewarding solutions that would not have been possible in the traditional situation;
- The procurer has to deal with only one party, which makes the relationships much simpler between the parties involved in design and construction;
- There will be fewer discussions about responsibilities and liabilities. The design partner cannot say any more that construction is badly done, and the construction partner cannot say any more that the design is poor;

- Execution of the works is improved. This is often defined as the introduction of specific construction knowledge into the design process. This improvement in construction appears as follows:
  - Design and works preparation are fully defined by the construction process/production system, which means that:
    - Time is gained;
    - Less delays are encountered;
    - Better priorities are put forward;
    - More adequate planning is done;
    - People understand better in which stage of the building process they are.
  - Design is aimed at efficient methods of construction, which means that:
    - A minimum number of components and elements is involved, enabling faster assembly;
    - Materials are easier to come by as they are selected from a range of readily available types;
    - Connections are designed to be simpler to construct.
- Standardisation can be pursued so that:
  - The assembly learning curve can be utilised;
  - Discounts are received by buying in larger quantities;
  - It is rewarding to establish cooperation relationships in the supply-chain;
  - Procurement and materials management generally is simplified.
- During the design phase, the use of modular components and elements is optimised towards production, transport and assembly needs;
- The designs take the construction conditions on site into account in a better way;
- Unnecessary complexity is avoided;
- Construction time can be shortened considerably if the final stages of design overlap with the early stages of construction;
- Consultancy costs can be reduced.

Disadvantages of integrated contracting for the procurer
(Ridder & Noppen 2008, ARTB 2002, SBR 2006, Griffith & Sidwell 1995)
- Not everything is specified in advance, so you have to have the ability to deal with the resulting uncertainty;
- The number of companies capable of working in the new way is not that large. It implies that the number of competing companies is also not as large as in the traditional construction industry. That can have price consequences;
- The procurer is, already in an early stage, legally bound to adhere to contractual conditions (including financial regulations). This is in contradiction with the desire, in the early stages of a project, to have a certain freedom of action because a number of aspects still are vague in nature;

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- A possibility of higher prices as a result of risk pricing by the suppliers;
- Increased transaction costs in the case of design cost reimbursement;
- Traditionally, contractors do not have a designing attitude. Fears are that this will result in bids that are aesthetically less appealing;
- For some civil engineering projects, it is quite difficult to find solutions that are better than the solutions that are found in the traditional situation;
- Sometimes, both the contractor and the procurer continue working in the traditional way, because they think the new contract form on it self will solve all their problems. The procurer tends to neglect the fact that costs (that were estimated by the design department) will probably rise. The construction partner only looks at the budget and follows a regime of spending money on items perceived to be 'right'. This will go on quite smoothly until the end of the construction stage is almost reached, were everybody is suddenly disappointed and in search of someone to blame. Obviously, both parties will have to change their working methods in order to actively pursue the advantages of the new contract form.

Advantages of integrated contracting for the supplier
(Ridder & Noppen 2008, ARTB 2002, SBR 2006, Griffith & Sidwell 1995)
- Possibility for introducing (and being rewarded for) specific capabilities;
- Clarity, not being confronted with a for and back changing demand, because the earlier involvement created more clarity about the possibilities;
- Possibility of compensation for design costs;
- Possibility to distinguish yourself from your competitors by conceiving new solutions;
- Procurer is less rigid;
- Accepting a Design-Build contract could be a help to characterise oneself for a strategic market position, because the number of companies that are competent in this field is restricted;
- Possibility for increasing your technical ability to deal with problem solving;
- Typically, the profit margin on design activities is higher than the profit margin on construction activities. By integrating both activities the construction entrepreneur could considerably increase his profit margin;
- Theoretically, the confusion about design- and construction responsibilities is reduced because there are only two players (procurer, supplier) instead of three (procurer, consultant/engineer and contractor).

Disadvantages of integrated contracting for the supplier
(Ridder & Noppen 2008, ARTB 2002, SBR 2006, Griffith & Sidwell 1995)
- The effect of becoming responsible for the (estimated) cost is underestimated by some suppliers/contractors. The traditional 'bid low, claim high' behaviour does not work anymore. It takes time before everybody in the entire organisation realises that and acts accordingly;

- It takes more effort and competences to empathise with the procurer position and to act accordingly. It takes more anticipating skills and a pro-active attitude;
- Increased risk as a result of increased design responsibility;
- Increased acquisition costs, even in the case of design cost compensation, since that almost never covers the entire costs (although it could be seen as a challenge to streamline tendering processes).

2.3.6 Why integrated contracting?

The premise behind the idea of integrated contracting is that currently many problems arise in the construction industry because of the fragmentation of the supply chain. How that fragmentation leads to performance-, quality- and many other problems is described in the renowned Egan report (DTI 1998), as illustrated by the following quote of paragraphs 8 through 10:

> *We recognise that the fragmentation of the UK construction industry inhibits performance improvement. One of the most striking things about the industry is the number of companies that exist – there are some 163,000 construction companies listed on the Department of the Environment, Transport and the Regions' (DETR) statistical register, most employing fewer than eight people. We regard this level of fragmentation in construction both as a strength and a weakness:*
>
> *• On the positive side, it is likely that it has provided flexibility to deal with highly variable workloads. Economic cycles have affected the industry seriously over past decades and have meant that it has been forced to concentrate more on survival than on investing for the future;*
> *• On the negative side, the extensive use of subcontracting has brought contractual relationships to the fore and prevented the continuity of teams that is essential to efficient working.*
>
> *It was the consequences of fragmentation which Sir Michael Latham principally examined in his landmark report published in 1994. The Task Force recognises that we are building on the firm foundations which Sir Michael laid. We welcome the impact that his report has had on the industry and the developments arising from it, including the establishment of the Construction Industry Board and the recent legislation on adjudication and fair payment. Together with the Government's current initiative "Combating Cowboy Builders", this will help to reform the way*

the industry does business and to counter the strongly ingrained adversarial culture.

Paragraph 72 describes how this relates to integrated contracting:

The Task Force's view is that those companies with the right culture deserve to thrive. Cut-throat price competition and inadequate profitability benefit no-one. For the sake of the long-term health of the industry and its clients we wish to see a culture of radical and sustained improvement in performance enabled in UK construction.

The situation in the Netherlands was generally the same as in the UK, so the developments in the UK were adopted in the Netherlands. An interdepartmental working group for the implementation of integrated contracting (EZ et al. 1998) stated that logistics and information streams could be improved if main contractors would establish strategic cooperation relationships with suppliers.

Drawbacks of competition solely based on price
EZ et al. (1998) identified the sole use of the lowest price award mechanism by procurers as a major obstacle for contractors to optimise their production processes.

Please note the term "cut-throat price competition" in the Egan quote. In literature it can also be encountered as detrimental price competition or destructive competition (Dorée 2005). The online economics dictionary of Britannica (www.britannica.com) defines destructive competition as competition that forces several producers out of the market. Destructive competition usually occurs when there are so many producers of a product that prices are driven down to the point where no one makes a profit. It can also happen if a single producer is significantly wealthier than other producers and can afford to cut prices drastically until the other producers are driven out of business. Usually, price competition is perceived as normal and even necessary. In a free market economy, a surplus in capacity will inevitably result in bankruptcies. That is detrimental for the concerned companies, but looking at a higher level, it is nothing to worry about.

However, in the construction industry, it can be questioned whether the "forced" price competition is still economical. It would be healthy if overcapacity is removed, but it is not certain whether there is an overcapacity. Reducing the production capacity could lead to increasing prices as a result of monopolistic or oligopolistic behaviour by the survivors. Dorée (2004, 2005) questioned the effects of too much price based competition. He argues that the focus on price competition rules out the suppliers to differentiate themselves as well as their

product. Product differentiation is a normal reaction for producers in a highly competitive environment and it is major driving force for innovations Katz & Rosen (1998). However, the price focus leaves the suppliers with no other choice than to battle each other. This creates an environment in which sustainable business behaviour is not empowered. Offering quality is not empowered, because that is too expensive. In such a situation it is sooner rule than exception that it is the most opportunistic and untrustworthy supplier that gets the contract. In practice, this has several negative effects:

- Extra quality control is needed;
- Atmosphere of distrust, negativism and suspicion;
- Proactive attitude of suppliers is suffocated;
- Any room for interpretation differences is miss-used to the maximum;
- Suppliers feel that unethical business methods are justified, because they are not being treated fair as well;
- Increase in legal fees.

Katz & Rosen (1998:514-517) described several factors with affecting the occurrence of collusion. One of these factors is a lack of differentiation possibilities. In such a scenario, the contractors decide to compete with their main client instead of competing with each other, by resorting to making price agreements, blocking competitors and dividing the market.

The level of client involvement in the construction industry
The key element of the plea for restructuring the construction industry (Ridder et al. 2002, Dorée 2005, ARtB 2002, EZ et al. 1998) is that, in order to become more competitive, productive, innovative and cost effective, the contractual distinction between the design- and construction phase should be eliminated. If the design and construction activities would fall under one responsibility and under one organisation, the barriers for integrating production knowledge into the designs would be removed. It would also make it possible to use standardised or recycled components, production teams and processes and patented solutions. All of that would result in more feasible, more realistic, more predictable (in the terms of costs, quality and delivery time), more reliable and more innovative products.

This change implies a lower customer involvement in the production process. The model of the primary process of firms of Boer & Krabbendam (1993:63) can be used to indicate the difference between the "traditional" situation and the desired situation in the construction industry. Figure 9 depicts a translated and slightly adapted version of the model.

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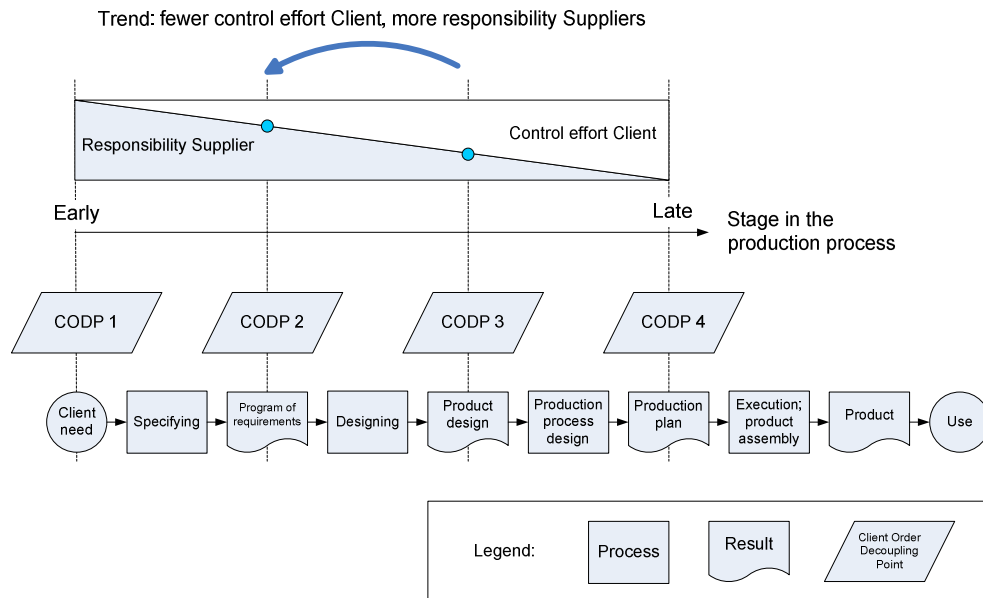
Figure 9   *Client-Order Decoupling Points (Boer & Krabbendam 1993)*

The model distinguishes several activities in the process of transforming the client needs into a product. For some products the client wants to be involved in specifying the product and for other products the client does not want to be involved at all and just purchases what is offered. In order to indicate this difference, several "Client-Order Decoupling Points" (CODP) have been identified, also see Figure 9:

- CODP1 corresponds with a consumer walking in the supermarket and buying a product of the shelf;
- At CODP2 the client has a program of requirements that suppliers use in order to formulate a product proposal. The client will select the best product proposal, but there is a possibility that the client will have to change the requirements if it is not possible to deliver a product that exactly matches the requirements;
- CODP3 corresponds with a situation in which the client has got a detailed product description, for which he tries to find a suitable party to make that design;
- At CODP4 the client tells producers not only what to make, but also how to make it. In that case the customer knows the primary process of the producer better than the producer himself.

Traditionally, in the Dutch construction industry the decoupling point is at CODP3. The idea of integrated contracting is to move the decoupling point to CODP2. Porter (1980) called this move vertical integration. Another term commonly used is supply chain integration, although in order to speak of supply chain integration, other aspects need to be integrated as well. As elaborated in section 2.3.3 the CODP shift implies changes in the task allocation between procurers and contractors, with changing organisations and contracts as a result. Veen et al. (2006:22) point out that taking a proactive attitude could be successful for suppliers. Besides stimulating contractors to become more 'mature' and responsible, the earlier CODP could also contribute to "leaner" procurement authorities in the Dutch construction industry.

Development of the construction industry; from demand driven to supply driven
Vrijhoef & De Ridder (2007) argued that in order to become a 'normal' economic sector, the construction industry should be transformed from demand driven to supply driven.
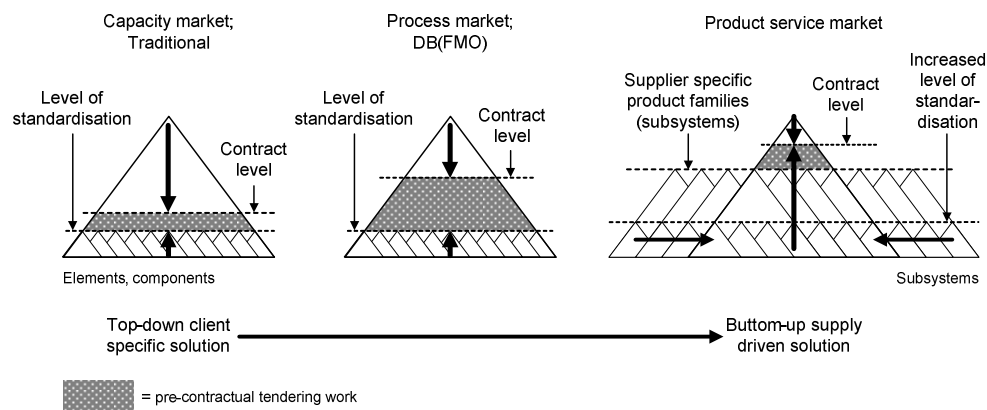
Figure 10   Transition of the construction industry (Vrijhoef & Ridder 2007)

As explained in Figure 10, the role and the influence of public procurers on the supply chain of the construction industry should be reduced. Ideally there would be integrated suppliers with a proactive approach and who take responsibility for the product they deliver.

Motives of procurers for applying integrated contracting
Several motives of procurers for applying integrated contracting and the related EMAT award mechanism can be distinguished. These motives are based on the bibliography as well as on 'off the record' conversations with industry professionals during interviews, workshops and expert meetings. Because this

information contains confidential elements, it is presented in a less traceable form. The motives for procurers for applying integrated contracting or EMAT are grouped into several categories:

Dogmatic reasons
- It is the policy;
- The boss says I have to do it;
- They say it is good;
- Follow the fashion/hype;
- New, thus better.

Relevant reasons
- Seeing chances for improvement, probably as a result of experience with missed chances due to lowest price competition;
- Wanting to empower another type of competition by allowing differentiation;
- Having a need for stimulating innovation;
- Acknowledging that the supplier market is probably more knowledgeable on a certain aspect than yourself;
- Wanting to mobilise creativity (in the positive sense of that word) and potential of the production systems of suppliers;
- Making a distinction in requirements; not wanting to pay 'top dollar' for things that are not that important;
- Transfer responsibility for the construction phase to the relevant party.

Strategic reasons
- Discourage suppliers to make price agreements;
- Enable learning in own organisation;
- Enable learning in supplier market;
- Wanting to reward suppliers that deliver superior performance;
- Bypassing 'traditional' regulation regarding too strict requirements that would exclude a too large portion of the market. Another naming for the portion of the market that is reached is the level of market penetration.

Opportunistic reasons
- Acquire subsidy.

Illegal reasons
- Misuse subjective criteria in order to obscure the fact that you try to favour certain (befriended) parties (violation of integrity, procurement regulation).

It can be stated that procurers should only implement integrated contracting or EMAT for the relevant and strategic reasons. Doing it for other reasons leads to

ill-inspired implementations, that could form a barrier for successful implementations in the future.

Collusion in the Dutch construction industry and the parliamentary enquiry
As described in section 2.2.4 and appendix section E.3, as a result of the effectuation of the European procurement directives, the common practice of contractors to make price agreements "suddenly" became illegal in the early nineties. However, generally speaking, the contractors continued their old practices. The publication of evidence (Bos 2001) of collusion and bribing of procurement officials in the Dutch construction industry, especially in the sector of public works, caused great public outrage. A parliamentary enquiry committee concluded that radical measures were needed to prevent similar cases and to develop the construction industry into a healthier, more responsible sector. As a result, the transformation institutes PSIB ("Proces- en SysteemInnovatie in de Bouw", organisation for creating process and system innovation in the Dutch construction industry) and RRB ("RegieRaad Bouw", council for coordinating renewal initiatives in the Dutch construction industry) were installed and contractors that had made illegal price agreements were persecuted. After the parliamentary enquiry, the attention for integrity and accountability increased.

2.4   Barriers for applying the EMAT award mechanism

This section presents the answer to the fourth background question "why is the current application of EMAT problematic?" That is done by listing and structuring the reasons for problematic application of the EMAT award mechanism.

Despite the understanding of the advantages of integrated contracting (RWS 2002a) and all the good intentions surrounding it (RWS 2004a), it turns out it is not applied as often as wanted and when it is done, problems are encountered (RWS 2004b). The EMAT award mechanism turns out to be one of the major hurdles, because it is perceived as more complicated than the traditional lowest price award mechanism.

Boer (1998:15) mentions fear of time consuming complicated processes and the administrative burden as possible explanations for the problems government organisations have with implementing the EC-procedures.

The publication "Aanbestedingsregels moeten innovatie bouw stimuleren" (Procurement regulation should empower innovation in the construction industry)

(RRB 2005) clearly states that the EMAT award mechanism should be applied more often, but that there are practical barriers (translated quote):

> *The council thinks the EMAT award mechanism should be used more often, so that qualitative aspects are rewarded as well. It offers more room for innovation and for an optimal quality/price ratio. Because of the need for transparency and equal treatment, regulation seems to favour the lowest price award mechanism: for procurers it is the simplest way to account oneself towards other political institutions and towards the judge. Because of jurisprudence, the demands regarding the EMAT procurement procedure are fairly high.*
> *Both in the (Dutch) regulation as well as in the policies, possibilities for stimulating awarding based on EMAT need to be found. It could be a possibility to give independent advisors a certain role in the procedure, so the accountability problem becomes easier to handle for contracting public authorities. It could also be conceivable that in regulation or in the policies for certain case a clear preference for this form of awarding is pronounced.*

In the era after uncovering the collusion in the Dutch construction industry, it is understandable that procurers take as many precautions as possible to prevent being accused of nepotism. Integrity and legitimate, justifiable, accountable ways of spending tax-payers money have priority (Pol & Straathof 2005:81). From that point of view the EMAT award mechanism can appear less attractive than the lowest price award mechanism. Because of the use of more or less "subjective" award criteria, like aesthetics, there have been rumours that EMAT could be misused to give projects to befriended suppliers. And probably, it has happened in some cases, although that will remain hard to prove. Favouring certain parties on false arguments remains forbidden. Although it is very hard to favour parties with a correctly formulated EMAT mechanism, given the rumours, it is understandable why some procurers think that using EMAT is too risky.

There are several explanations for the lacking implementation of the EMAT award mechanism. As a result of interviews (PSIB 2006a, RWS 2002), conversations and work experience, several explanations for the reluctance to apply integrated contracting and EMAT have become apparent. Sunding's four categories of barriers for organisational change (Sunding & Ekholm 2007), see Table 7, will be used to group the explanations.

Table 7   Four categories of barriers for organisational change (Sunding &
*   Ekholm 2007)*

Barrier	Related concept
Do not understand	Consciousness
Do not want	Motivation
Do not dare	Fear
Cannot	Ability, means

2.4.1   Barriers from the category "do not understand"

Procurers
- Sometimes, both the contractor and the procurer continue working in the traditional way, because they think the new contract form on it self will solve all their problems. Obviously, both parties will have to change their working methods in order to actively pursue the advantages of the new way of working;
- Confusion about the background of integrated contracting;
- The available information about the EMAT award mechanism is unclear.

Suppliers
- Sometimes, both the contractor and the procurer continue working in the traditional way, because they think the new contract form on it own will solve all their problems. Obviously, both parties will have to change their working methods in order to actively pursue the advantages of the new way of working;
- The effect of becoming responsible for the (estimated) cost is underestimated by some suppliers/contractors. The traditional 'bid low, claim high' behaviour does not work anymore. It takes time before everybody in the entire organisation realises that and acts accordingly.

2.4.2   Barriers from the category "do not want"

Procurers
- Resistance to change;
- Being satisfied with lowest price selection;
- Time pressure;
- The number of companies capable of working in the new way is not that large. It implies that the number of competing companies is also not as large as in the traditional construction industry. That can have price consequences;
- A possibility of higher prices as a result of risk pricing by the suppliers;
- Increased transaction costs in the case of design cost reimbursement;

- Why ask the market to design something, when you are better able to do it yourself?;
- Maybe some more obscure reasons like existing 'modes of understanding' between suppliers and procurers;
- Non-stimulating reward mechanisms;
- Conservativeness of legal advisors that want to reuse their old knowledge;
- The project situation is not suitable for integrated contracting, for instance when the project complexity is low and the procurer exactly knows the market possibilities;
- Organisation aspects; the people responsible for setting up the new system do not get enough funding, support and/or clarity of the other parties involved;
- Politics; tenders are sometimes part of a bigger scheme wherein other/larger interests play a role than only the construction object at hand, that can have a major impact on the entire process;
- Sabotage; new ways of working often imply change in the social structure and balance of power. This can be a reason for employees to thwart the intended change.

Suppliers
- Resistance to change;
- Increased acquisition costs, even in the case of design cost compensation, since it almost never covers the entire costs (although it could be seen as a challenge to streamline tendering processes).

2.4.3 Barriers from the category "do not dare"

Procurers
- Examples of 'failed' integrated contracts lead to extra hesitation; fear for juridical procedures and the resulting delays;
- Not everything is specified in advance, so you have to have the ability to deal with the resulting uncertainty about the project outcome;
- Traditionally, contractors do not have a designing attitude. Fears are that this will result in bids that are aesthetically and functionally less appealing;
- They do not trust the information for formulating EMAT award mechanisms;
- They have heard stories about integrated contracts going wrong, or have experienced it themselves;
- Risk avoiding attitude;
- Fear for poor accountability;
- Conservativeness of legal advisors;
- Unfamiliarity; they feel they do not have enough knowledge about the "ins and outs" of the new way of procuring in order to be able to make a rational choice.

Suppliers
- Increased risk as a result of increased design responsibility.

2.4.4   *Barriers from the category "cannot"*

Procurers
- When too much is arranged in earlier phases. Often, the procurer is, already in an early stage, legally bound to adhere to contractual conditions (including financial regulations). This is in contradiction with the desire, in the early stages of a project, to have a certain freedom of action because a number of aspects still are vague in nature;
- Existing organisational barriers; for instance the separation between construction- and maintenance budgets does not empower integrated thinking;
- The procedures for obtaining permits are not ready for the new situation;
- The tools, the criteria and the reasons are not clear, e.g. the boss has said it must be done, but not how;
- They have insufficient information and experience regarding implementing the award mechanism;
- The difficulty of translating quality/value aspects into monetary terms in a legally acceptable and practical way;
- The information that is needed to make informed decisions about formulating EMAT award mechanisms is missing.

Suppliers
- For some civil engineering projects, it is quite difficult to find solutions that are better than the solutions that are found in the traditional situation;
- It takes more effort and competences to empathise with the procurer position and to act accordingly. It takes more anticipating skills and a pro-active attitude;
- The procedures for obtaining permits are not ready for design and build contracts;
- The production processes are not ready yet to deliver what has been promised.

Each mentioned barrier could be an entrance for a study into the improvement of the application of integrated contracting and the EMAT award mechanism. This thesis will continue with the obstacles from the category "cannot".

Obstacles from the category "do not understand" can be solved by explaining the background of integrated contracting and EMAT to the people involved. Barriers from the category "do not want" can be taken away by ensuring that, before a project starts, the right conditions are present. Barriers from the category "do not dare" are harder to take away because the people involved will have to gain

positive experiences with integrated contracting and EMAT to overcome their fears.

Main obstacle from the "cannot" category appears to be the lack of information for procurers to formulate EMAT award mechanisms in a legally acceptable and practical way. Because there is a lot of knowledge about Multi Criteria Evaluation (MCE), as shown in section 2.1.3, it can be concluded that the difficulty of translating quality aspects in monetary terms is one of the major difficulties procurers are facing.

3 A model for presenting EMAT award mechanisms

A cynic is a man who knows the price of everything and the value of nothing - Oscar Wilde, Irish dramatist, novelist & poet (1854 - 1900)

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┌─────────────────────────────┐          ┌─────────────────────────────┐
│ Section 2. Problem inquiry   │          │ Section 3. A model for       │
│ (BQ 1-4)                     │          │ presenting                   │
│                              │          │ EMAT award mechanisms (BQ 5) │
└─────────────────────────────┘          └─────────────────────────────┘
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
┌─────────────────────────────┐          ┌─────────────────────────────┐
│ Section 4. Constrains on EMAT│          │ Section 5. EMAT award        │
│ award mechanisms (KQ 1)      │          │ mechanisms                   │
│                              │          │ applied in practice (KQ 2,   │
│                              │          │ KQ 3)                        │
└─────────────────────────────┘          └─────────────────────────────┘
                    ┌─────────────────────────────┐
                    │ Section 6. Suitable EMAT     │
                    │ configuration options (KQ 4, │
                    │ MQ)                          │
                    └─────────────────────────────┘
                    ┌─────────────────────────────┐
                    │ Section 7. Conclusions &     │
                    │ Recommendations              │
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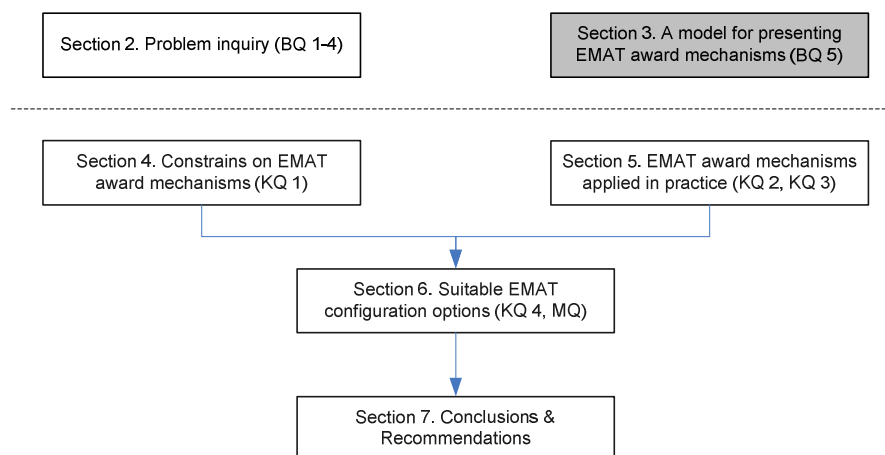
This section presents the answer to the fifth background question "how can the EMAT award mechanism be modelled?" by presenting the value price model. Before the fundamentals of the value price model are described in section 3.2, section 3.1 gives an elaborate description of the concept of value. The procurers concern is elaborated into more detail in section 3.3 where the procurement space is introduced. There are several strategies for obtaining the bid with the best value price ratio from the market. These are described in section 3.5, but before that, two main value-price systems are distinguished in section 3.4. Section 3.6 describes how the model is used to determine the concept of bidding freedom and section 3.7 describes the procedures for presenting the results of the identified EMAT main types two-dimensionally.

3.1 Definition of the concept of value

Using the EMAT award mechanism is also referred to as 'value based procurement' or 'awarding on the basis of value'. In order to model the EMAT award mechanism, a value-price model will be introduced. This implies that the two main dimensions that need to be determined are value and price. The price of a bid is hereby defined as *the amount of money a supplier wants to receive for the performance he or she promises in the bid*. The concept of value is less straightforward to define. This section evaluates several definitions of value in order to formulate an unambiguous definition (Dreschler 2005, Dreschler et al. 2005).

3.1.1 Literature investigation of value definitions

The value engineering definition

According to Kelly et al. (2004:17) value is "a measure expressed in currency, effort or exchange or on a comparative scale which reflects the desire to obtain or retain an item, service or ideal". They also state that in other literature the relationship of value to function and cost is represented by the following expression:

$$Value = \frac{Function}{Cost}$$

Also the international norm on value management (NEN 2000a) uses this definition. Kelly et al. (2004:17) define 'function' as "a characteristic activity or action for which a thing is specifically fitted or used or for which something exists. Therefore something can be termed 'functional' when it is designed primarily in accordance with the requirements of use rather than primarily in accordance with fashion, taste or even rules or regulations. Value engineers distinguish between a basic function and a secondary function. A basic function is defined as the performance characteristics that must be attained by the technical solution chosen. Secondary functions are the performance characteristics of the technical solution chosen other than the required basic function."

According to this definition, value is a ratio, of which the dimension is dependent on the unit of function. The ratio resembles efficiency or productivity. The outcome of decisions using this definition depends on the way functionality is measured.

Definition used in economics

Several definitions of value can be found in the economic literature. A general definition of value is "the amount (of money or goods or services) that is

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considered to be a fair equivalent for something else" (Dobson & Palfreman 1999:34). This is also called 'willingness to pay' (Ruijgrok et al. 2004). In neoclassical economics, the willingness to pay for a product differs for different customers; they value the product differently. One customer may derive more utility from a product (or has more to spend) than another, so the value of objects is subjective. If the 'willingness to pay' for different people is combined with the theoretical number of products that will be sold, a demand curve as shown in Figure 11 can be plotted, assuming the higher the willingness to pay, the sooner a customer buys a product. In the same way the 'minimum supply price' for several suppliers is combined into the supply curve. The neoclassical theory states that in an open and competitive market, an equilibrium point (Q_e, P_e) will be reached at which society's profit is maximised.
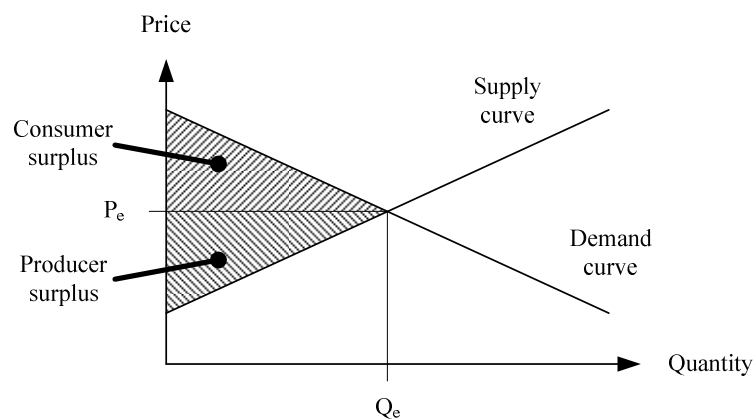
Figure 11   Market equilibrium & related principles (Dobson & Palfreman 1999:34)

In neoclassical economics, the value of an object or service is defined by the price it would bring in an open and competitive market. This equilibrium value is referred to as market value. Consumers who would be willing to pay more than the market value experience a benefit. This difference in value is called the 'consumer surplus'. Producers who would be willing to sell for less than the market value also experience a benefit. This difference in value is called the 'producer surplus'. The total surplus, the sum of consumer surplus and producer surplus, is called the net valuation in a market. At the equilibrium point the society's net valuation is maximised. A higher or a lower price would amount to a lower profit for society.

Value-Price-Cost model definition
As a framework for analysing transactions in the construction industry, De
Ridder et al. (2002) introduced the Value-Price-Cost model (Figure 12).
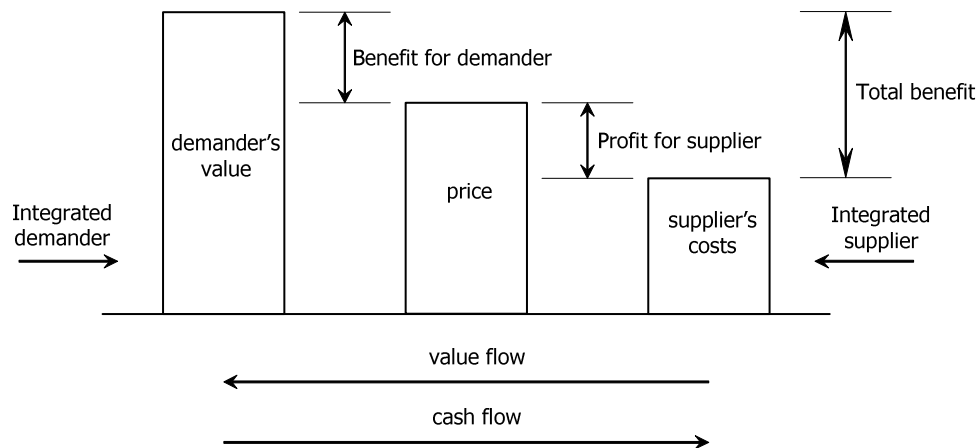
Figure 12   The Value-Price-Cost model (Ridder et al. 2002)

The Value-Price-Cost model represents some of the relevant parameters in the
transactions between integrated parties in the construction industry. It emphasises
that the total benefit should be increased. The total benefit consists of the benefit
for the demander (procurer in the context of this thesis), which is the difference
between value and price, and the profit for the supplier, which is the difference
between price and costs. If the total benefit is positive, the transaction is
beneficial for both parties.

The parameters in this model can be compared to the principles of neoclassical
economics. Value can be related to the willingness to pay for a certain object.
Cost can be related to the minimum amount of money a producer is willing to
accept. The price lies somewhere in between value and cost, dividing the total
benefit into a consumer surplus and a producer surplus.

Cost-Benefit Analysis definition
The Cost-Benefit Analysis is described in many sources; see for instance (EZ et
al. 2000a, EZ et al. 2000b, Wee & Dijst 2002). In an integral or societal Cost-
Benefit Analysis (CBA), value consists of all the inflows and other intangible
benefits of a project. The value is compared with all the outflows (the costs and
disadvantages) of the project. As with the previous two definitions, the difference
is the net value or total benefit. A frequent problem with CBA is that typically
the costs are tangible, hard and financial, while the benefits are hard and
tangible, but also soft and intangible. Caution should be taken here against

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people who claim that "if you can't measure it, then it does not exist or it has no value". Especially in more strategic investments, frequently the intangible benefits clearly outweigh the financial benefits. The starting-point of a societal CBA is that the 'go/no go' decision is based on the effects the project has on the well-being of all citizens. This starting-point is known as "welfarism" (EZ et al. 2000a). Welfarism is based on the premise that actions, policies and/or rules should be evaluated on the basis of their consequences. Welfarism is the view that the morally significant consequences have impacts on human welfare. There are many different understandings of human welfare, but the term 'welfarism' is usually associated with the economic conception of welfare. Economists usually think of individual welfare in terms of utility functions. Social welfare can be conceived as an aggregation of individual utilities. Welfarism can be contrasted to other consequentialist theories, such as "utilitarianism". Welfarist views have been especially influential in the law and economics movement. Kaplow and Shavell (2002) have argued in their influential book "Fairness versus Welfare" that welfare should be the exclusive criterion on which legal analysts evaluate legal policy choices.

Van der Heijden and Mol (1990) present three methods for expressing the effects of projects. If the advantages and disadvantages of a project can be measured in physical units, valuation can be based on existing market prices. Prerequisite is a well functioning price mechanism. If this prerequisite lacking then the so-called "shadow"- or calculation prices can be used. For non-priced effects, many approximation methods can be found in the literature. Non-priced effects are effects corresponding to products and/or services, for which an (economic) market does not exist, such as clean air.

The ethical definition
The values that a group or person holds are usually categorised into ethical values and ideological values. Ethical values may be thought of as those values, which serve to distinguish between good and bad, right and wrong, and moral and immoral. At a societal level, these values frequently form a basis for what is permitted and what is prohibited. Ideological values deal with the broader or more abstract areas of politics, religion, economics, and social mores. In theory, the broader ideological values should derive logically, as natural consequences from the particulars of fundamental ethical values and their priorities. But although ideally a value system ought to be consistent, quite often this is not the case (Wikipedia 2005).

The financial definition
Investment decisions are often based on the difference between expected costs and expected revenues. To compare future cash flows, the Net Present Value (NPV) is calculated (Heijden and Mol 1990). Sometimes aspects like quality (-deterioration) and risks are included in these calculations. If the calculated value

is positive, the 'go' decision is likely. If the value is negative, the 'no go' decision is very likely. Typically the alternative with the highest value is selected. Often the result of decision making using this financial definition of value depends on assumptions about parameters such as interest.

3.1.2   Evaluation of the definitions

Based on this literature research, already some conclusions can be drawn. All definitions except the ethical definition compare some level of performance, functionality, utility, benefit or quality (-perception) with the associated level of price or cost. As illustrated in Figure 13, three categories can be distinguished: value as a ratio (category I), value as a surplus (category II), or value as an absolute quantity (category III). In the mathematical sense "absolute" means larger than zero. Since value can also be negative, for instance when a project has a negative impact on a stakeholder, in the context of this thesis "absolute quantity" should be read as "some level of performance, functionality, utility, benefit or quality (-perception)".
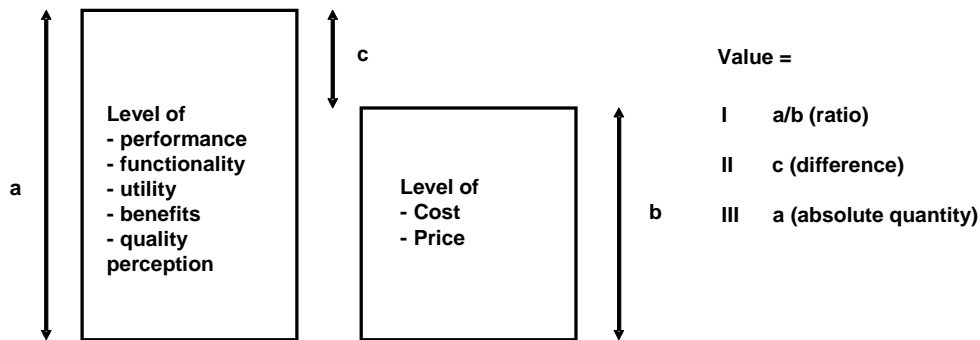
Figure 13   Three categories of value definitions

The value engineering definition belongs to the first category, the financial definition to the second. The economic and the Value-Price-Cost model definitions belong to the third category. The Cost-Benefit Analysis definition is used in both the second and third category.

For this thesis the third category is adopted because in the context of value based procurement the focus needs to be on the desirable product characteristics instead of the already well known price characteristics.

3.1.3 Definition of 'value' for this investigation

Since the award phase of public construction projects forms the context of this research, value is defined as follows:

The value of a bid is the performance of that bid, determined by the procurer and expressed in monetary terms.

The performance of a bid is determined by the aggregation of the individual performance criteria. These criteria are determined by the procurer. Procurement regulation does not prescribe explicitly that these criteria (European Parliament 2004) should be expressed in monetary terms, but they must have an economical dimension. Furthermore, the relative importance of the criteria must be given in advance to all suppliers.

For a number of reasons, the performance of bids should be expressed in monetary terms. Firstly, a real monetary incentive for suppliers must be provided in order to empower the wanted developments in the construction industry. Secondly, the monetary value of partial performances can be calculated once the award is granted, so the performance needs to reflect the real willingness to pay of the procurer.

Why not use the term quality instead of value?
It is easy to use value, functionality, quality or performance as interchangeable concepts in sentences. There is however a subtle but conclusive reason to use the term value instead of for instance quality. The difference between value and quality is that a product can be of high quality, but not necessarily of value for the demander; the demanders has to have a need for a certain quality in order to be willing to pay for that quality. This can be illustrated by the 'styrofoam example'. Imagine a supplier who produces premium quality Styrofoam; all product characteristics are top of the line: strength, weight, heat conductivity, sound isolation, fire resistance, etc. The supplier tries to sell one cubic meter to a client, but the client is not interested, because he or she has no need for it. Even drastic price cuts will not convince the client. The client does not 'value' the quality. Some time later, the client is involved in a construction project and needs Styrofoam. The client remembers the bid and all of a sudden the product qualities have value; the client is willing to pay for the product and if the need becomes high enough maybe even more than the original price. So in order to speak of value, product qualities need to be in line with customer needs.

Framing
Not only product characteristics determine the willingness to pay for an object. Noble prize winners Kahneman and Tversky (Schwartz 2004) showed that 'framing' can influence the outcome of choice problems. If for instance a vase is presented on the lower shelf of an old rack, covered in dust, people will not think

it has much value. If the same vase is presented on a pedestal, behind protective glass, with a guard protecting it, people will think it has much more value. So the environment of objects and the way in which objects are presented play a role in determining the value of objects. However, in the context of a public procurement it cannot, since the award criteria need to be known in advance, so framing does not play a role in this research.

Combining different "willingnesses to pay"
Value is subjective; the willingness to pay for a certain object is not the same for everyone. When more than one person or interest group is involved, which is often the case in the construction industry, selection of the alternative with '*best value for money*' becomes difficult. Decision makers need an acceptable (realistic and fair) method for determining the total value of an alternative solution. This implies that they need to combine partial value judgments into a total value judgment. The most common methods to do so are (societal) Cost-Benefit Analysis (CBA) and Multi-Criteria Evaluation (MCE). Most impact-evaluation methods can be used as a part of one of these two analysis methods (Heijden & Mol 1990, EZ et al. 2000a, Wee & Dijst 2002). However, since this subject does not fit in the scope of this research, it will not be taken into consideration.

3.2   The value price model

Basis for the value price model is the Value-Price-Cost model by De Ridder et al. (2002), see section 3.1.1. Since the research presented in this thesis focuses on the procurement phase, the attention is shifted to the parameters value and price, which results in the value-price model as depicted in Figure 14.
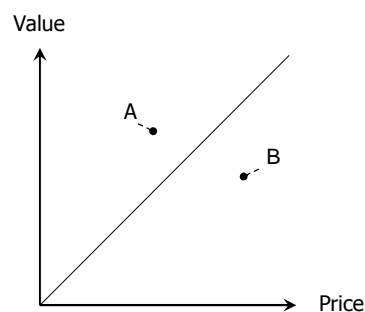
Figure 14   The value-price model

The value price model is a graphical representation of a procurement situation. It models the "value for money" notion. For the procurer, value of the product corresponds with "what you get" and the price corresponds with "what you give". For the supplier, the price corresponds with "what you get" and the value of the product corresponds with "what you give". Ideally, the price for the supplier is higher than the costs. For the procurer it is ideal when the value is higher than the price.

The diagonal line in Figure 14 represents the collection of points for which the price and value are exactly in balance; any bid above that line (see point A) is "economically rational", any bid below that line (see point B) is not attractive for procurers.

The value-price model is not only used by De Ridder et al. (2004:39) but also by Johnson & Scholes (1993) and Kottler & Keller (2006).

An important principle of the EMAT award mechanism is that it is not necessarily the cheapest bid that wins. Figure 15 shows that the value price model is able to represent that principle graphically. The figure presents two bids, bid 1 and bid 2. The price of bid 2 is lower than the price of bid 1, but the value of bid 1 is relatively higher than the value of bid 2, making bid 1 the more attractive option.
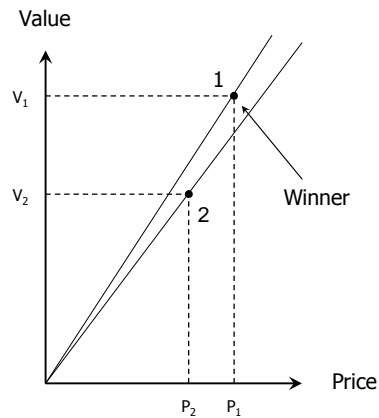
Figure 15   It is not necessarily the cheapest bid that wins

Because the value-price model is able to represent the important EMAT principle, it is suitable as a 'common denominator' for comparing the results of EMAT award mechanisms. Note that for this example preference is based on the highest

value-price ratio. Preference can also be based on the highest difference between value and price. That difference is elaborated in section 3.4.

3.3 The procurement space

There are several boundaries that put constraints on proposals that suppliers can make.

First of all, the procurer often has a certain budget for the construction project. The budget forms the upper limit of the price; bids with a higher price cannot be accepted, as illustrated in Figure 16a).

Furthermore the procurer has certain minimum requirements, to which any bid must comply in order to be acceptable. These minimum requirements represent the minimum acceptable performance of the construction project. Because performance (see Appendix A for how "performance" is defined in this thesis) is linked to value, a minimum value constraint can be represented in the value price model, see Figure 16b).

For EMAT awards, bids can receive an added value, based on extra performance. It is also possible that the EMAT award mechanism is formulated in such a way that bids can receive a negative added value in case of lacking performance. That option is not represented in the figure. In most EMAT award mechanisms, the maximum possible extra performance that is rewarded is limited. This forms the upper limit for the value of bids, as shown in Figure 16c). Please note, that according to this model, total value is defined and determined by the value of the program of requirements plus the added value.

Finally, to protect suppliers for themselves or to prevent fight-contracts, there is a minimum price for which the project can be made, see Figure 16d). Bids with a lower price are not realistic. This kind of bids can occur when suppliers have made calculation errors in their tender or when they show strategic behaviour in order to get the assignment. Either way, it can prevent a lot of trouble in later phases when a minimum price restriction is in place.
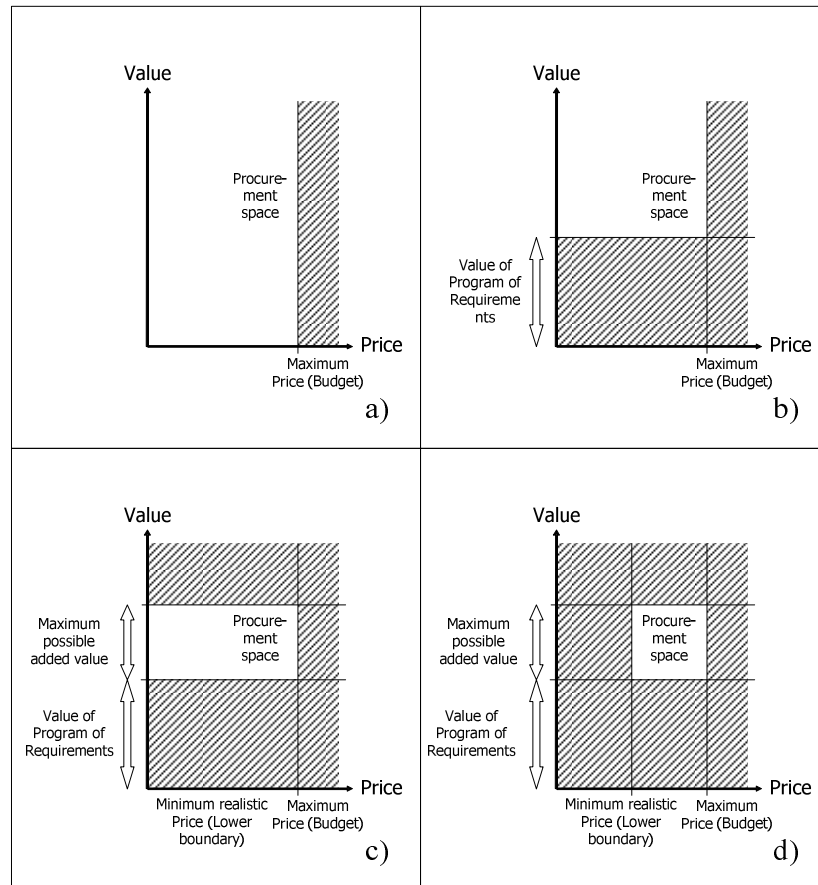
Figure 16   Formation of the procurement space

3.4   Two value price preference determination methods

Two value price preference systems can be distinguished; a system that bases preference on the highest value price ratio and a system that bases preference on the highest difference between value and price.

The system that bases preference on the highest value price ratio – in short the V/P preference system – is depicted in Figure 17. The diagonal lines represent

the collections of points with equal preference; the steeper the line, the higher the preference.
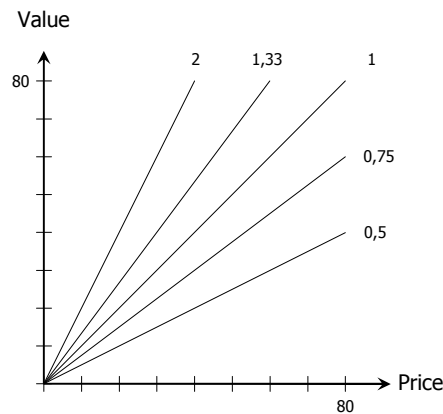
Value

Figure 17   Lines of equal preference of the V/P (ratio) preference system

The system that bases preference on the highest difference between value and price – in short the V-P preference system – is depicted in Figure 18. The diagonal lines represent the collections of points with equal preference; the higher the line, the higher the preference.

Value
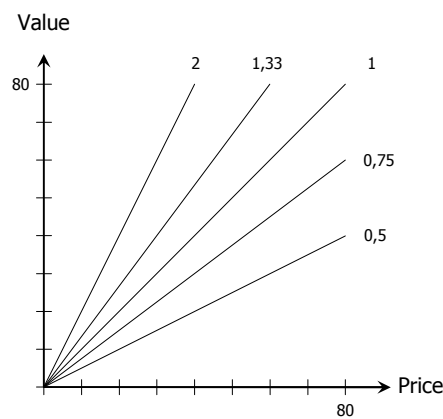
Figure 18   Lines of equal preference of the V-P (difference) preference system

In normal speaking language, one would say that the V/P preference system selects on basis of the cost-effectiveness or profitability of the investment. The

V-P preference system selects on the basis of the highest procurement profit. Both types of selection are economically rational. Please note that the regulation (see section 2.1.1) does neither prescribe which method must be used in order to determine the EMAT nor does it provide any clues. And at the moment of writing this section it is not known whether legal precedence exists that disapproves either of these options. Hence it is assumed both options are legally acceptable.

Figure 19 shows that the type of preference system that is used can lead to different rankings.
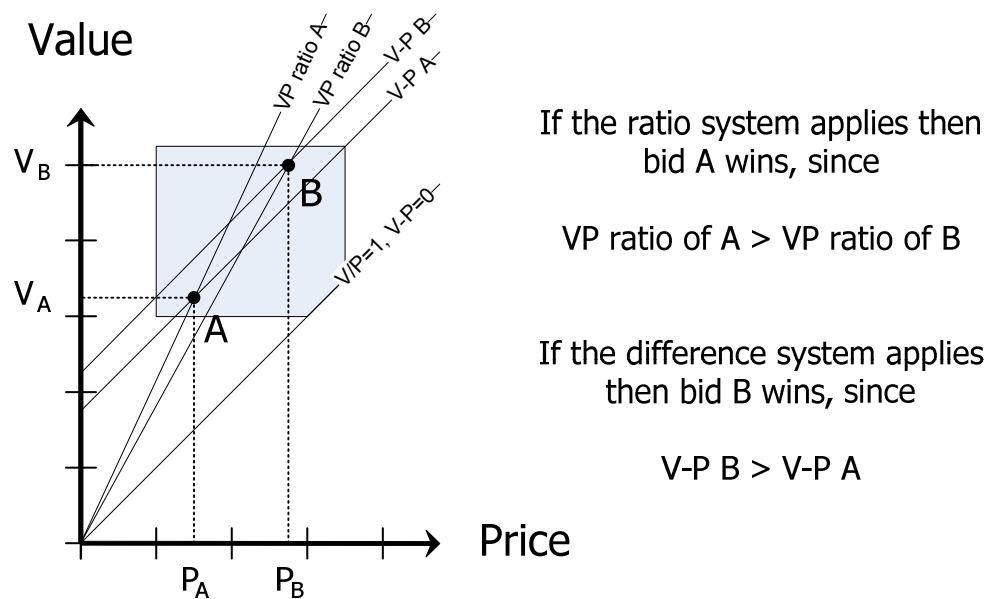
Figure 19   Type of preference system can lead to different rankings

In the example of Figure 19, bid A would win in case of V/P preference, because the value price ratio of bid A is higher than the value price ratio of bid B. However in case of V-P preference, bid B would win because the difference between price and value of bid B is higher than the difference between price and value of bid A.

3.5 Award strategies

The distinction between "lowest price" and "economically most advantageous" is unclear to many people. Intuitively, one would expect the bid with the lowest price to be automatically the most economical. In order to understand the difference, one has to be familiar with the legal meaning of these concepts.

As stated in section 2.1.1, the lowest price award mechanism grades bids based on price only; the economically most advantageous award mechanism also takes other product dimensions into consideration. This is visualised in Figure 20 and Figure 21 respectively. Note that the mentioned product dimensions are just examples. In these figures, criteria with a precisely prescribed performance are represented with a closed lock and criteria on which performance is allowed to vary are represented with an open lock.
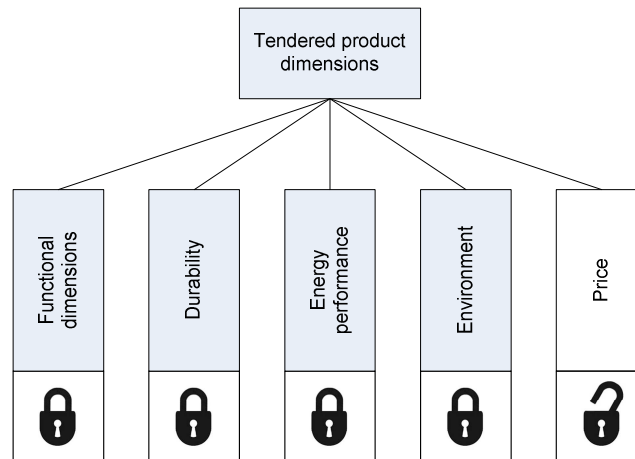
Figure 20   Flexibility for the lowest price award mechanism
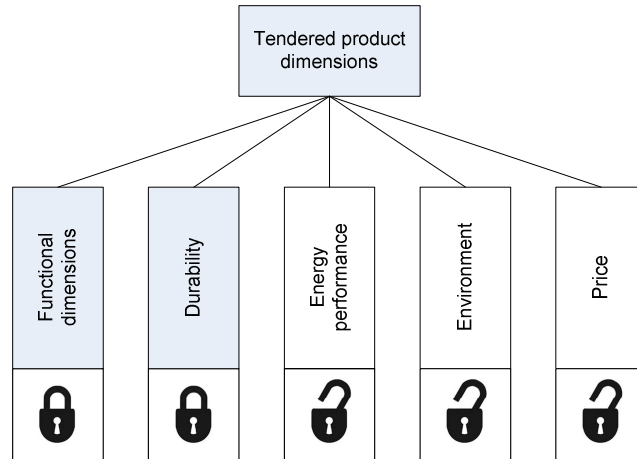
Figure 21   EMAT flexibility; several aspects are allowed to vary

A special type of the EMAT award mechanism is the one in which the price is fixed and given in advance to the suppliers; bids are allowed to vary on several other product dimensions, see Figure 22. This type is called a design contest. The most important characteristic of the design contest is that the price of the product is fixed; note that not all other product dimensions have to be variable, some of them could be fixed as well.
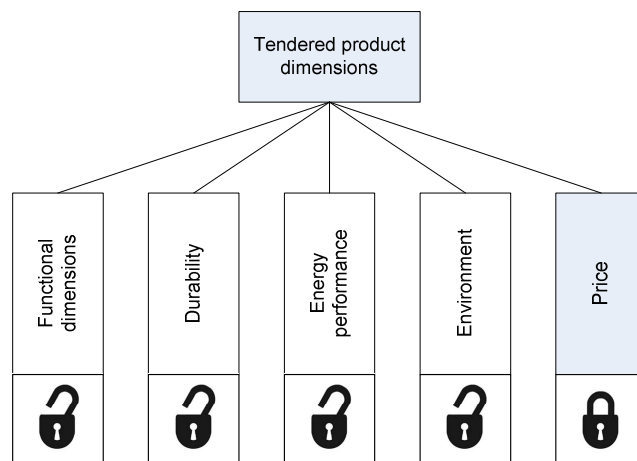
Figure 22   Design contest flexibility

In this thesis, the three flexibility modes are called award strategies (Table 8). If we assume that all dimensions other than price are combined into a new dimension called 'value', it can be stated that the objective of all three award strategies is to obtain best value for money.

Table 8   Strategies for obtaining best value for money

Award strategy	Price	Value	Best value for money
1. Lowest price	Variable	Fixed	Price minimisation
2. Design contest	Fixed	Variable	Value maximisation
3. EMAT	Variable	Variable	Value Price optimisation

In Figure 23 the award strategies are mapped into the procurement space. This way of visualising award strategies was introduced by Dreschler et al. (2006).
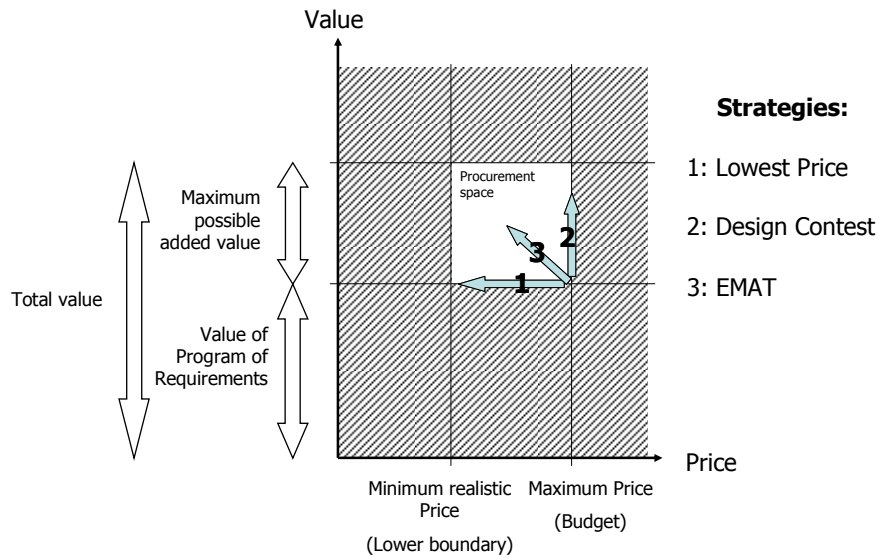
Figure 23   Award strategies mapped in the procurement space

As described in section 2.3.6, the choice of a specific strategy can have very different effects on the resulting processes. Best value for money is the goal of any economical transaction. Distinguishing features of public procurement compared to other types of procurement (see Appendix F) are the need to comply with procurement regulation, the high number of administrative procedures and thus high transaction costs. However, these higher transaction costs are justified as it may cost a little extra to uphold the important open market principle.

3.6   The influence of added value; design and bidding freedom

The influence of the maximum possible added value on the total preference determination is an important parameter since it determines to what degree delivering a high performing bid can compete with a low priced bid. It can be seen as an indication of the 'progressiveness' of the EMAT award mechanism in the sense that it is an indication of the level of trust a procurer has in the ability of suppliers to deliver added value. This section defines the parameter "bidding freedom" and introduces a method for determining the bidding freedom for the different types of EMAT award mechanisms.

The essential concepts that are needed to determine the "bidding freedom" are depicted in Figure 24. The example of Figure 24 uses a V-P preference system. The "bidding freedom" is established in three steps.

- Step 1; establish "the cheapest option": estimate the cost of a bid that just barely meets minimum requirements and thus scores the minimum possible added value (negative added value is also possible). The cheapest possible option is represented by point X in Figure 24. Because this bid barely meets minimum requirements it can also be called the "6⁻ estimate". Please note that in the Dutch school grading system, a "6⁻" is barely sufficient.
- Step 2; establish "the most expensive competitor": determine how much more expensive the bid that scores the maximum possible added value may be in order to be just as attractive as the cheapest possible option. The most expensive competitor is represented by point Y in Figure 24. Because the budget should be large enough to accommodate this bid, it could be called the "budget tester".
- Step 3; determine the "bidding freedom": divide the price difference of point X and point Y by the price of point Y.
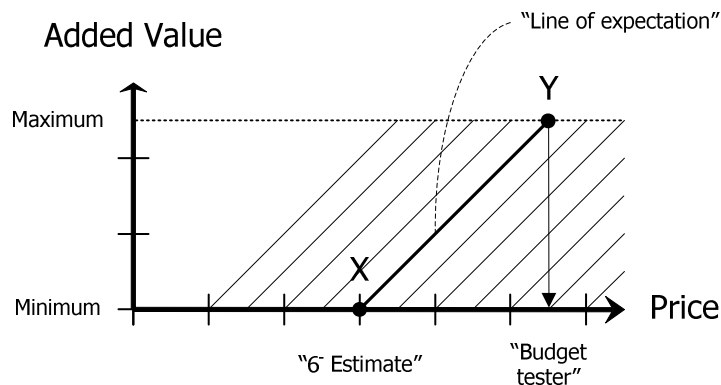
Figure 24   Concepts related to the "bidding freedom"

Note that the line between points X and Y in Figure 24 can be called the "line of expectation"; bids above the line are a positive surprise for the procurer, bids below the line are a negative surprise.

At step 3, the "bidding freedom" could be determined as well by dividing the price difference of point X and point Y by the price of point X instead of the price of point Y, which leads to different results, see Figure 25.
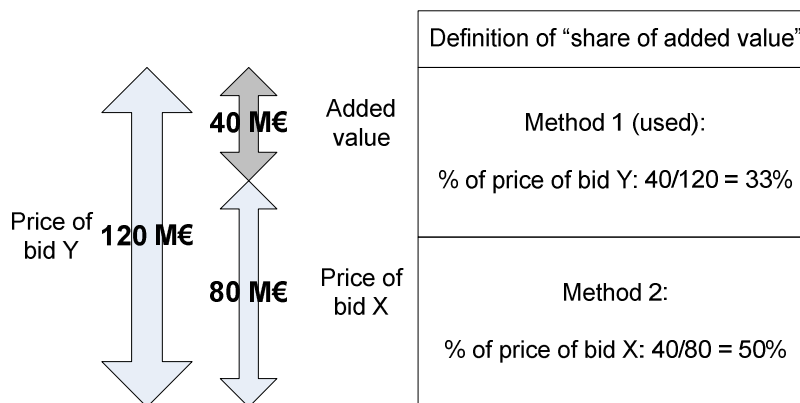
Figure 25   Two methods for determining the "share of added value"

If for instance the price of point X would be 80 M€ and the price of point Y would be 120 M€, the bidding freedom would be 40/120=33% if the price of point Y would be used as reference. If the price of point X would be used as reference, the bidding freedom would be 40/80=50%, a significant difference with the 33% calculated earlier. For this thesis the first method is used, in order to focus the attention to the idea that the budget should accommodate "the budget tester" (the price of bid Y).

3.7   Procedures for presenting EMAT in the value price model

The outcome of an EMAT award is usually presented "one-dimensionally", as was done by Doornbos (2005). Main criticism for presenting the results one-dimensionally is that it still looks like decision making is one-dimensional as well. As a result, one could get the impression that selection still amounts to lowest price selection. Arguably, by presenting the results two-dimensionally, the idea that adding value matters is conveyed more effectively. In order to illustrate

the difference in presentation, the fictitious bid situation presented in Table 9 will be used to present the results of the price correction system, the point system and the ratio system one-dimensionally and two-dimensionally.

Table 9   Fictitious bid situation

Bid	Price (M€)	Added Value (M€)
A	60	0
B	70	20
C	80	40

3.7.1   *Price correction system, result presented one-dimensionally*

If a price correction system is used to assess the bid situation presented in Table 9, bid C is awarded the contract because it has the lowest corrected price, as shown in Table 10 and in Figure 26.

Table 10   Fictitious bid situation assessed with the price correction system

Bid	Price (M€)	Added Value (M€)	Corrected Price = Price - Added Value (M€)	Rank
A	60	0	60	3
B	70	20	50	2
C	80	40	40	1
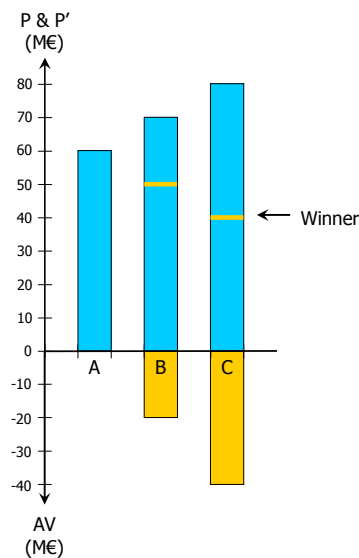
Figure 26   Price correction system, result presented one-dimensionally

Figure 26 presents the bids A, B and C. The positive side of the vertical axis presents the price of the bids (P) and the corrected price (P'). The negative side of the vertical axis presents the added value (AV) of the bids, which may be subtracted from the price. Bid C is the most expensive, but receives the highest added value as well. Bid C wins because it has the lowest corrected price.

3.7.2 *Point system, result presented one-dimensionally*

Assume a point system is used in order to assess the bid situation presented in Table 9. The point system gives 100 points to the lowest bidder. Other bids receive 1 point less for each M€ they are more expensive. The bids receive bonus points for extra performance. Note that this is the type of point system that could be encountered in practice. Again bid C wins, as shown in Table 11.

Table 11   Fictitious bid situation assessed with a point system

Bid	Price (M€)	Price points	Added Value points	Total points	Rank
A	60	100	0	100	3
B	70	90	20	110	2
C	80	80	40	120	1

This situation is graphically represented one-dimensionally in Figure 27.
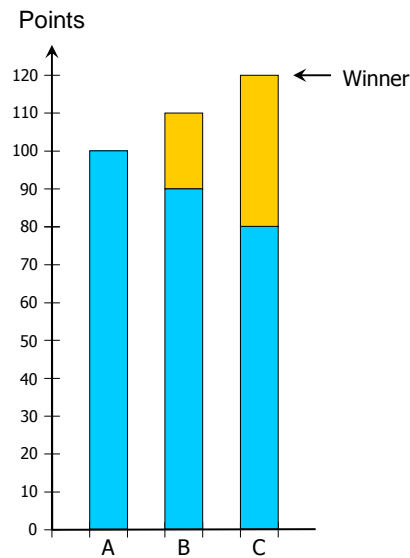
Figure 27   Point system, result presented one-dimensionally

Figure 27 presents the bids A, B and C. The cheapest bid (A) receives the highest amount of price points. However, it does not receive extra points for adding value. Bid C wins because it has the highest total amount of points.

3.7.3 Price correction system, result presented two-dimensionally

Since both price and added value of the bids are known, it is quite straightforward to present the results of Table 10 two-dimensionally in the value price model, as shown in Figure 28. Since the total value is not known, only the added value is used on the vertical axis. The diagonal lines in the figure are "lines of equal preference", which were described in section 3.4. P' is used to indicate the corrected price of a bid.
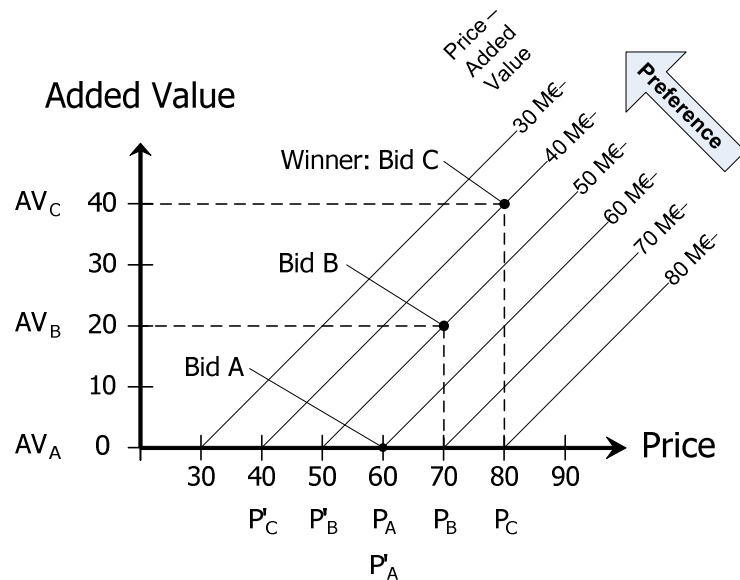
Figure 28   Price correction system, result presented two-dimensionally

Figure 28 shows that although bid C has the highest price, it has the highest preference as a result of high added value.

3.7.4 Point system, result presented two-dimensionally

In order to present the results of Table 11 two-dimensionally in the value price model, the added value needs to be calculated. Since the value of one point was defined as one M€, the added value of bid A equals 0 M€, the added value of bid B equals 20 M€ and the added value of bid C equals 40 M€.

Furthermore, two assumptions need to be made. First assumption is that the point system is a subtype of the V-P preference system (see Figure 18). Second assumption is that the number of points corresponds with the diagonal equal-preference lines of the V-P preference system; the higher, the better. Again the vertical axis corresponds with added value instead of total value since only the added value is known. Several figures are used to show how the result of the point system can be modelled two dimensionally. As shown in Table 11, the lowest priced bid receives 100 points; in other words the "60 M€" equal preference line of Figure 28 is relabelled to "100 points", see Figure 29.
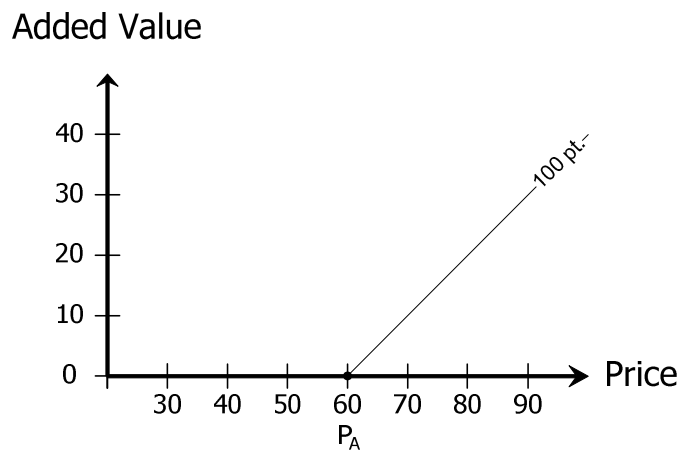
Figure 29   Point system, result presented two-dimensionally (1)

Consequently, the equal preference lines of 90 points (a diagonal line through the price of bid B) and of 80 points (a diagonal line through the price of bid C) are added, see Figure 30.

Added Value
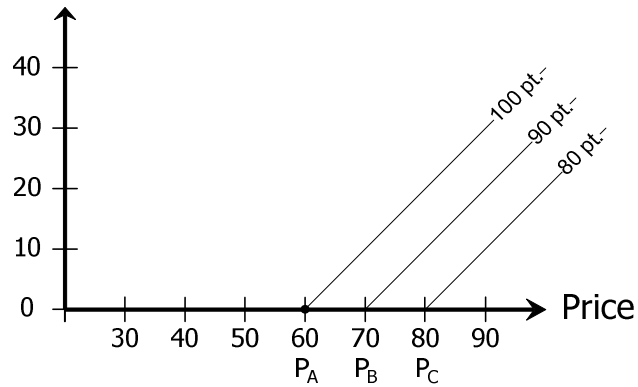
Figure 30   Point system, result presented two-dimensionally (2)

As stated, bid A receives 0 value points, bid B receives 20 value points and bid C receives 40. Based on this information, the total point score of the bids can now be calculated, as indicated by the arrows in Figure 31. Bid A does not receive any points so its total remains at 100. Bid B gets 90 + 20 = 110 points and bid C gets 80 + 40 = 120 points. Bid C has the highest point score and thus wins. Note that the intersections of the "equal preference" lines with the horizontal axis correspond with the corrected prices (indicated by P') of Figure 28.

Added Value
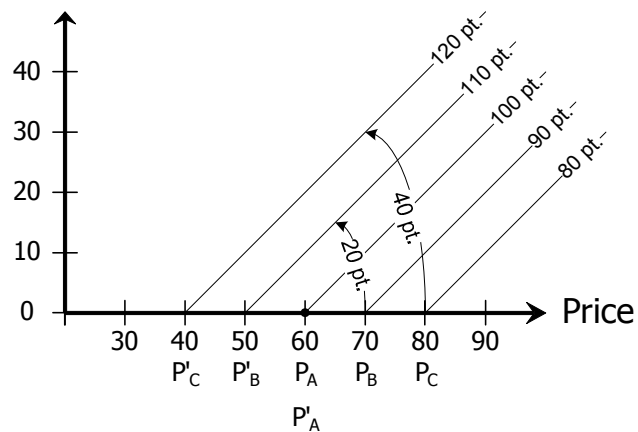
Figure 31   Point system, result presented two-dimensionally (3)

Because the added value of the bids is known as well, the exact position of the bids in the value price diagram can be shown (Figure 32).
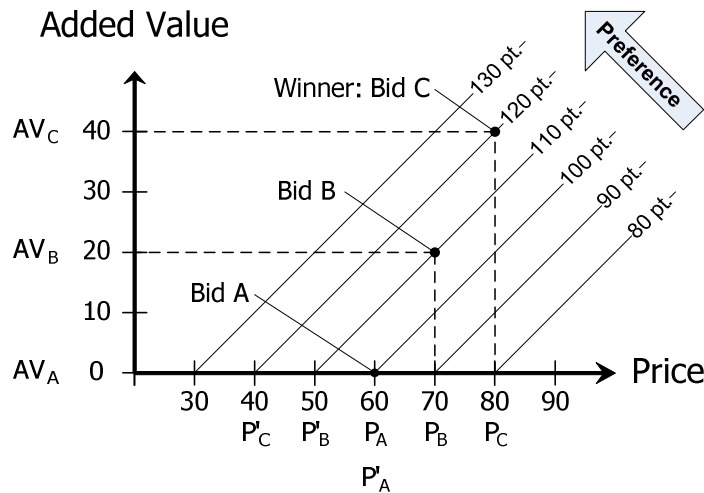
Figure 32   Point system, result presented two-dimensionally (4)

This example shows that the point system is actually the same as the price correction system.

The example of the fictitious bid situation and the point system assessment will be used to show that in the transformation of price into points, the initial point reference is of no consequence. Assume that instead of 100 points, the cheapest bid receives zero points. The other bids still receive 1 point less for each M€ they are more expensive. Again, the bids receive bonus points for extra performance. Table 11 shows the situation with the new initial point reference for the price point transformation. Again bid C wins.

Table 12   Fictitious bid situation assessed with another point system

Bid	Price (M€)	Price points	Added Value points	Total points	Rank
A	60	0	0	0	3
B	70	-10	20	10	2
C	80	-20	40	20	1

This situation is graphically represented in Figure 33.
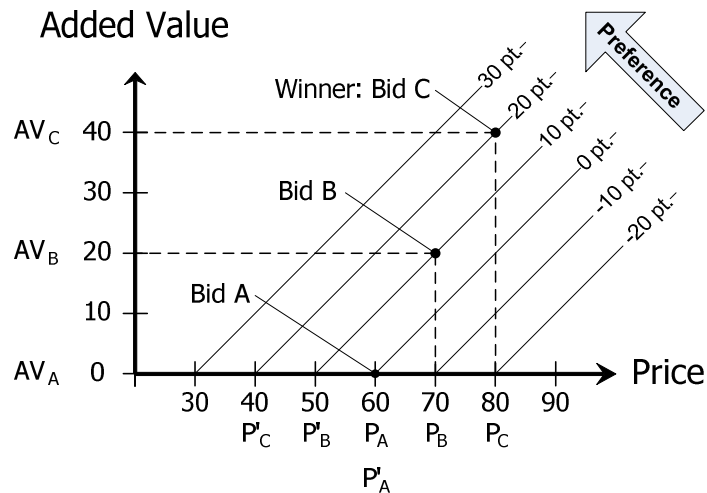
Figure 33   Modified point system, result presented two-dimensionally

Note that the preference and appearance of Figure 33 remain exactly the same as Figure 32; this shows that the initial point reference for the price point transformation is of no consequence at all. Similarly, it can be shown that the reference price (the price of the lowest bid, or the second or the average, or whatever price reference) is of no consequence.

Elaborating on this, it can be concluded that the point system introduces an extra, unnecessary variable, which makes things unnecessarily complicated. Furthermore it introduces an appearance of certainty and precision which is not there.

Several point systems were encountered where precise statements about the influence of value criteria were made (the influence of quality is 40% for instance) by relating the maximum amount of value points to be earned with the maximum amount of points for the lowest price. As demonstrated, the amount of points to be earned with the lowest price is of no consequence on the preference. It is a completely arbitrary variable. Therefore the percentage could have been anything.

3.7.5   *Ratio system results presented in the value price model*

In order to assess the fictitious bid situation presented in Table 9 with the ratio system (V/P system), an assumption about the value of complying with the terms of reference needs to be made since the total value consists of that value plus the

added value. Table 13 shows the result when the value of complying with the terms of reference is assumed to be 60 M€.

Table 13   Fictitious bid situation assessed with the ratio system

Bid	Price (M€)	Added Value (M€)	Value$_{ToR}$ (M€)	Total value (M€)	Total value / Price	Rank
A	60	0	60	60	1	3
B	70	20	60	80	1.143	2
C	80	40	60	100	1.25	1

The result of Table 13 is presented two dimensionally in Figure 34.
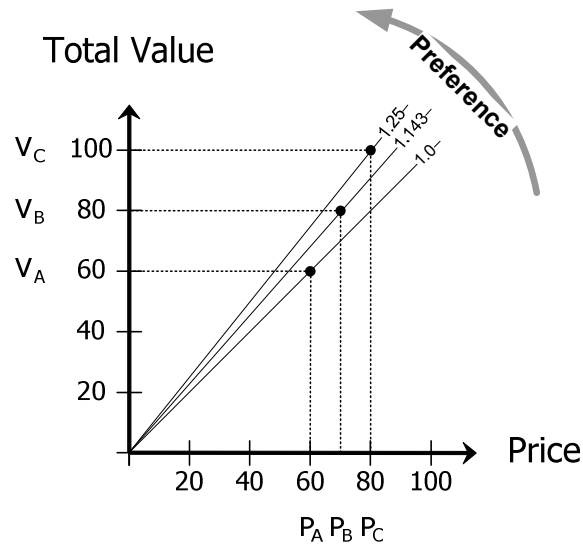
Figure 34   Ratio system, result presented two-dimensionally

Note that the procedure for presenting the results of the fourth main EMAT type (value maximisation) in the value price model is not included in this overview; since the price is fixed, it makes no sense to map it in a two dimensional model. It is sufficient to present the results of the value maximisation EMAT type in a one dimensional model.

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4   Suitability requirements for EMAT award mechanisms

Science may set limits to knowledge, but should not set limits to imagination - Bertrand Russell, English author, mathematician, & philosopher (1872 - 1970)

Section 2. Problem inquiry (BQ 1-4)	Section 3. A model for presenting EMAT award mechanisms (BQ 5)
Section 4. Constrains on EMAT award mechanisms (KQ 1)	Section 5. EMAT award mechanisms applied in practice (KQ 2, KQ 3)

Section 6. Suitable EMAT configuration options (KQ 4, MQ)

Section 7. Conclusions & Recommendations
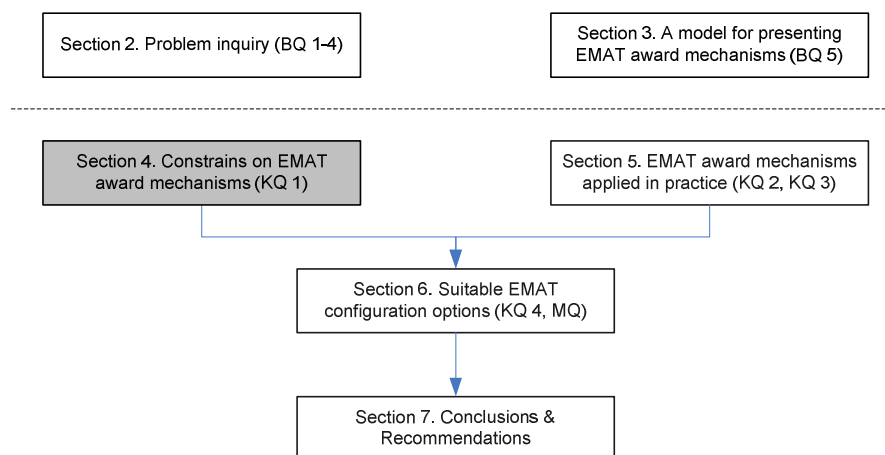
This section presents the answer to the first key question "which requirements determine whether an EMAT award mechanism is suitable or not?" by investigating what "legally advisable" and "practical" should comprise. Section 4.1 elaborates the requirement of legal advisability; section 4.2 elaborates the requirement of practicality.

4.1   Legal requirements

Besides the general principles of proper government (integrity, accountability, reliability, rigour, efficient allocation of means, prevention of 'detournement de pouvoir') as laid out in administrative law, there are specific principles for public procurement. In the Directive (European Parliament 2004) these are as follows.

General consideration 43 and articles 45 through 52 make statements about minimum standards. Procurers are required to exclude suppliers who have been convicted of membership of a criminal organisation, bribery, fraudulent behaviour or money laundering. They may exclude suppliers in case of bankruptcy, conviction for misconduct or professional fault, not having paid taxes, false statements, etc.

General consideration 2 states that the award of contracts is subject to the principles of the Treaty and in particular to the principle of *freedom of movement of goods*, the principle of *freedom of establishment* and the principle of *freedom to provide services* and to the principles deriving therefrom, such as the principle of *equal treatment*, the principle of *non-discrimination*, the principle of *mutual recognition*, the principle of *proportionality* and the principle of *transparency*.

These principles are repeated in general consideration 46, that states that contracts should be awarded on the basis of *objective criteria* which ensure compliance with the principles of *transparency*, *non-discrimination* and *equal treatment* and which guarantee *that tenders are assessed in conditions of effective competition*. General consideration 46 continues by stating that, as a result of the mentioned principles, it is appropriate to allow the application of two award criteria only: 'the lowest price' and 'the most economically advantageous tender'.

Article 2 is short, clear and concise about the principles of awarding contracts: "Contracting authorities shall *treat economic operators equally* and *non-discriminatorily* and shall *act in a transparent way*".

From the above mentioned and other fragments from the Directive, it can be concluded that the principles are not used very consistently. VNG (2003:18): deems that the criteria transparency, objectivity and non-discrimination are most important. In this research objectivity is not recognised as a strict constraint since objectivity was merely introduced as one of the possible ways of safeguarding transparency. See the consideration about conflicting principles for more reasons for not recognising objectivity as a strict constraint. Based on Pijnacker Hordijk et al. (2004:366) the following four principles are seen as constraints for EMAT award mechanisms.

1. Non-discrimination (equal treatment)

This principle is often mentioned in Dutch procurements without real understanding of the principle. Non-discrimination means that no distinction should be made on criteria that are unconstitutional. Then the question is what these criteria really are? Article 1 of the Dutch constitution (Grondwet 2005) states: "All those who are in the Netherlands, are treated equal in equal cases. Discrimination because of religion, convictions of life, political orientation, race, gender, or whatever ground, is not allowed." (Translated). These criteria can hardly apply to construction firms, but nonetheless non-discrimination is often mentioned as an important principle for procurers.

As a matter of fact, general consideration 33 of the Directive allows positive discrimination: contract performance conditions (…) may, in particular, be intended to favour on-site vocational training, the employment of people experiencing particular difficulty in achieving integration, the fight against unemployment or the protection of the environment. For instance, mention may be made, amongst other things, of the requirements — applicable during performance of the contract — to recruit long-term job-seekers or to implement training measures for the unemployed or young persons, (…) and to recruit more handicapped persons than are required under national legislation.

Article 3 gives insight in how the non-discrimination principle should be interpreted: procurers must comply with the principle of non-discrimination on the basis of nationality.

Article 29.3 continues on that: During the dialogue, contracting authorities shall ensure equality of treatment among all tenderers. In particular, they shall not provide information in a discriminatory manner which may give some tenderers an advantage over others. Article 29.6 gives another criterion for discrimination: (…) final tenders (…) may be clarified, specified and fine-tuned at the request of the contracting authority. However, such clarification, specification, fine-tuning or additional information may not involve changes to the basic features of the tender or the call for tender, variations in which are likely to distort competition or have a discriminatory effect.

Article 42.4 states that the tools to be used for communicating by electronic means, as well as their technical characteristics, must be non-discriminatory, generally available and interoperable with the information and communication technology products in general use.

No prior knowledge

Suppliers that were involved in earlier stages such as the design phase cannot participate in the award phase, because their intimate knowledge of the project would be such an advantage over other potential suppliers, that the principle of

equal treatment of suppliers would be jeopardised. Because prior knowledge endangers the principle of equal treatment it is grouped under the main principle of non-discrimination. The prior knowledge of the privileged supplier would form a high barrier for the other suppliers to compete.

The early advising supplier can become a candidate again if his advantage is undone by making all the information that had been exchanged public. However, from a legal point of view this will remain tricky because it will be very hard to prove that all the exchanged information indeed has been made public.

2. Proportionality
The principle of proportionality is only mentioned once in the Directive. It is mainly associated with the selection phase; procurers are not allowed to formulate the selection criteria in such a way that a large portion of the suppliers is excluded. Common errors are to require much more turnover on previous comparable projects than is realistic when looking at the project that is procured (Koenen 2008b), or to require more reference projects than is realistic within a certain timeframe, i.e. five years. Most common cause of these disproportional requirements is uncertainty of the procurer (GWR meeting). However, the principle is gaining more and more importance for the award phase as well. Inexperienced procurers like to use non-continuous scales in order to create artificial differences in the bids in order to facilitate the decision making process, but for instance in "case Lindewijk" (Rechtbank 2005) the use of a non-continuous scale for the price was judged to be disproportional and thus invalid. Chen (2008) and Telgen (2006) have shown that the use of such scales also leads to the "Ranking Paradox". This leads to the conclusion that non-continuous scales should no longer be used in EMAT award mechanisms, at least not for price criteria. In the same way it can be argued that it also should not be used for the performance criteria. All of these recommendations follow from the principle of proportionality.

3. Transparency
General consideration 39 states that verification of the suitability of tenderers should be carried out *in transparent conditions*. For this purpose, *non-discriminatory* criteria should be indicated which the contracting authorities may use when selecting competitors and the means which suppliers may use to prove they have satisfied those criteria. In the same spirit of transparency, the contracting authority should be required, as soon as a contract is put out to competition, to *indicate the selection criteria* it will use and the level of specific competence it demands of the suppliers *before* admitting them to *the procurement procedure*.

General consideration 40 states that a reduction of candidates should be performed on the basis of *objective criteria* indicated in the contract notice. These objective criteria do not necessarily imply weightings.

General condition 46 states that, to ensure the necessary transparency, it is the responsibility of contracting authorities to *indicate the criteria* for the award of the contract and the relative weighting given to each of those criteria *in sufficient time* for tenderers to be aware of them when preparing their tenders.

Chapter 6 (articles 35 trough 43) of the Directive elaborates the rules on advertising and transparency.

Consideration about conflicting principles
Sometimes the principle of the open market (equal changes for everybody in the EU) seems more important than the principle of efficient allocation of means. That is underlined by irritated statements about high transaction costs (Ridder 2006:23). One could wonder if it would not be more efficient to just give the assignment to a contractor that has delivered good performance in the past because that could lower transaction costs. The risk then is that the procurer enters a path of bribery and corruption, which is unwanted, given the paralysing effect it has on some countries.

Another consideration is that it is possible to implement the principles of transparency, equal treatment and objectivity in such a way that the general principle of efficient allocation of means is endangered. Usually, complying with the objectivity principle is secured by describing the desired product into detail and by awarding the contract to the supplier with the lowest price. However that also requires that each minute requirement is checked by the procurer, thus significantly increasing transaction costs. The principle of efficient allocation of means is compromised even further, because, as argued in section 2.3.6, awards based on EMAT will yield better results. Currently, many procurers hesitate to apply EMAT, mainly because they do not know how to formulate the EMAT award mechanism in an objective way. It is indeed difficult to formulate an EMAT award mechanism that is entirely objective. Some criteria, mainly the technical criteria, can be formulated in such a way that every person in the world would come to the same evaluation, given the evaluation mechanism. But there are other criteria, such as aesthetics, that are essentially subjective; not every person will evaluate these criteria in the same way. Furthermore it must be mentioned that also technical criteria can have their peculiarities and discussion about interpretation. So is EMAT even possible when objectivity is required? Luckily, article 53 provides clarity, because it states that the economically most advantageous tender *is determined from the point of view of the contracting authority*. That point of view is inherently subjective, because it represents the interests of the procurer. RWS (2005b:13, 2006) states that some degree of

subjectivity is inevitable and even facilitated by the European procurement guideline. However, the procurer needs to make the assessment process measurable. The most important steps to do that are dividing criteria in clear sub criteria and to let different expert score the bids. To conclude, it can be stated that 100% objectivity is not possible. Difference in value perception (which is a subjective assessment) is the basis for each economic transaction. Furthermore, objectivity is never mentioned as one of the guiding principles, it is merely an implementation of the principles of non-discrimination, equal treatment and transparency.

4.2   Practical requirements

The requirement of practicality which is imposed on the EMAT award mechanisms is broken down into several sub requirements.

Requirements resulting from the philosophy of integrated contracting
EMAT mechanisms must sufficiently facilitate integrated contracting in order to be useful. A research into government procurements (PWC 2002:35) stated that EMAT was applied, but often not 'in the spirit' of the mechanism. (RWS 2004b:10) states that the share of quality (read: bidding freedom as defined in section 3.6) should be about 40%. In an evaluation of that policy (RWS 2007:28) it turned out that the influence of EMAT was still too little to make much difference in the preference ranking; too often the added value could not compete with the lowest price.

As described in the section about integrated contracting (section 2.3.5), the bidding freedom is a crucial factor for integrated contracting. In the traditional situation, contactors often have no other alternative than to comply with all detailed client requirements for the lowest price, which often results in suboptimal behaviour. There is room for smart construction processes and site logistics, but not for smart alternative design solutions, that often have a relationship with process optimisations. A higher level of bidding freedom in procurement procedures enables suppliers to integrate their production knowledge and optimised solutions in their bids. The level of bidding freedom is an indicator for the level of trust a procurer has in the suppliers and their expertise.

"Elegance" and simplicity
On various occasions experts have stated that it is important to keep the EMAT award mechanism as insightful a possible, in order to keep transaction costs low.

One of the main motivations for this statement is the experience that the average EMAT award mechanism becomes complicated very quickly, especially when every MCE technique available is applied. In such cases the evaluation mechanism quickly becomes very mathematical and "artificial". It then becomes very easy, even for experts, to lose track of what is really happening.

The experts have stated that it is rewarding to give the "elegance" of the EMAT award mechanism extra attention, for instance by improving its presentation, because the problems arising from an unclear award mechanism increase exponentially. Suppliers will have to invest extra time to understand the mechanism in order to determine their bid, which in turn will cost extra effort for the procurer because of extra requests for information. Also the procurer will have to spend more time conducting the assessment of the bids. Finally, the chance of getting sub-optimal bids increases with an unclear award mechanism.

Traditional project management requirements
The traditional project management requirements of time, quality and budget - the 'triple constraint' (Ridder & Noppen 2008:22) - will always remain boundary conditions. EMAT award mechanisms may not be set up in such a way that it interferes with these boundary conditions.

4.3   Conclusion 1

The first key question "which requirements determine whether an EMAT award mechanism is suitable or not?" is answered by the requirements presented in this section:

Legal requirements:
- Non-discrimination;
- Proportionality;
- Transparency.

Practical requirements:
- Sufficient bidding freedom;
- Simplicity and elegance; no unnecessary variables and a clear presentation;
- Safeguarding of traditional project management requirements.

5   EMAT award mechanisms applied in practice

If you are out to describe the truth, leave elegance to the tailor - Albert Einstein, US (German-born) physicist (1879 - 1955)

Section 2. Problem inquiry (BQ 1-4)	Section 3. A model for presenting EMAT award mechanisms (BQ 5)

Section 4. Constrains on EMAT award mechanisms (KQ 1)	Section 5. EMAT award mechanisms applied in practice (KQ 2, KQ 3)

Section 6. Suitable EMAT configuration options (KQ 4, MQ)

Section 7. Conclusions & Recommendations
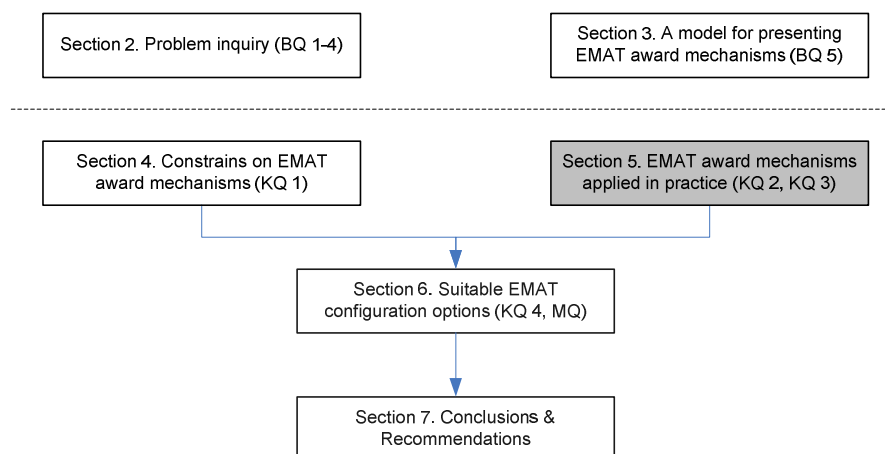
This section presents the answer to the second key question "which EMAT award mechanisms are used in practice?" by collecting and studying the procurement documents of EMAT cases. Section 5.1 presents the methodological considerations of the data collection process, section 5.2 presents which properties of EMAT award mechanisms were collected. Section 5.3 presents the resulting case information. Section 5.5 correlates several parameters in order to see which developments can be distinguished in EMAT.

5.1   Methodological considerations

Information obtaining method

There are several methods for obtaining information. Brinkman (2000) mentions for instance interviews (face to face or telephonic, structured or unstructured), file research (digital or on paper, at location or from a distance) or using a questionnaire (mailed, by internet, telephonic survey). Because of the level of detail required, file research appeared to be the best information gathering method for this investigation. So the detailed information of applied EMAT award mechanisms was gathered by analysing the relevant procurement documents. Additional case information was gathered by specialist magazines, websites, scientific papers, newspapers, evaluations, presentations, telephonic interviews, face to face conversations, etc. With hindsight it can be stated that this is the only possible way for data collection for this type of research, because project information is never distributed in a uniform way.

Sources for EMAT case information

Several sources for finding EMAT projects and the accompanying procurement documents were considered. For instance the following "portals" provided the needed information:

http://www.aanbestedingskalender.nl
http://bestekken.sdu.nl
http://tenderned.nl
http://www.aanbestedingenonline.nl
http://www.gwwkrant.nl / http://aanbestedingskrant.nl
www.cobouw.nl / http://www.cobouwplaats.nl
http://ted.europa.eu
http://simap.europa.eu/index_en.html
http://www.aanbesteden.prorail.nl
http://www.attender.nl

Looking at the background (public clients involved, goals, number of invitations for tendering, amount of detailed information, etc.) of the websites it became clear that www.aanbestedingskalender.nl or http://ted.europa.eu could be considered as the most suitable sources. The selected portals also provided the possibility to upload accompanying documents. That provided an alternative for finding the needed information, which could be useful, because the individual procurers often did not provide the information in a uniform way. In many cases a telephone number was mentioned for obtaining the needed information, which slowed down the data collection process. So in the end most case information was obtained by contacting the right persons; the portals provided a good source for finding these people.

Number of cases
Maso & Smaling (1990) distinguish qualitative research and quantitative research. Qualitative research requires only a few cases, which are studied in-depth. Quantitative research is less in-depth; it focuses only at a few parameters, which allows many cases. This difference is illustrated in Figure 35.
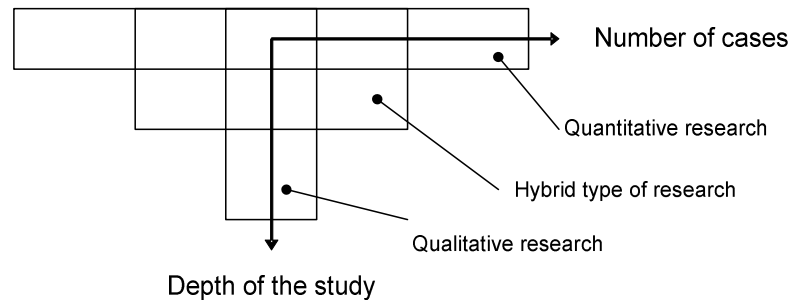
Figure 35   Different data collection approaches

Both approaches were suitable for this research. The qualitative approach is suitable for establishing which parameters need to be collected or whether these parameters even can be collected. Quantitative research is also suitable because of the quantitative nature of EMAT award mechanisms. Based on these considerations a hybrid approach has been adopted for this investigation. In the first instance a qualitative approach was applied and once the most relevant parameters (as presented in section 5.2) were established, a quantitative dimension was added to this research.

During the data collection process a full quantitative approach turned out to be impractical; practitioners were sometimes reluctant to give information because in some cases it was quite labour intensive to find the required information and also because the information is often perceived as being confidential. For these reasons it also turned out to be difficult to obtain complete information for all cases. Section 5.3.4 presents some other difficulties that were encountered during the data collection. Another reason for why a full quantitative approach was not possible is that an overview of the entire population of procurements in the Netherlands was not available.

To conclude, data about EMAT award mechanisms was obtained by collecting and studying the relevant procurement documents of suitable projects. This was complemented by information gathering through interviews and project related publications. Due to its confidential nature, the project identifying information is not included in this thesis.

5.2   Relevant properties of EMAT award mechanisms

This section describes which properties of EMAT award mechanisms were collected. In case of a "multiple choice question", the possible answers are numbered and mentioned after the question between parentheses. Furthermore, additional information about the query is included if necessary.

General project information
- Project name, location.
- Type of object. This determines whether the project belongs to the civil or the commercial sector.
- Information source; person and contact data.
- Procurement procedure (1: open, 2: restricted, 3: competitive dialogue, 4: other – see section 2.2.2).
- Administrative conditions; basis of contract (1: UAV 1989, 2: UAVgc 2000, 3: UAVgc 2005, 4: SR, 5: DNR, 6: RVOI, 7: other – see appendix E.3.
- Type of task allocation (1: Traditional, 2: Design Team, 3: Design-Build, 4: Partnering/Alliance, 5: BOT, 6: other – see section 2.3.3).
- Type of evaluation technique (1: point system, 2: price correction mechanism, 3: ratio, 4: design contest, 5: other (this fifth option has been included to leave the possibility for new types open) – see section 2.1.2).

Price
List of price components. Examples of price components besides the tender price: prices for maintenance, prices for change scenarios. Other requests for price, such as the Net Present Value, are also possible.

Value criteria
List of value criteria. For each criterium, information about the accompanying evaluation mechanism needs to be gathered as well.

Preference determination
- Formula. The formula that will be used to determine the preference of bids. Depending on the type of evaluation technique, additional information needs to be gathered.
- Monetisation of value aspects. (1: direct, 2: indirect). Several answers are possible. See section 6.9 for more information.
- Controversiality. For instance when there has been a lawsuit against the award decision/mechanism or when the legality of the award mechanism is disputable, for instance when the mechanism does not comply with procurement regulation, or when elements have been used in the award mechanism that are disapproved by jurisdiction.

- Availability of results. (1: Yes, 2: Partially, 3: No). This question is incorporated because most procurers are reluctant to disclose that information.

Other questions
- Presence of tie-break.
- Scale. (1: national government, 2: province, 3: region, 4: municipality). This question is included to get an idea of the involved parties.
- Budget (Euros). This question is included to get an idea of the size of the project.
- Bidding freedom. See section 3.6 for how this share is defined. Applies for all types of evaluation techniques, except for the design contest. When price information is missing it is necessary to assume a realistic price in order to determine this parameter.
- Specialities. Room for remarks made by interviewees or considerations/ideas that occur while processing the procurement documents.
- Motive for applying EMAT.
- Sources of information. Reference to specific documents.
- Date. There are many moments in the life cycle of the EMAT award mechanism that could be used as 'anchor point'. For this investigation the date for submitting tenders has been chosen as reference point because from that point on, the EMAT award mechanism is supposed to be stable. For the purpose of trend analysis, an accuracy of about a month is accurate enough.
- Other questions. Room for questions as a result of unclear answers.

5.3   Raw data

This section presents the collected case material. Specific case details have been left out for confidentiality, since that was promised to the participants in order to gain their confidence. The cases are first sorted by type and then by date.

5.3.1   Point systems

This section presents the most relevant properties of the encountered point systems. Six point systems were found, four in the civil sector and two in the commercial sector, see Table 14. The column "ID, date" indicates the case identification number and the case date (format: m/yy). The case identification number consists of a letter and a number. The letter can be a C or an U. The C stands for a project of the civil sector, the U stands for a project of the

commercial sector (commercial sector translated in Dutch is "utiliteitsbouw", hence the letter U). The numbers indicate the order in which the cases were entered into the database. The column "Object" states the type of object that was procured. The column "Formula" presents the formulae that were used to combine points for quality with price information. The column "Ok?" states whether problems regarding the EMAT award mechanism were encountered.

Table 14   Formulae of point systems

ID, Date	Object	Formula	Ok?
C3, 4/02	Wildlife passage	$Pts._T = 0.6Pts._Q + 0.4Pts._P$ $Pts._Q$: Weighed average score on 4 criteria, [6.0, 10.0]$^@$ $Pts._P$: $16 – (P_x * 10 / P_E)$	Yes
C2, 2/04	Highway objects	$Pts._T = Pts._Q + Pts._P$ $Pts._Q$: Performance on 3 criteria, [-3, 7]. $Pts._P$: The bid with the lowest Net Present Value gets 90 points; the other bids get 2 points fewer per percent difference.	Yes
C10, 9/04	Sewage system	$Pts._T = Pts._Q + Pts._P$ $Pts._Q$: Performance on 2 criteria, [3.5, 35]. $Pts._P$: By an incorrect procedure of "weighed prices" the bid that is cheapest on all price elements can earn a maximum of 65 points.	No
C1, 2/05	Quay wall	$Pts._T = Pts._Q + Pts._P$ $Pts._Q$: Performance on 5 criteria, [0, 80]. $Pts._P$ = The bid with the lowest price receives 120 points; the other bids get 1 point fewer per percent difference.	Yes
U3, 12/06	Office building	$Pts._T = Pts._Q + Pts._P$ $Pts._Q$: Performance on 3 criteria, [0, 30]. $Pts._P$: The bid with the lowest price receives 100 points; the other bids get 1 point fewer per M€ price difference.	Yes
U7, 4/07	Sporting facilities	$Pts._T = Pts._Q + Pts._P$ $Pts._Q$: Performance on 2 criteria, [0, 6.5]. $Pts._P$: The prices for 7 posts lead to [0, 3.5] points.	?[#]

$Pts._T$ = Total points, $Pts._Q$ = points for quality, $Pts._P$ = points for price, P_x = the price of bid x, P_E = estimated price, $[s_{min}, s_{max}]$ = scoring range. @: bids need to score 6 or higher in order to be considered. # The legality of the determination of price points is dubious, but it is not known whether a lawsuit was started or not.

All encountered point systems have in common that the bid with most points wins. The third column of Table 15 presents the award criteria that were used in each case, their determination method, the score range of each criterion and their relative influence in the qualitative point range, which is represented in the fourth column. The fifth column presents the value of each quality point, which is calculated on the basis of the formulae in Table 14. There are two options for determining the scores of bids: "comparative", which means the bids are

compared with each other using the so-called pair wised comparison technique (KC BPI 2004, RWS 2005b, RWS 2006). The other option is "guideline", which means the bids are scored on the basis of a guideline, often with sub criteria, so no knowledge of other bids is required. There are two ways for expressing quality points in monetary terms, "price dependant" or "non price dependant". The price dependant method requires price information of the bids; the non price dependant method can do without that information.

Table 15   Award criteria of point systems

ID, Date	Object	Award criterion, Determination, Score range, Weight	Pts.$_Q$	€/Pt$_Q$, Basis
C3, 4/02	Wildlife passage	Aesthetics, G, [6.0, 10.0], 30% Ecology, G, [6.0, 10.0], 40% Sustainability, G, [6.0, 10.0], 15% Technical quality, G, [6.0, 10.0], 15%	[6.0, 10.0]	0.15*P$_E$, NPD
C2, 2/04	Highway objects	Nuisance, C, [-1, 1], 1 Traffic safety, G, [0, 3], 1 Aesthetics, G, [-3, 0, 3], 1	[-3, 7]	0.5%*LNPV, PD
C10, 9/04	Sewage system	Project quality plan, G, [1, 10], 50% Preliminary design, G, [1, 10], 50%	[3.5, 35]	1/65*LP$^@$, PD
C1, 2/05	Quay wall	Planning, C, [0, 16], 1 Risk, C, [0, 16], 1 Maintenance, C, [0, 16], 1 Innovation, C, [0, 16], 1 Quality, C, [0, 16], 1	[0, 80]	1%*LP, PD
U3, 12/06	Office building	Visual quality, ?, ?, 40% Functionality, ?, ?, 40% Flexibility, ?, ?, 20%	[0, 30]	1M€, NPD
U7, 4/07	Sporting facilities	Quality, G, [1, 10], 0.5 Maintenance, G, [1, 10], 0.15	[0.65, 6.5]	1/35*LP, PD

Pts.$_Q$ = points for quality, Pts.$_Q$ = one quality point, P_E = estimated price (not given), [s_{min}, s_{max}] = points scoring range, C = Comparative, G = Guideline, LNPV = Lowest Net Present Value, LP = Lowest Price, PD = Price dependant, NPD = Non Price Dependent. @: approximation, since the price consists of several components.

As described in section 3.6 the bidding freedom is a parameter that gives an indication of the possibility for suppliers to distinguish themselves by delivering added value. In that respect it indicates the "progressiveness" of the EMAT award mechanism when compared with the Lowest Price award mechanism; the higher the bidding freedom, the more progressive the EMAT award mechanism.

Table 16 presents the bidding freedom of the encountered point systems. The columns "estimate of the 6⁻ product" and "added value range" present the parameters that are needed to determine the bidding freedom, which is presented in the column "BF". Since the "6⁻ estimate" of the bids was not known, several slightly different assumptions for approximating it are done. For cases C1 and U3

the lowest price of the bids is taken, for case C3 a price estimate is used, for case C2 the lowest net present value is taken as reference and for cases C10 and U7 an estimate of the weighed price components is made.

Table 16   Bidding freedom of point systems

ID, Date	Object	Estimate of 6ᵗ product	Added Value Range (AVR)	BF
C3, 4/02	Wildlife passage	About 3.5M€	$P_x = P_E$ and $Pts._Q = 6$ results into the same amount of points as $P_x = 1.6P_E$ and $Pts._Q = 10 => 0.6*3.5M€ = 2.1M€$	38%
C2, 2/04	Highway objects	About 80M€@	1% of 80M€ equals 2 points => 0.4M€/point * 10 points = 4M€	5%
C10, 9/04	Sewage system	About 5M€	5M€ gets 65 points => 0.077M€/point * 35 points = 2.7M€	35%
C1, 2/05	Quay wall	About 60M€	1% of 60M€ => 0.6M€/point * 80 points = 48M€	44%
U3, 12/06	Office building	About 180M€	1 point equals 1 M€ => 30 points = 30M€	14%
U7, 4/07	Sporting facilities	About 470k€	470k€ gets 35 points => 13.4k€/point * 65 points = 873k€	65%

BF = Bidding Freedom = AVR / (6ᵗ estimate + AVR) in percent. @: Assumption.

5.3.2   Price correction systems

Eleven price correction systems were found, eight come from the civil sector and three from the commercial sector. All encountered price correction systems have in common that the bid with the lowest corrected price wins. The price is corrected by subtracting the added value from the tender price. The encountered price correction mechanisms are presented in Table 17. The explanation for the columns "ID, date", "Object" and "Ok?" is the same as for the point system table. The column "Formula" presents the formulae that were used to determine the added value of the bids.

Table 17   Formulae of price correction system

ID, Date	Object	Formula	Ok?
U4, 5/04	Parking garage	Performance on 4 direct criteria can lead to an added value.	Yes
C14, 1/05	Sluice doors	Added value = S_Q * 0.429 * median price of the validated bids. S_Q: Performance on 4 criteria [-1, 0.5].	Yes
C13, 7/05	Highway objects	Added value = (S_Q * 0.176 * median price of the validated bids) + value of the performance on 3 direct criteria. S_Q: Performance on 2 criteria [-1, 1].	Yes
C15, 8/05	Dredge works	Added value = S_Q * 0.667 * median price of the validated bids. S_Q: Performance on 2 criteria [-1, 1].	Yes
C11, 8/05	Waste soil depot	Added value = (S_Q * 0.15 * median price of the validated bids) + value of the performance on 2 direct criteria. S_Q: Performance on 4 criteria [-1, 1].	Yes
C12, 12/05	Bridge	Added value = (S_Q * 0.176 * median price of the validated bids) + value of the performance on 1 direct criterion. S_Q: Performance on 1 criterion [-1, 1].	Yes
U2, 7/06	Secondary school	Performance on 4 direct criteria can lead to an added value of 5.3 M€.[#]	Yes
C6, 10/06	Road renovation	Performance on 2 direct criteria can lead to an added value of about minus 4 M€ to 2 M€.[#]	Yes[@]
U6, 3/07	Ice skating track	Performance on 5 direct criteria can lead to an added value of 0.7 M€ to 3.5 M€.[#]	?
C19, 3/07	Road maintenance	Performance on 2 direct criteria can lead to an added value of 100 k€.	Yes
C18, 11/07	Dredge works	Subtracted value = (10 - S_Q) * QU, QU = Quality Unit. QU = median price of the validated bids * (40/60) / average (S_Q). S_Q: Performance on 3 criteria [1, 10].	?

S_Q = quality score. [s_{Qmin}, s_{Qmax}] = scoring range of the quality points. #: price consists of several components. @: one of the suppliers that did not get the assignment started a lawsuit but lost.

The third column of Table 18 presents the award criteria that were used in each case, their determination method, the score range of each criterion and if applicable their relative influence. In the price correction systems, two types of award criteria were encountered; criteria for which the performance was translated into a monetary value directly and criteria for which the performance was grouped first and then the resulting group performance was translated into a monetary value. For grouped criteria the weight is given, for single criteria the weight factor is 1. Some price correction mechanisms use both types; these cases have two cells in the third and fourth column. Besides the score determination methods mentioned in the previous section (Comparative and Guideline), a new method was encountered (Measure), which amounts to simply measuring or reading a certain promised performance.

Table 18   Award criteria of price correction systems

ID, Date	Object	Award criterion, Determination, Score range, Weight	Valuation, Basis
U4, 5/04	Parking garage	Earlier delivery, M, ?, 1 Extra parking place months during construction, M, ?, 1 Shorter traffic diversion, M, ?, 1 Risk charge for encountering ground obstacles, M, ?, 1	50k€ per month, NPD 4k€ per 24 parking place months, NPD 5k€ for each week, NPD € cheaper than estimate, NPD
C14, 1/05	Sluice doors	Integrated project management, C+G, [-1, 1], 25% Design approach, G, [-1, 1], 40% Work method, C, [-1, 1], 25% Earlier delivery, C, [-1, 1], 10%	[-1, 0.5]*0.429*Median, PD
C13, 7/05	Highway objects	Project management, G+C, [-1, 1], 40% Work method, C, [-1, 1], 60%	[-1, 1]*0.176*Median, PD
		Earlier delivery, M, ?, 1 Fewer weekend closures, M, [0, 10], 1 Lower road height, M, ?, 1	50k€/week, NPD 10k€/weekend, NPD 25k€/cm, NPD
C15, 8/05	Dredge works	Work method, G, [-1, 1], 65% Project management, C+G, [-1, 1], 35%	[-1, 1]*0.667*Median, PD
C11, 8/05	Waste soil depot	Work method, G, [-1, 1], 30% Planning, G+C, [-1, 1], 20% Environmental management, G+C, [-1, 1], 10% Contract management, C, [-1, 1], 40%	[-1, 1]*0.15*Median, PD
		Extra depot content, M, [0, 1Mm^3], 1 Extra covered area, M, [0, 100ha], 1	€2.50/m^3, NPD 15k€/ha, NPD
C12, 12/05	Bridge	Risk management, C, [-1, 1], 1	[-1, 1]*0.176*Median, PD
		Shorter traffic blockade, M, [0, 16], 1	25k€/12 hours, NPD
U2, 7/06	Secondary school	Energy performance, M, [EPC 1.4, EPC 0.8], 1 Satisfaction of wishes, G/M, [0 pt., 395 pt.], 1 Level of cooperation, G, [0, 1], 1 Value creation, G, [0, 1], 1	[0, 1.8 M€], NPD [0, 2.0 M€], NPD [0, 0.5 M€], NPD [0, 1.0 M€], NPD
C6, 10/06	Road renovation	Availability, G, ?,? Risk management, G, ?, ?	[-2, 0M€], NPD [-2, 2M€], NPD
U6, 3/07	Ice skating track	Information construction plan, G, [1, 5], 1 Quality construction plan, G, [1, 5], 1 Sustainability and environment, G, [1, 5], 1 Proces and risks, G, [1, 5], 1 Exploitation and maintenance, G, [1, 5], 1	[0.1, 0.5 M€], NPD [0.18, 0.9 M€], NPD [0.06, 0.3 M€], NPD [0.16, 0.8 M€], NPD [0.2, 1.0 M€], NPD
C19, 3/07	Road mainte-nance	Duration phase 1, M, [0 days, 35 days], 1 Duration phase 2, M, [0 days, 35 days], 1	50k€/day earlier, NPD 50k€/day earlier, NPD
C18, 11/07	Dredge works	Functionality of the design, G, [1, 10], 40% Proces design, G, [1, 10], 37% Sustainability, G, [1, 10], 23%	[1, 10]*(0.66/Av. Score)*Median, PD

[s_{min}, s_{max}] = points scoring range, C = Comparative, G = Guideline, M = Measure, Median is median price of the bids, PD = Price Dependant, NPD = Non Price Dependent.

The fourth column of Table 18 presents how performance on the award criteria is translated into money. Again, this can be done in a Price Dependant (PD) or Non

Price Dependant (NPD) way. Table 19 presents the bidding freedom of the encountered price correction systems.

Table 19   Bidding freedom of price correction systems

ID, Date	Object	Estimate of 6^- product	Added Value Range (AVR)	BF
U4, 5/04	Parking garage	About 12M€	Estimate: about 60k€	0.5%
C14, 1/05	Sluice doors	(1 - 0.429) * Median	1.5*0.429*Median	53%
C13, 7/05	Highway objects	(1 - 0.176) * 6.472 M€ = 5.3M€	PD part: 2*0.176*6.472M€ = 2.23M€ NPD part: 300k€ (estimate)	33%
C15, 8/05	Dredge works	(1 - 0.66) * Median	2*0.66*Median	80%
C11, 8/05	Waste soil depot	(1 - 0.15)*48.7 M€ = 41.4M€	PD part: 2*0.15*48.7M€ = 14.6M€ NPD part: 4M€	31%
C12, 12/05	Bridge	(1 - 0.176) * 50M€ = 41.2M€	PD part: 2*0.176*50M€ = 17.6M€ NPD part: 400k€ (estimate)	30%
U2, 7/06	Secondary school	About 18M€	5.3M€	23%
C6, 10/06	Road renovation	About 126M€	6M€	5%
U6, 3/07	Ice skating track	About 11M€	3.5M€	24%
C19, 3/07	Road maintenance	About 1.2M€	100k€	8%
C18, 11/07	Dredge works	0.66 * Median	0.66 * Median	50%

BF = Bidding Freedom = AVR / (6^- estimate + AVR) in percent.

The procedure for determining the bidding freedom is mentioned in section 3.6. Since the "6^- estimate" of the bids was not known, several slightly different assumptions for approximating it are done. For cases C11 trough C15 in Table 19 a special approach was used in order to make an assumption for the 6^- estimate. These systems take the median price of all the bids as a reference for determining the added value, while it is also possible to score negative added value. In order to determine the 6^- estimate for these cases, the negative added value range (which is determined by penalty multiplier * estimate of median price) is subtracted from the estimate of the median price, as shown in Figure 36. This can be rewritten as multiplying the estimate of median price with (1 - multiplier), which explains the approximations of the 6^- estimate for cases C11 trough C15 in Table 19.
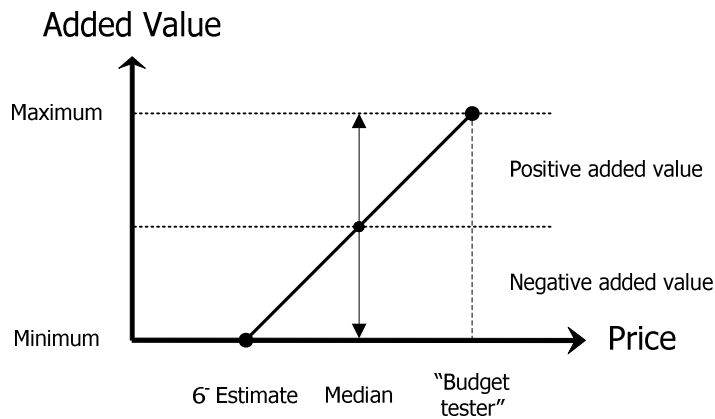
Figure 36   Determining bidding freedom with the median as reference

Please note that for all cases the bidding freedom is based on (approximations of) the price estimates of the procurers. If the actual market conditions are used, the bidding freedom can be entirely different. For instance in case C6, the lowest price bid was about 49M€ while the procurers estimate was 130M€. The recalculated bidding freedom (influence of added value) then becomes 6/(6+49)= 11%, instead of 5%.

5.3.3   Ratio systems

Two ratio systems were encountered, see Table 20. For both cases the bid with the highest value price ratio wins.

Table 20   Formulae of ratio systems

ID, Date	Object	Formula	Ok?
C20, 11/07	Intake works	Value/Price. Value = "6⁻ price estimate" + (0.25 * "6⁻ price estimate" * S_Q). S_Q: Performance on 4 criteria [-0.25, 1].	Yes
U9, 12/07	Government building	IndexQ / IndexP. IndexQ = price estimate unchanged part + price estimate design mutations * S_Q. S_Q: performance on 4 criteria [-0.75, 0.75]. IndexP = Bid price + correction for earlier completion + correction for rejected mutations) / price estimate	Yes
S_Q = quality score, $[s_{Qmin}, s_{Qmax}]$ = scoring range of the quality points.			

Table 21   Award criteria of ratio systems

ID, Date	Object	Award criterion, Determination, Score range, Weight	Valuation, Basis
C20, 11/07	Intake works	Functionality, G, [-0.25, 1], 50% Risk management, G, [-0.25, 1], 10% Innovation, G, [-0.25, 1], 15% Technical lifespan, G, [-0.25, 1], 25%	[-0.25, 1] * 0.25 * P_E, NPD
U9, 12/07	Government building	Aesthetics, G, [-0.75, 0.75], 25% Technical quality, G, [-0.75, 0.75], 25% Functional quality, G, [-0.75, 0.75], 25% Maintenance, G, [-0.75, 0.75], 25%	[-0.75, 0.75] * RI * P_E, NPD
		Earlier or later delivery, M, ?, 1	6.5k€/day, NPD
[s_{min}, s_{max}] = points scoring range, G = Guideline, M = Measure, RI = Relative Influence of the proposed changes in terms of share of the estimate, P_E = estimated price (not given), NPD = Non Price Dependent.			

Table 21 presents the award criteria that were used in both ratio system cases in the same way as the price correction system table. The bidding freedom of the encountered ratio systems is presented in Table 22.

Table 22   Bidding freedom of ratio systems

ID, Date	Object	Estimate of 6⁻ product	Added Value Range (AVR)	BF
C20, 11/07	Intake works	About 1M€	0.25*1M€ = 0.25M€	20%
U9, 12/07	Government building	About 43M€	Assumption that the room for improvements is about 3%	3%
BF = Bidding Freedom = AVR / (6⁻ estimate + AVR) in percent.				

5.3.4   Other systems

This section presents five systems that do not belong to one of the previously mentioned categories. Table 23 presents a "subjective" system, a system that was introduced by the supplier and a value maximisation system. Table 24 presents the award criteria that were used in these systems and Table 25 presents an estimate of the bidding freedom of these systems.

Table 23   Formulae of other systems

ID, Date	Object	Formula	Ok?
C17, 11/04	Waterworks	None. The procurement document states that 3 criteria will be taken into account in relationship with the price, but it does not state how. One could call this a "subjective" method.	No
U1, 3/05	School + residences	This was not a real EMAT case. It is included because the supplier was able to convince the client to increase the scope of the project with 4 value aspects.	Yes
C4, 11/05	Wildlife passage	Value maximisation. The reward is fixed on 2.6 M€. The value is determined by the performance on 3 criteria. Bids can earn a maximum of 69 points.	Yes

Table 24   Award criteria of other systems

ID, Date	Object	Award criterion, Determination, Score range, Weight	Valuation, Basis
C17, 11/04	Waterworks	Quality work plan, ?, ?, ? Sustainability, ?, ?, ? Product and process innovation, ?, ?, ?	?, ?
U1, 3/05	School + residences	Functionality, ?, ?, ? Energy performance, ?, ?, ? Aesthetics, ?, ?, ? Sustainability, ?, ?, ?	"Monetisation" of aspects; plausible calculations of delivered added value; NPD
C4, 11/05	Wildlife passage	Ecology/environment, C, [13, 39], 1 Traffic hindrance, C [6, 18], 1 Aesthetics, C, [4, 12], 1	Not applicable.

$[s_{min}, s_{max}]$ = points scoring range, C = Comparative, NPD = Non Price Dependent.

The bidding freedom of the other encountered systems is presented in Table 25.

Table 25   Bidding freedom of other mechanisms

ID, Date	Object	Estimate of 6̄ product	Added Value Range (AVR)	BF
C17, 11/04	Waterworks	About 12M€	Estimate: about 60k€	1%
U1, 3/05	School + residences	About 2M€	About 700k€	26%
C4, 11/05	Wildlife passage	2.6M€	Not applicable	n.a.

BF = Bidding Freedom = AVR / (6̄ estimate + AVR) in percent.

Table 26 presents two cases of which the essential information about combining performance information with price information was missing. These cases are still included in this thesis because they provide useful information such as the used value aspects, see Table 27. Obviously, the bidding freedom of these two cases could not be determined since the formula was lacking. Another reason why these cases are included is to indicate the difficulty of the data collection. Perhaps an appeal based on the law of openness of public administration could have been used to force the revelation of the information, but it was chosen not to do so because that procedure would take a lot of time and it could harm the good relationships.

Table 26   Systems of which the formula is unknown

ID, Date	Object	Reason for lacking formula	Ok?
C5, 6/04	Wildlife passage	Project leader did not respond.	?
C8, 11/07	Highway renovation	Project leaders decided to keep the formula secret, because that is what they agreed with the suppliers.	?

Table 27   Award criteria of systems of which the formula is unknown

ID, Date	Object	Award criterion, Determination, Score range, Weight	Valuation, Basis
C5, 6/04	Wildlife passage	Durability, G, [5.9, 10], ?	Unknown.
C8, 11/07	Highway renovation	Work plan, ?, [?, 100], 20% Cooperation, G, [20, 100], 40% Traffic plan, CM [?, 100], 35% Aesthetics, G, [?, 100], 5%	Unknown.
$[s_{min}, s_{max}]$ = points scoring range, G = Guideline, CM = Comparative Measure; the performance is measured using a tool, the best scoring alternative receives 100 points.			

5.4   Conclusion 2

The second key question "which EMAT award mechanisms are used in practice?" is answered by presenting the properties of 24 EMAT award mechanisms that were applied in practice. Four main types are distinguished; the point system (6 cases), the price correction system (11 cases), the ratio system (2 cases) and the value maximisation system (1 case).

5.5 Trend analysis

In order answer the third key question "which developments can be distinguished in EMAT?" several cross-sections of the database are made. The parameters "type of EMAT award mechanism", "moment of application", "project size" and "bidding freedom" have been correlated. As shown in Figure 37, this leads to six correlations. These will be described in the respective sub sections. In sub section 5.5.7 the usage of award criteria will be investigated.
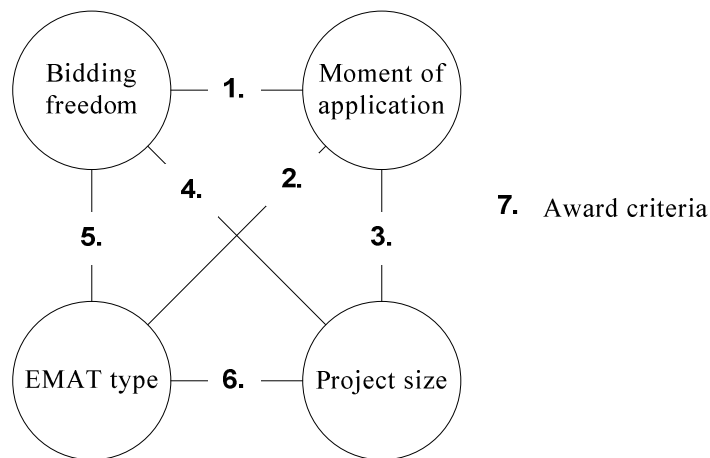
Figure 37   Correlation of several parameters.

Other parameters (type of procurer, type of object; type of contract) have not been correlated because these parameters were perceived to be of lesser interest given the limited amount of time.

Note that since there is no exact idea of the total number of EMAT awards in the Dutch construction industry for the given timeframe, it cannot be determined whether the case material is enough to be statistically relevant. Still, the trend analysis has been carried out because it can give a tentative impression of the current state of the art of the EMAT award mechanism.

5.5.1   Bidding freedom in time

Section 3.6 defined the concept of bidding freedom. Figure 38 presents the relationship between the bidding freedom of projects and the moment of application in the civil sector.

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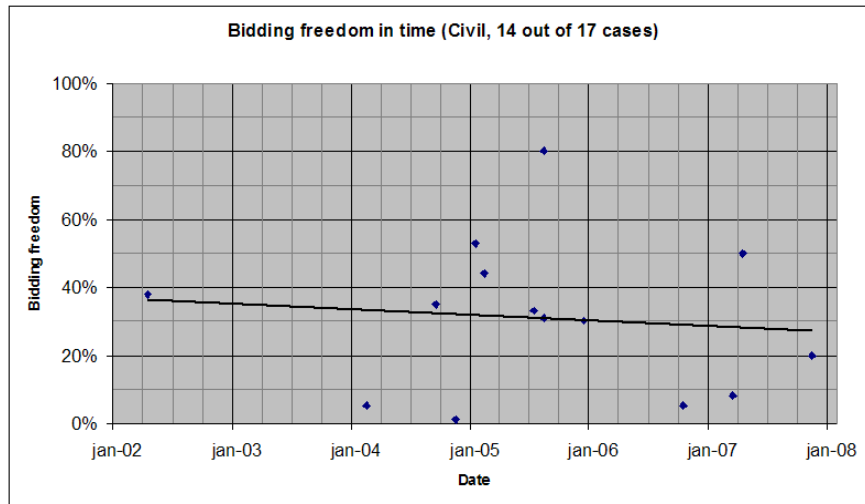
Figure 38   Development in time of bidding freedom; civil projects

The graph shows a slightly downward sloping trend around 30%. However, if only the positive added value is used for the determination of bidding freedom, because the median price bid is taken as 6⁻ reference (see Figure 36 in section 5.3.2 for the accompanying consideration) the average bidding freedom would be about 20% and would show a slightly increasing trend, around 20%.
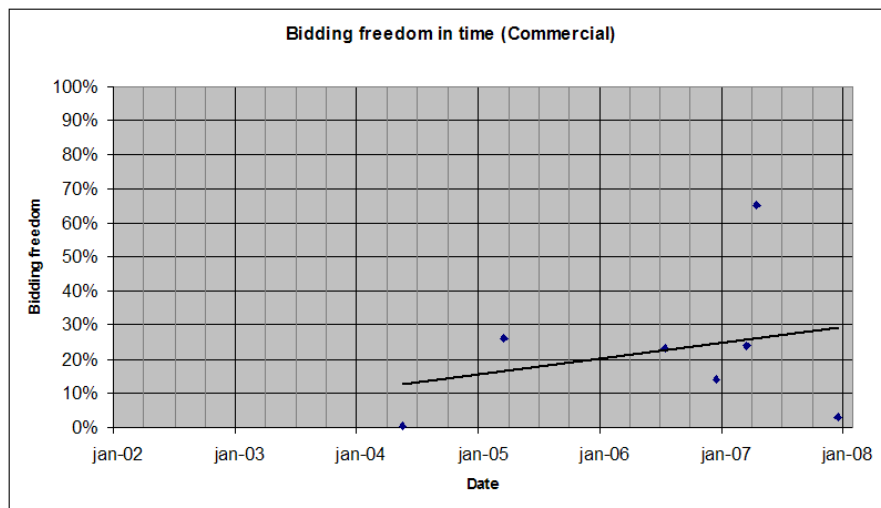
Figure 39   Development in time of bidding freedom; commercial projects

Figure 39 presents the relationship between the bidding freedom of projects and the moment of application in the commercial sector. The graph shows a slightly upward sloping trend around 20%.

The combined average bidding freedom of the civil sector and the commercial sector is about 25%.

5.5.2 Type in time

Figure 40 presents how often the types occurred in each year in the civil sector.
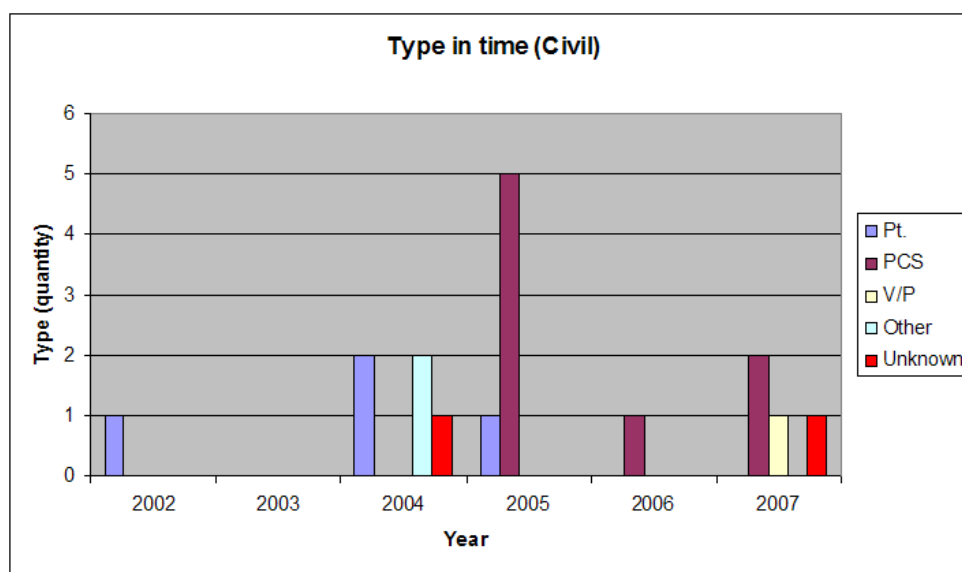
Figure 40   Types of EMAT in time; civil projects

Figure 41 presents how often the types occurred in each year in the commercial sector.
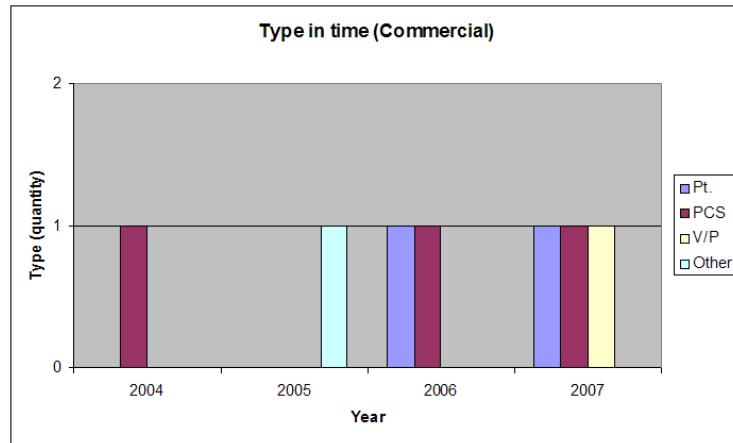
Figure 41   Types of EMAT in time; commercial projects

Remarkable for the civil sector is the use of the point system until 2005 and then a sudden period of price correction systems. This difference can be explained by the introduction of the RWS manual for EMAT award mechanisms in 2005. In the commercial sector there is not such a clear distinction. However, very remarkable is the sudden appearance of the ratio system for both sectors in 2007. These appearances can be explained by the continuous attention for the ratio type of evaluation, as generated by for instance De Ridder (2006:209). Another explanation is the progressing insight of procurers and their advisors as a result of good and bad experiences and knowledge sharing.

5.5.3   Size in time

Figure 42 presents the relationship between project size and moment of application in the civil sector.
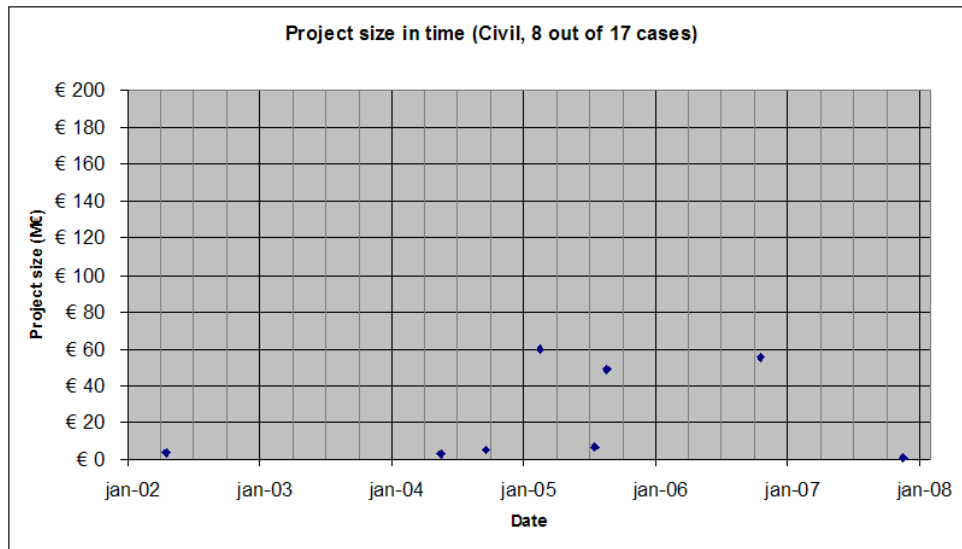
Figure 42 Development in time of project size; civil projects

Figure 42 shows an upward sloping trend, suggesting that procurers in the civil sector have first tried EMAT on some smaller projects and then became bold enough to try it on bigger projects.

Figure 43 presents the relationship between project size and moment of application in the commercial sector. This graph does not really show any relationship, other than that most of the projects were relatively small.
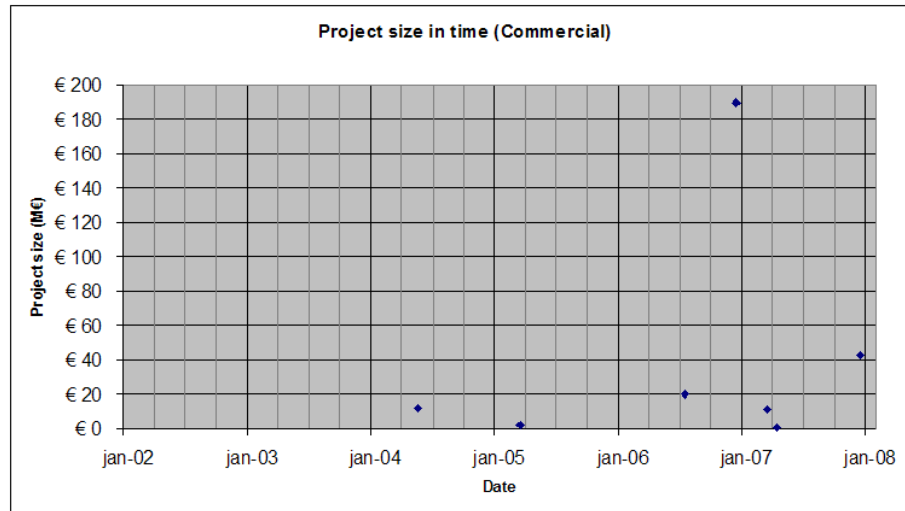
Figure 43   Development in time of project size; commercial projects

5.5.4   *Bidding freedom versus project size*

Figure 44 presents the bidding freedom related to project size in the civil sector. There does not seem to be a real correlation between project size and the bidding freedom, where one might expect a downward sloping line because procurers of bigger projects might be more conservative (the bidding freedom is an indication of progressiveness) because a lot of money is involved. On the other hand, larger projects also probably mean greater specification effort; hence it would be a convenient way to avoid specifying everything in advance.
Two groups can be identified; several projects smaller than 10 M€ and a group of cases around 50 M€.
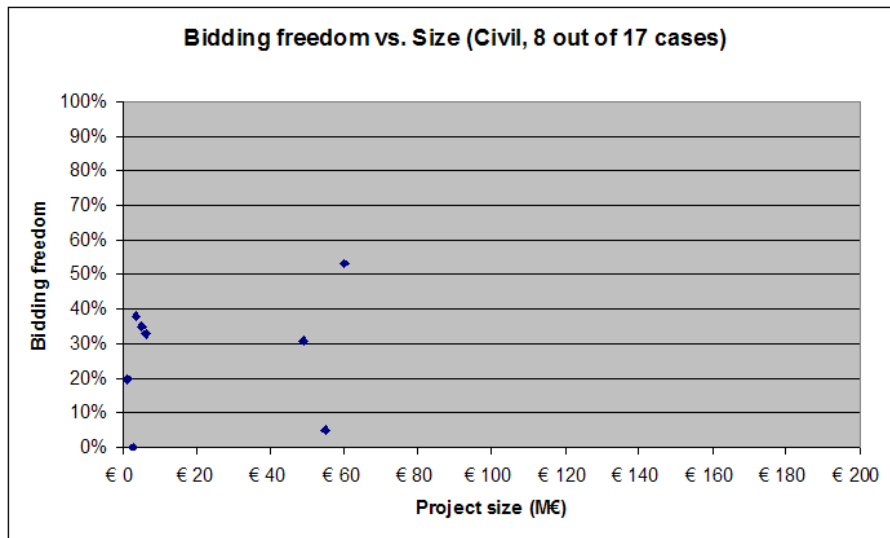
Figure 44   Bidding freedom related to project size; civil projects

Figure 45 presents the bidding freedom related to project size in the commercial sector.
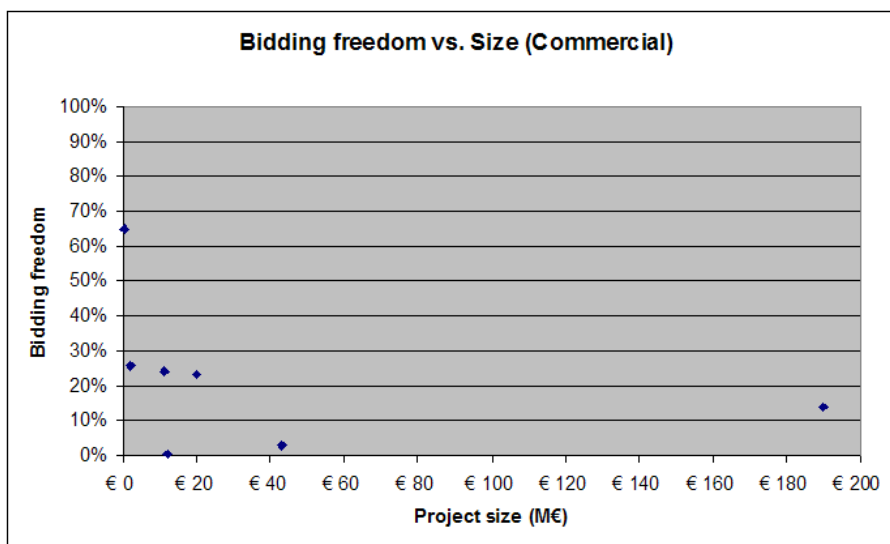
Figure 45   Bidding freedom related to project size; commercial projects

Figure 45 would suggest a slightly downward sloping line around a bidding freedom around 20% but there are really too few cases to draw conclusions about that.

5.5.5 Bidding freedom of each type

Figure 46 presents the average bidding freedom of each EMAT type in the civil sector. The category "other" (design contest or cases for which some information is missing) are excluded from the overview since it is impossible to determine the bidding freedom of these cases.
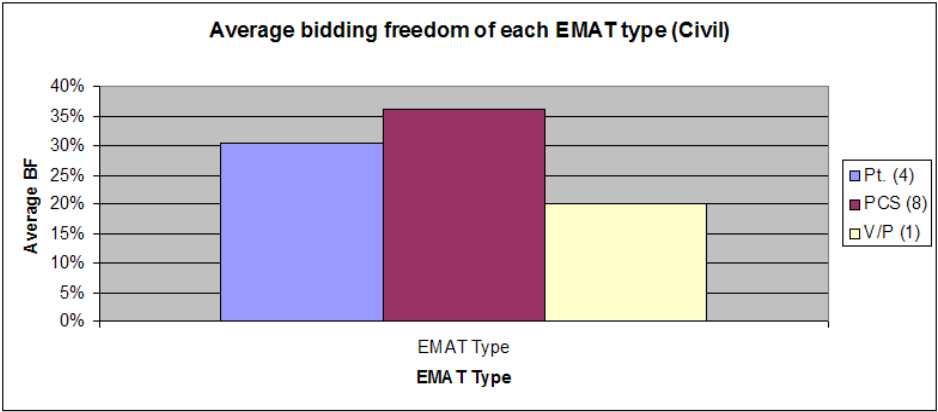
Figure 46   Average bidding freedom of each type; civil projects

Figure 47 presents the average bidding freedom of each EMAT type in the commercial sector.
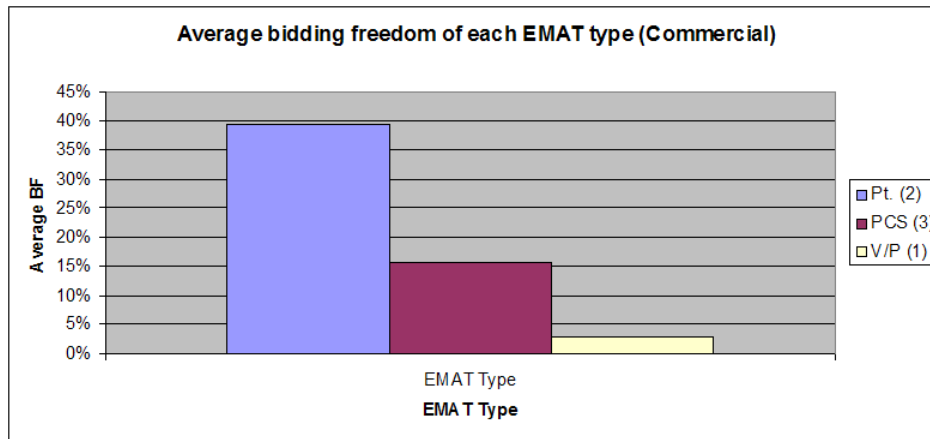
Figure 47   Average bidding of each type; commercial projects

Remarkable item in the civil sector, see Figure 46, is that the average bidding freedom of the point systems is almost the same as that of the price correction mechanisms, measured over 4 and 8 cases respectively. At a general level there seems to be some consensus between the procurers that use point systems and the procurers that use price correction systems.

In the commercial sector, see Figure 47, the users of point systems seem to be a bit more progressive than the users of price correction mechanisms.

5.5.6   Type versus size
Figure 48 presents the type – project size relationships in the civil sector. From this graph no real preference for a type can be distinguished for the three project size categories. Rather the other way around; for the small civil projects, each type has been applied.
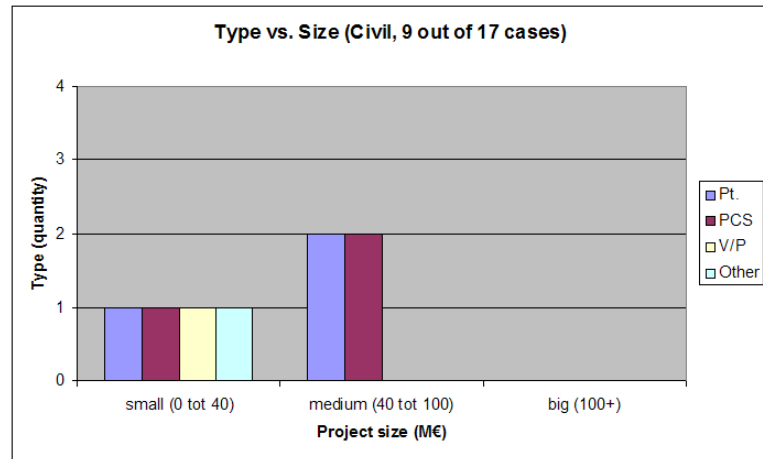
Figure 48   Types of EMAT related to project size; civil projects

Figure 49 presents the type – project size relationships in the commercial sector. In the commercial sector, there seems to be a preference to apply the price correction system for the smaller project size category. There is no real underlying explanation for this preference other than the speculation that procurers of relatively small projects in the commercial sector want to keep it simple and do not feel the need to "obscure" their willingness to pay by expressing the added value in points.
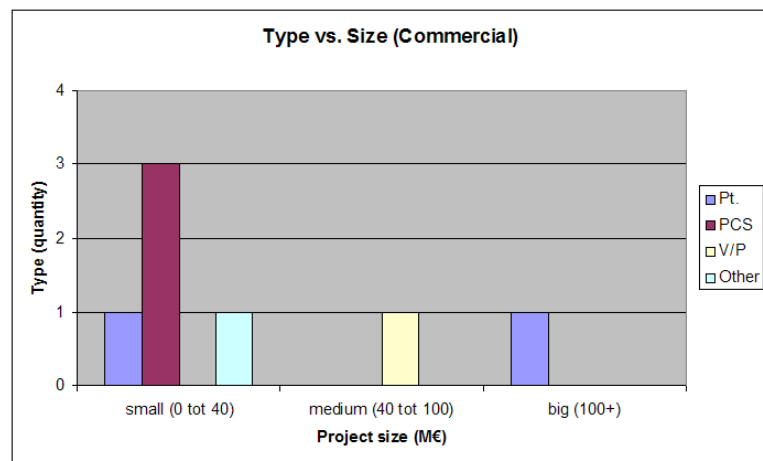
Figure 49   Types of EMAT related to project size; commercial projects

5.5.7   *Applied award criteria*

This section presents an overview of which award criteria were used in the collected EMAT award mechanisms.
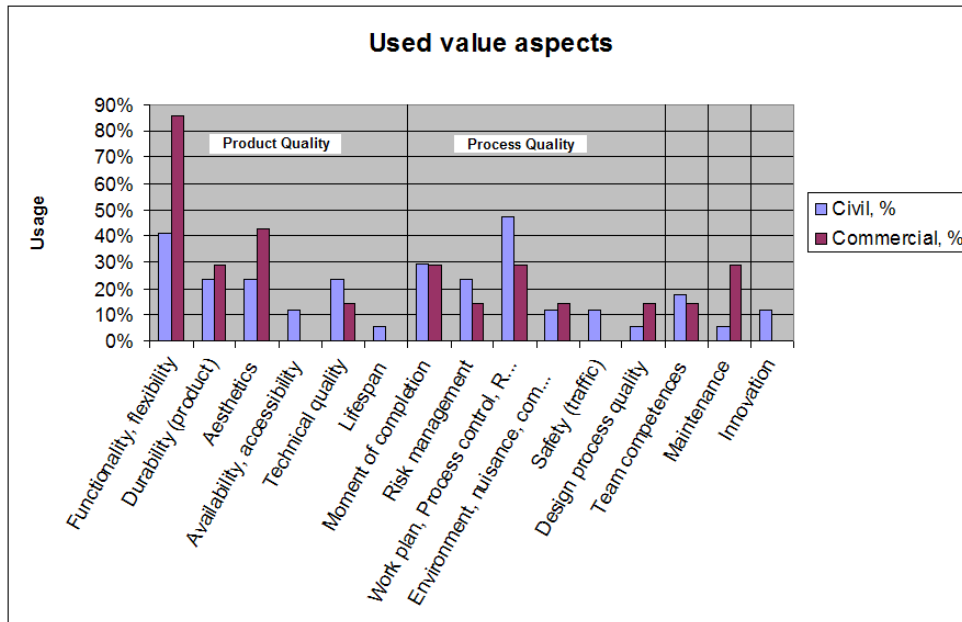
Figure 50   Used award criteria

Figure 50 shows in how many percent of the projects a certain type of award criteria was used, for the civil sector (17 cases) and for the commercial sector (7 cases).

Most used award criterion in the civil sector is the quality of the project management plan, a process quality criterion. This corresponds with Otto's findings (2009) in a study for Rijkswaterstaat.

Most used award criterion in the commercial sector is the functionality of the built object, which is a product quality criterion.

5.6   Conclusion 3

The third key question "which developments can be distinguished in EMAT?" is answered by presenting several correlations of the properties of the 24 EMAT award mechanisms that were applied in practice.

The average bidding freedom is about 30% for cases from the civil sector and about 20% for the commercial sector, amounting to a combined bidding freedom of about 25%.

Remarkable for the civil sector is the use of the point system until 2005 and then a sudden period of price correction systems. This difference can be explained by the introduction of the RWS manual for EMAT award mechanisms in 2005. In the commercial sector there is not such a clear distinction. However, very remarkable is the sudden appearance of the ratio system for both sectors in 2007.

Most used award criterion in the civil sector is the quality of the project management plan, a process quality criterion. Most used award criterion in the commercial sector is the functionality of the built object, which is a product quality criterion.

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6 Suitable EMAT award mechanism elements

Everything is vague to a degree you do not realise till you have tried to make it precise – Bertrand Russell, English author, mathematician & philosopher (1872 - 1970)
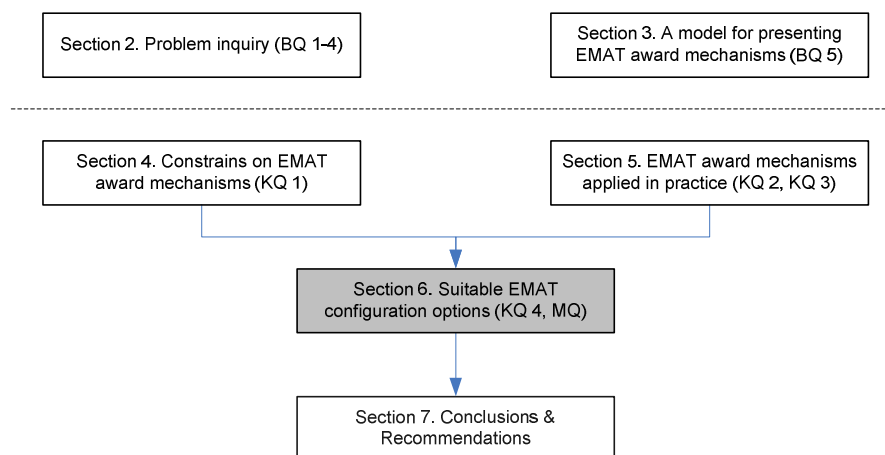
This section presents the answer to the third key question "which EMAT award mechanism elements are suitable?" by identifying the elements of EMAT award mechanisms presented in section 5.3 and comparing them with the suitability requirements identified in section 4. The main question "which EMAT award mechanisms are suitable for the Dutch construction industry?" is answered by presenting the suitable EMAT elements in a configuration tree.

The suitable elements of the investigated EMAT award mechanisms are presented in a configuration tree. Before the tree is displayed, some instructions about how to read the tree are needed. There are two types of branches. The "or" branch represents a situation in which a choice between several possibilities must be made. The so-called "and" branch represents a situation in which all elements must be defined. The graphical representation of these two types of branches is given in Figure 51.
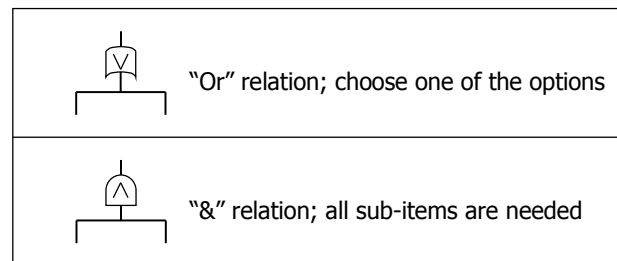
Figure 51   Explanation of the symbols used in the EMAT configuration tree

The "or" branches are numbered for referencing reasons. The decisions are accompanied by considerations. There are several sources for the considerations: the match with the requirements that were defined in section 4, literature, information from the case files, conversations with the involved persons and conversations with procurement professionals who have specialised in the EMAT award mechanism (see Appendix H for details).

For the readability the tree is divided into several figures. The reading direction of the three is from above to below. The coloured ends of the tree elements represent the start of another tree element.

The reading direction would suggest a top-down decision process, but note that in reality often other paths are followed and many choices are made implicitly.

Several configuration options turned out to be conflicting with the limitations as mentioned in section 4. These configuration options are mentioned in the text for the sake of completeness and for explicitly showing why these options should not be used, but they are not included in the configuration tree in order to avoid confusion.

6.1   The basic decisions

Assume there is a procurer who has arrived at the stage in which an award mechanism needs to be formulated. In an earlier stage, the decision to apply the EMAT award mechanism has been made and all accompanying choices (i.e. task allocation, organisation form, procurement procedure, contract form) are made in such a way to facilitate that decision. This excludes the lowest price award mechanism; see Figure 52a). Value price optimisation (Figure 52b) or value maximisation (Figure 52c) are the remaining options.
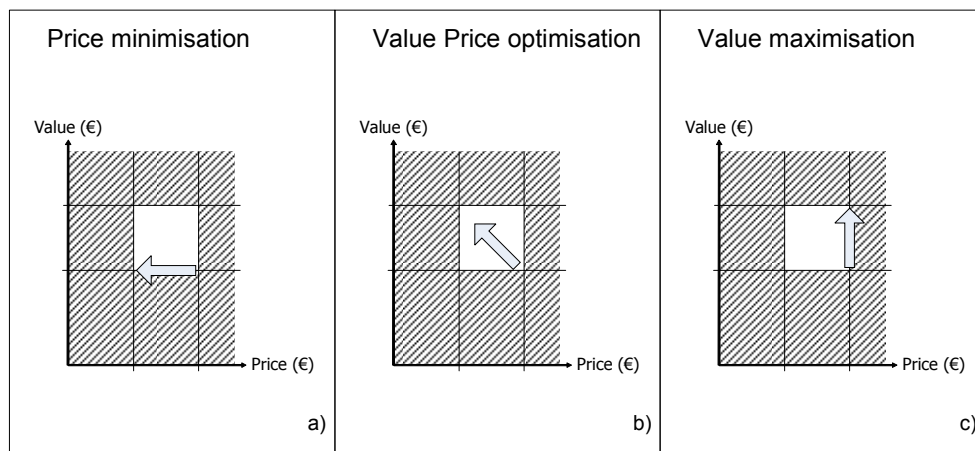
Figure 52   The three award strategies

This situation forms the starting point for the EMAT configuration tree, as depicted in Figure 53.
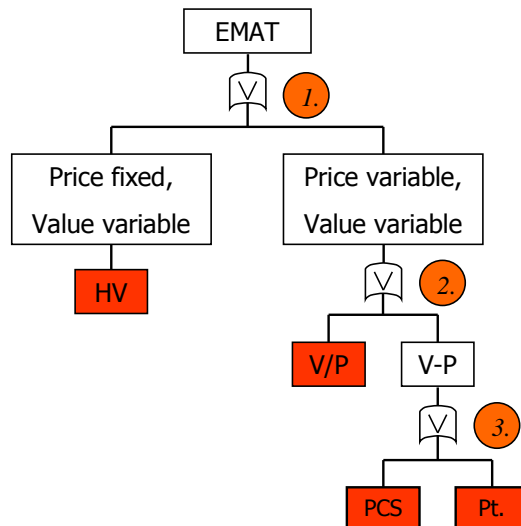
Figure 53   Main configuration options for EMAT award mechanism

6.1.1   Decision 1: Value maximisation or *Value Price optimisation?*

Typical characteristic of the EMAT award mechanism is that the performance on one or more award criteria is allowed to vary. One of the main decisions is whether price is allowed to vary as well or not, see decision number 1 in Figure 53. In the case the price is fixed, the procurer publicly announces the budget; the supplier that bids the highest value for that budget (and meets all other requirements) wins the contract. This procedure is also known as a value maximisation system and it is elaborated in section 6.2.

Consideration
Advantage of the value maximisation system is that the value of bids does not have to be expressed in monetary terms. Drawback is that some procurers think that stating the budget in advance increases the risk of cost overruns. Drawback from a theoretical point of view is that value maximisation imposes the same limitations as price minimisation; the price is fixed and thus the number of solutions suppliers can formulate in order to find the best possible solution is restricted.

6.1.2   Decision 2: V-P or V/P?

In case the procurer decides that both price as well as value of bids should be allowed to be variable, the choice between the two main preference systems (see Figure 54 and section 3.4) needs to be made, see decision number 2 in Figure 53.

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The system that bases preference on the highest value price ratio – in short the V/P preference system – is elaborated in section 6.3. The possibilities for a system that bases preference on the highest difference between value and price – in short the V-P preference system – are elaborated in section 6.1.3.
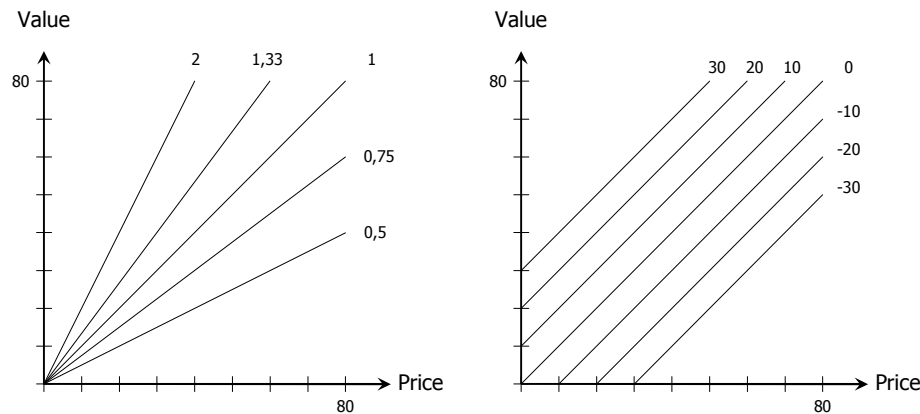
Figure 54   Equal preference lines of ratio and difference system respectively

Consideration
Seventeen of the twenty-four analysed cases (six point systems and eleven price correction systems) base preference on the highest procurement profit (highest value minus price, or lowest price minus added value). Only two of the twenty-four analysed cases based preference on the highest value price ratio. So the majority bases preference on the absolute amount of procurement profit instead of profitability in relative terms.

Both types of selection are economically rational. However, it is important to make a choice, because depending on the preference system, the ranking of bids can change, as shown in Figure 19.

Literature (Kelly et al. 2004:17, Ridder 2006:209, Ridder & Soons 2006:10-2, NEN 2000a:12) states that preference should be made on V/P. In that respect it is strange that in such a large portion of the encountered cases preference is based on V-P.

Advantage of the V-P system is that is does not need to estimate the value of the terms of reference; all of the encountered price correction mechanisms are in the form of "price minus added value" instead of "total value minus price", in which total value consists of the value of the terms of reference and the added value.

Drawback of the V-P system is that it increases the chance that a higher portion of the budget will be spent, since it is relatively easier to get a higher difference between value and price if the price is higher, see also Figure 19. However, depending on the way added value is defined, spending a higher portion of the budget could very well be a bargain. If the reward for extra performance is "conservative" (hard to obtain added value + extra performance is rewarded cheaply), then it is not attractive for suppliers to deliver extra value. For procurers however it then becomes attractive to apply the V-P system. If the reward for extra performance is "progressive" (easy to obtain added value + extra performance is rewarded generously), then it is attractive for suppliers to deliver extra value. For procurers it then becomes attractive to apply the V/P system. These considerations do not play a role when the added value is determined as realistic as possible.

A consideration that supports the V-P system is that procurers often hesitate to make their price estimate publicly known in advance; they think it increases the risk of suppliers not making their price bid as competitive as possible. Although that does not have to be the case, since the suppliers are in competition, the combined experience of procurers is something that should be taken into account.

Based on these considerations, there seems to be a slight preference for the V-P system. In the EMAT expert meeting of may 2008 (see Appendix H) the idea was introduced that if the profitability is higher than a certain threshold (i.e. 4%, which is commonly used in government investment decisions) then the profit should be maximised, so then the V-P system should be applied; otherwise the V/P system should be applied, because then the remaining budget could better be spent on other projects.

Furthermore, it might be possible to base preference on the procurement profit multiplied by the profitability percentage. For instance consider the following situation: there are two options, option A with profitability of 4% and a procurement profit of 10 M€ and option B with profitability of 3% and a procurement profit of 15 M€. The products then would be 40 and 45 respectively. Since 45 is higher than 40, option B would win. The consequences of this new preference determination method would have to be investigated.

6.1.3   *Decision 3: Price correction system or point system?*

When preference is based on the highest difference between value and price – in short the V-P preference system – the procurer can choose between two methods; the point system (Pt.) or the Price Correction System (PCS), see decision number 3 in Figure 53. The configuration options for the price correction system, in which both value and price are expressed in monetary terms, are described in

section 6.4. The parameters for the point system, in which both value and price are expressed in points, are elaborated in section 6.5.

Consideration
The examples in section 3.7 show that the principle of point systems and PCS's is actually the same; the added value is calculated and subtracted from the price and the bid with the lowest corrected price wins. The only difference is the way in which the calculations and results are presented. However setting up a point system requires that price is translated into points, which requires the introduction of an extra parameter, which has no influence on the preference and thus unnecessarily complicates things. Furthermore it is easy to make errors in the system for translating price into points, increasing the chance of lawsuits and delays. So for the sake of simplicity and elegance, the price correction system should always be chosen. Expressing extra performance in monetary terms is more comprehensible for everyone involved; it is perceived as less artificial and it is easier to explain and to 'defend'. Furthermore, "tuning" the point system needs monetary estimates anyway.

An argument for applying the point system is that expressing extra performance in monetary terms gives a suggestion of accuracy that is not justified. Procurers can only make approximating/indicative statements about how much they are willing to pay for a certain extra performance.

All in all the price correction system has more advantages. The point system introduces an extra variable which makes it unnecessarily complex; first both added value and price differences are expressed in points and then, in order to get an idea of what really happens, one must translate the points back into money. The advice is to keep it simple and just express value and price differences in money.

6.2   Value maximisation systems

This EMAT award mechanism subtype selects the bid with the highest value. The price dimension is of no consequence, since the procurer has stated to be willing to spend a fixed amount of money, provided certain minimum requirements are met as well. The value of the bids is determined with a Multi Criteria Evaluation (MCE), which will be described in section 6.8. The bid with the highest value is awarded the contract. This procedure is also known as a design contest.

Two envelope system
The evaluation report of one of the cases described the use of a so-called two envelope system; suppliers were required to deliver their bid in two envelopes, a price envelope and a design envelope. First all design envelopes were opened, the added value of each design was determined (using a publicly known determination mechanism) and then the price envelope of the bid with the highest added value was opened. If the price would fit within the budget then that bid would win the contract. If not then the price envelope of the bid with the second highest value would be opened, the budget check would be performed again and this procedure would be repeated until there was a bid that would fit within the budget. Strange thing about this procedure is that it would be possible that the "economically most advantageous tender" would not win the contract. For instance, a very cheap solution with no added value would lose from a bid with only a small amount of added value, while being disproportionally more expensive than the other bid. Furthermore, it is strange to allow the price to vary in a value maximisation system. Because of the aforementioned problems, the two envelope system is not presented here as a suitable solution. Also, in the mentioned case it was eventually decided that all envelopes should be opened. Luckily for them, the added value was expressed in monetary terms, so the value maximisation system could be converted into a valid price correction system.

Please note that for any EMAT procedure it is possible to require that the bid is delivered in a price envelope and a design envelope, but that is not a two envelope system as described above.

6.3   Ratio systems

The ratio system bases preference on the highest profitability of bids. That profitability is determined by dividing the total value of a bid by the price of that bid. The price configuration options will be described in section 6.6.

6.3.1   Decision 4: Expressing total value with or without fixed part?
There are two possibilities for determining the total value of the bids (see decision 4 in Figure 55). The first option uses a Multi Criteria Evaluation (MCE), see section 6.8 for the description of that procedure. The other option divides the total value into an obliged part (V_{ToR}, value of the Terms of Reference, see section 6.7) and a variable part (AV, added value), see section 6.9.
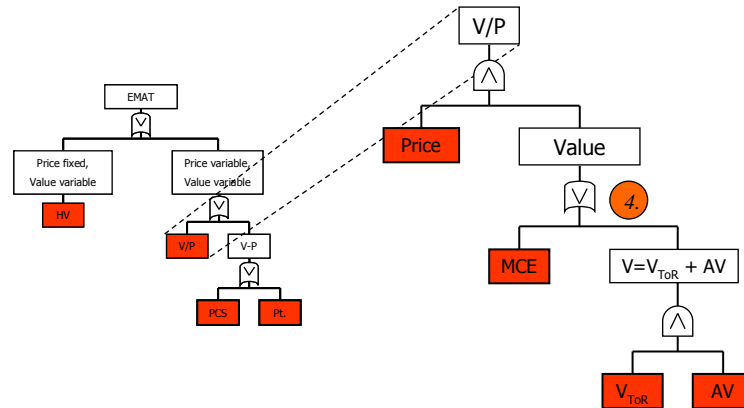
Figure 55   Configuration options for the ratio system

Why dividing the added value by the price is not suitable
One could argue that in order to avoid the difficulty of having to determine the total value of bids, one could just divide the added value by the price. However, as explained by the example in Figure 56, this method has a certain bias which makes it unsuitable.
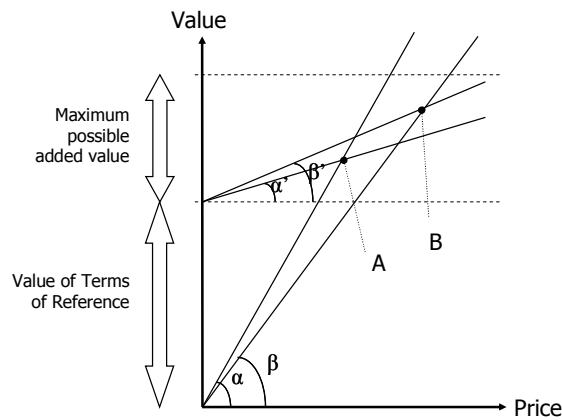
Figure 56   Added value divided by price is not suitable

Figure 56 shows bids A and B. If preference is determined by added value divided by price, then bid B wins, because the angle β' is larger than the angle α'. If preference is determined by the total value divided by price, then bid A wins, because angle α is larger than angle β. Because of this bias, the system of dividing the added value by the price cannot be considered as a suitable award

mechanism. That unsuitability is demonstrated by the following example: a bid with zero added value could still have a very nice price for complying with minimum requirements, but since "added value divided by price" would yield zero, it would never win against a bid with just a little added value, however bad the price of that bid may be.

In the same manner it can be shown that a system that divides Δvalue by Δprice is also unsuitable (Δvalue is the added value and Δprice is defined as the difference between the price of the bid and some reference price).

Consideration
The main advantage of just using a MCE to express the total value of bids is that the value of the terms of reference does not have to be determined. But as shown in Figure 55, that is also the main drawback; leaving out the value of the terms of reference will most probably lead to sub-optimal results, because suppliers are empowered to look only at the award criteria. Please note that the option of expressing the total value of bids was derived from theory; it has not been encountered in practice.

6.4 Price correction systems

The Price Correction System (PCS) bases preference on the lowest corrected price.

6.4.1 Decision 5: P-AV or V-P?

As shown in Figure 57 there are two PCS types; subtracting added value from the price or subtracting price from the total value. Section 6.9 shows how the added value (AV) is determined. Section 6.7 shows how to determine the value of the Programme of Requirements (V_{ToR}). See section 6.6 for the price configuration options.
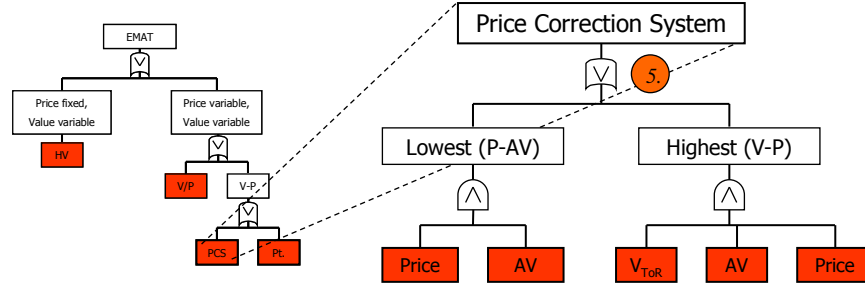
Figure 57   Configuration options for the price correction system

In the following it is shown that choosing on the basis of the lowest Price (P) minus the Added Value (AV) is essentially nothing else than choosing on the basis of the highest total Value (V) minus the price, see Equation 1 for the mathematical expression of this statement.

$$\min(P - AV) \Leftrightarrow \max(V - P) \qquad \text{(Equation 1)}$$

Equation 2 describes the formula of maximising the procurement profit, Equation 3 describes the elements of value and Equation 4 shows that minimising a function corresponds with maximising the negative of that function.

$$\max(V - P) \qquad \text{(Equation 2)}$$

$$V = V_{ToR} + AV \qquad \text{(Equation 3)}$$

$$\min_{x \in \mathbb{R}}(f(x)) \Leftrightarrow \max_{x \in \mathbb{R}}(-f(x)) \qquad \text{(Equation 4)}$$

Substituting Equation 3 into Equation 2 and applying Equation 4 leads to Equation 5.

$$\min(-V_{ToR} - AV + P) \qquad \text{(Equation 5)}$$

Since V_{ToR} is the same for all bids, it can be ignored in the preference determination. Leaving V_{ToR} out of Equation 5 leads to Equation 6, which is the basic form of the price correction mechanism.

$$\min\left(P - AV\right) \qquad\qquad \text{(Equation 6)}$$

Hence it is shown that the PCS is an occurrence of the V-P preference system.

Consideration
The main advantage of the P-AV system over the V-P system is that it does not need to express the value of the terms of reference, making the system easier. Furthermore, if the value of the terms of reference would be expressed, one could apply the V/P system (idealised by literature, see decision 2) instead of the V-P system.

It is also theoretically possible to express the total value of a bid in points and then translate the point value into Euros; however, then the value of the terms of reference is not taken into account and that should be discouraged, as shown in Figure 55.

It could be a strategic decision to not give or prescribe the terms of reference; by doing so, the procurer deliberately gives suppliers a lot of trust, in the hope that the suppliers will return the favour. However, in the current climate, the risk that such a decision leads to disappointing results is high.

6.5   Point systems

At a first glance, the point system does not resemble the PCS. The point system seems to express both price and quality of the bids in points; the bid with most points wins. At least, that is common for the Dutch situation, the system can also be configured in such a way that the bid with fewest points wins, which is for instance common in the Swedish situation (Waara 2007). The essence of maximising or minimising the points remains the same.

However, as shown in section 3.7, the principle of the point system is actually exactly the same as that of the PCS; the added value forms a correction on the price.

As shown in Figure 58 there are several parameters that have to be determined in order to have a working point system. The extra performance of bids is expressed in points using a Multi Criteria Evaluation (MCE), see section 6.8. To express the price in points, three parameters are needed; a price reference (P_{Ref}), a point reference ($Pts._{Ref}$) and a value per point (α).
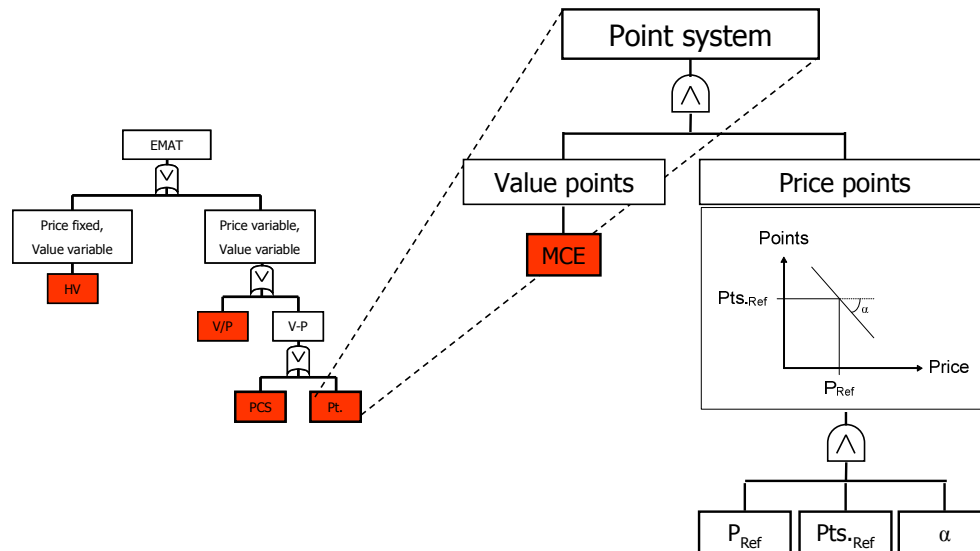
Figure 58   Parameters of point systems

Intermezzo: the monetary reference

Two methods for calculating the monetary value of a point were encountered; making it dependant on one or more of the prices of the bids or stating a fixed value per point in advance. Cases C2 and C1 used price information, cases C3 and U3 used a constant to determine the point value. However, Telgen (2006) and later Chen (2008) showed that making the value of points depend on price information would lead to undesirable results in the procurement procedure and thus should never be applied. It can happen that the reference bid has to be removed from the procurement procedure, for instance because another supplier can show in a lawsuit that it is not valid. In such a case, the monetary value of a point also changes, which could lead to an entirely different ranking of the remaining bids. This inconsistency is not only irrational and confusing; it can also be ground for successful lawsuits. Based on this example, it can be concluded that the procurers of cases C2 and C1 were lucky to finish their procurement procedure without lawsuits. If a constant is used for determining the point value, the problem does not occur. The inconsistency was also remarked by Kuiper & Buisman (2005). In 2008, Rijkswaterstaat (RWS 2008) abolished the use of referring to prices.

The linear price-point relationship
Basic assumption for the encountered point systems is that more points correspond with a higher preference. Figure 59 describes a linear price-point relationship. Basic principle for the linear price-point relationship is that there is a certain reference price, which will receive a certain amount of points, see point $(P_{ref}, Pts._{ref})$ in the graph of Figure 59. From that point on, higher prices become less attractive so they will receive fewer points, see point $(P_x, Pts._x)$. Furthermore, typical for linear price-point relationships, the amount of points becomes zero at a certain price; see point $(P_0, 0)$.
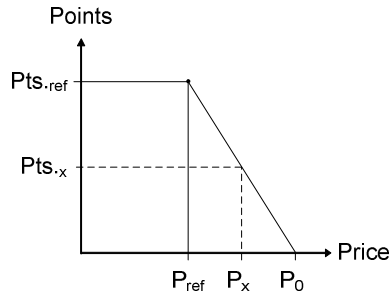
Figure 59   A linear price-point relationship

Based on Figure 59, the linear price-point relationship is described in Equation 7, with P_{ref} the reference price, $Pts._{ref}$ the points for the reference point, P_x the price of bid x and $Pts._x$ the points for bid x.

$$Pts._x = \frac{(P_0 - P_x)}{(P_0 - P_{ref})} * Pts._{ref}$$ (Equation 7)

P_0 can be any multiple of P_{ref}. For instance in a point system encountered in practice, P_{ref} was 2.5 times P_0. However, that point system was still in concept stage and it was never really applied, so it is not included in the database. In the database are only point systems with a point decline in terms of percentage. In the case of a difference in terms of percentage (i.e. a 50% higher price leads to 50% fewer points) P_0 equals $2*P_{ref}$. Substituting $P_0 = 2*P_{ref}$ in Equation 7 leads to Equation 8, which can be rewritten to Equation 9 and Equation 10.

$$Pts._x = \frac{(2*P_{ref} - P_x)}{(2*P_{ref} - P_{ref})} * Pts._{ref}$$ (Equation 8)

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$$Pts._x = \frac{2 * P_{ref} - P_x}{P_{ref}} * Pts._{ref} \qquad \text{(Equation 9)}$$

$$Pts._x = (2 - \frac{P_x}{P_{ref}}) * Pts._{ref} \qquad \text{(Equation 10)}$$

Rewriting Equation 10 to the general linear form y = a*x + b results in Equation 11.

$$Pts._x = -\frac{Pts._{ref}}{P_{ref}} * P_x + 2Pts._{ref} \qquad \text{(Equation 11)}$$

The term ($Pts._{ref}/P_{ref}$) in Equation 11 corresponds with α in Figure 58. In order to determine the monetary value of a point, 1/α or ($P_{ref}/Pts._{ref}$) can be used. As stated in the intermezzo, the monetary value of a point should not be made dependant on price information.

Price references
Several mechanisms were encountered that took the lowest price or the median price as reference for determining the added value. Theoretically, also the average price of the bids could be taken as reference or for instance the second lowest, since the chance that the lowest bid has to withdraw is higher. However, as shown in the intermezzo, price references for determining the added value should never be applied.

Curved price-point relationships
There are no curved price-point relationships in the database. However Telgen (2006) states that curved price-point relationships have been used in practice, in other sectors than the construction industry. Figure 60 shows the graph of a curved price-point relationship.
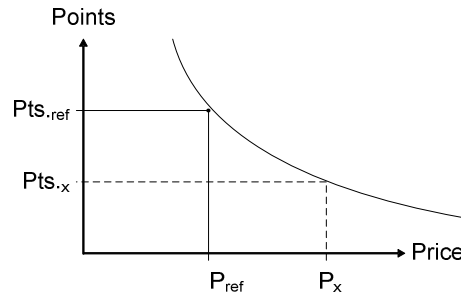
Figure 60   A curved price-point relationship

It also uses a reference point, so a certain reference price will receive a certain amount of points, the reference points; see point (P_{ref}, $Pts._{ref}$) in the Figure 60. Characteristic of the curved price-point relationship is that a bid can never get zero points, no matter how expensive it is. The number of points a bid receives is inverted to the ratio of the price and the reference price, so if for instance a bid is three times more expensive than the reference price it receives a third of the points. The general formula for curved price-point relationships is described in Equation 12, with P_{ref} the reference price, $Pts._{ref}$ the reference points, P_x the price of bid x and $Pts._x$ the points for bid x.

$$Pts._x = \frac{P_{ref}}{P_x} * Pts._{ref} \qquad \text{(Equation 12)}$$

Points systems with a curved price-point relationship cannot be used in V-P preference system, because the value per point is variable and the V-P preference system requires a fixed value per point.

The discrete price-point relationship
Case C10 used a so-called discrete price-point relationship. The principle of this mechanism is illustrated in Figure 61. The cheapest bid gets a certain amount of points, the second cheapest gets a certain amount fewer and so on. The main criticism for this type of relating points to price is that it is not rational; small price fluctuations can lead to large changes in preference, or the other way around. Because of this, the award mechanism of case C10 has been subject of a lawsuit, which turned out badly for the procurer. In "case Lindewijk" (Rechtspraak 2005) the court decided that this mechanism is not allowed. Hence the discrete price-point relationship is not included in Figure 58 as a viable option.

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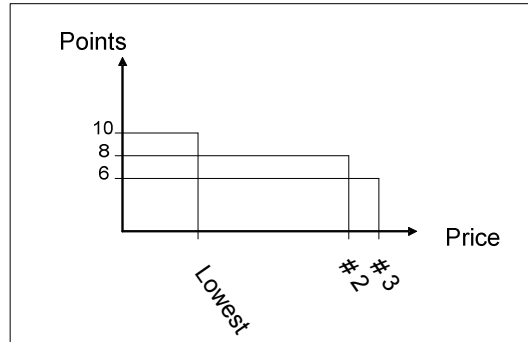
Figure 61   Discrete price-point relationship

Another problem of case C10 (see Table 15 and Table 16) was the use of "weighed prices". For instance the points earned for maintenance prices were weighed and added with the points earned for the bid price. This led to the strange situation of a "maintenance euro" being less valuable than a "construction euro". That is not only irrational; it also invites opportunistic behaviour of suppliers. To fix the problem, the weighing mechanism was not made publicly known in advance, which only made things worse for case C10. It can be concluded that error was stacked upon error in case C10. Please note that case U7 also used weighed prices, but it is not known whether that led to a lawsuit or not.

6.6   Price configuration options

Price is often thought of as a simple parameter, but as shown in Figure 62, several possibilities were encountered.

Used in:
- V/P system
- Price correction system
- Point system

Price

| Price | NPV | Several price components, such as maintenance | Unit prices, optionally in combination with scenarios |

Specialities:
- VAT
- Price level
- Indexation
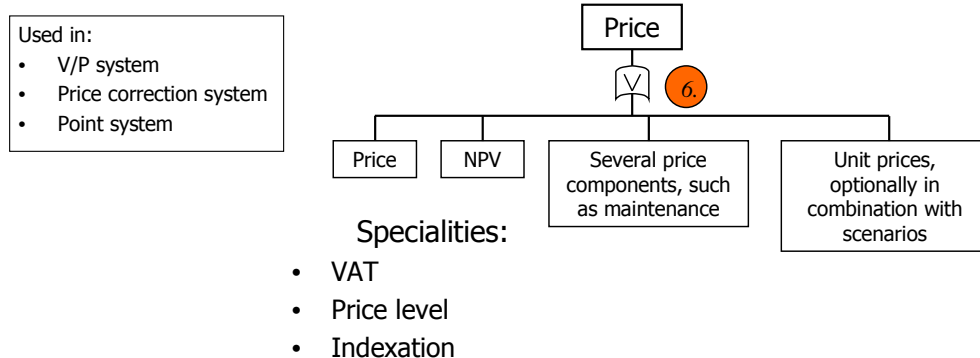
Figure 62   Price configuration options

6.6.1   *Decision 6: Price*

One can choose for asking a single price for the entire contract or for the Net Present Value (NPV), as was done in case C2. The net present value of an object consists of the sum of all yearly cash flows, corrected with a certain interest rate. Furthermore one can choose to ask the price of several components or even the price of change scenarios. As shown in the previous section, price components should not be translated into points and then added (with or without weights). Instead, the prices should remain in monetary terms and then just be added. For each of the options it needs to be specified whether VAT is included or not, which base year may be used for inflation correction and which posts are indexed.

From a methodological point of view it would be better to treat the "Net Present Value" as a EMAT award mechanism in its own right, because besides price elements (future negative cash flows) it contains value elements (future positive cash flows).

Consideration
Besides simply asking one price for the bid, procurers can ask for the Net Present Value (NPV), the prices of several components or unit prices. However, the use of asking the prices of several components is questionable; what the procurer will do with that information? It is not likely the procurer will suddenly leave certain components out of the deal, because that would change the scope of the assignment. The argument for asking unit prices is that the procurer fixes in advance what certain changes will cost, giving the procurer room to decide to change the scope after the contract award.

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From a methodological point of view it would be better to treat the "Net Present Value" as a EMAT award mechanism in its own right, because besides price elements (future negative cash flows) it contains value elements (future positive cash flows).

6.7 Options for determining the value of the terms of reference

There are two options for determining the value of the terms of reference, as shown in Figure 63.
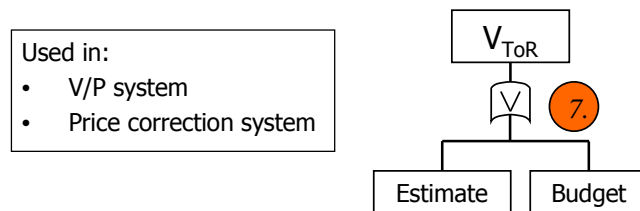
Figure 63   Options for determining the value of the terms of reference

6.7.1   Decision 7: Approximating the value of the terms of reference

Two main options for approximating the value of the terms of reference are distinguished; using a price estimate or the budget. In a certain sense the budget is also a price estimate, but it has a different connotation; the budget sets a target for the procurer, whether it is realistic or not. It is the general impression that the budget is usually lower than a "safe" estimate; see for instance Flyvbjerg (2003). In this context also the concept of a "political" budget is used. Using the budget or a percentage thereof is a theoretical option, because it was not encountered in practice. Only the use of a price estimate was encountered.

Analogous to the intermezzo in 6.5 the value of the terms of reference should not be determined by relying on price information. If one of the bidders would be forced to withdraw from the procurement procedure, the value of the terms of reference would possibly change, which could lead to the strange and undesirable situation of the ranking suddenly changing.

Consideration
There are two options for approximating the value of the terms of reference; using a price estimate or the budget. In a certain sense the budget is also a price estimate, but it has a different connotation; the budget sets a target for the procurer, whether it is realistic or not. It is the general impression that the budget is usually lower than a "safe" estimate.

Drawback of using the budget or a percentage thereof as a method for approximating the value of the terms of reference is that the budget is not necessarily realistic or compatible with market conditions. There is however something to say for using the budget; even if it is not very realistic, it still forms a reality for the procurer. However, looking at the misery caused by using unrealistic budgets, it is better to use a "safe" estimate.

6.8 Configuration options for the Multi Criteria Evaluation

The Multi Criteria Evaluation (MCE) is a method for combining several dissimilar performances into one parameter, and as described earlier in section 2.1.3, it is well documented. In the context of the encountered EMAT award mechanisms, the output is some score range, in which more points means better. Of course the scores could also be configured in such a way that fewer points means better. The main parameters of a MCE are shown in Figure 64. Without the pretence of being complete though, it is of no use to replicate the extensive amounts of literature on the subject.
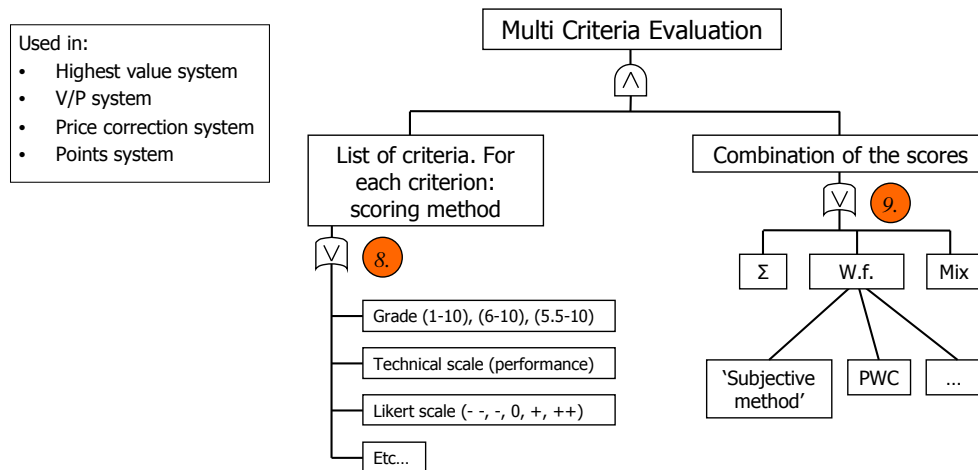
Figure 64   MCE configuration possibilities

As shown in Figure 64, the main ingredients for a MCE system are a list of criteria and some method for combining the dissimilar scores.

6.8.1   Decision 8: Award criteria

Basically anything that has a relationship with the procured object and is important to the procurer but allowed to fluctuate in performance is a potential award criterion. The criterion has to be measurable and the way of measuring has to be given in advance. Usually the performance has a lower and an upper limit. There are several ways to attach scores to the performance of bids, such as the grading scale, which is well known in the European educational system. The technical scale just displays a technical property, like fire resistance, energy performance coefficient, tensile strength, conduciveness, etc. The Likert scale specifies some expected performance and then establishing whether a bid performs worse, slightly worse, about equal, slightly better or better. Refer to the literature for more possibilities. In order to simplify the combination of dissimilar scores, there are several standardisation routines available, as shown in the literature mentioned in section 2.1.3.

Comparative assessment
There are roughly two options for determining the scores of bids: "comparative", which means the bids are compared with each other using the so-called pair wised comparison technique (KC BPI 2004, RWS 2005b, RWS 2006). The other option is "guideline", which means the performance of bids is determined by using a guideline, often with sub criteria, so no knowledge of other bids is required. The comparative assessment is not included in the tree because it can

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give strange results. First of all, the output of the pair wise comparison is always discrete, which can give proportionality problems (small variations in performance can give large variations in the evaluation). Secondly, it can happen that if one of the bids has to withdraw from the procedure, the rank of the remaining bids could change. For these reasons, the comparative assessment should be discouraged.

Consideration
There are several ways to attach scores to the performance of bids, such as giving a grade, using a technical scale or using a Likert scale. The choice for either one of these scales is not that important, because they can be configured in such a way that the outcome in points is exactly the same. More important are the award criteria itself; on what aspects do we allow variable performance, what is the minimum required performance on that aspect and is there a maximum after which extra performance ceases to be useful. For this kind of decisions this thesis does not provide any answers, because that would become to labour intensive; basically anything that has a relationship with the procured object and is important to the procurer can become an award criterium.

General consideration is to limit the number of award criteria. Too many award criteria will not only decrease the significance of each individual award criterium, but it will also provide a lot of extra work for all the parties involved.

6.8.2   Decision 9: Weights
The scoring ranges of the award criteria determine how these scores should be combined into one parameter. So the choice for a combination method cannot be seen in isolation of the choice of the award criteria and their scoring ranges. Notwithstanding, there are globally two methods for combining the scores. Simply adding them, or first multiplying them by weighing factors and then adding them. Both methods could be combined as well. The two main methods for establishing weight factors are the "subjective method" and Pair Wise Comparison (PWC). Refer to the literature for more possibilities. Note that this PWC is different than the one mentioned in the previous section; this one compares criteria, the one in the previous section compared bids. The "subjective method" relies on the gut feeling and educated guesses of the procurer of how the award criteria relate to one and other. PWC is a slightly more sophisticated method; every award criterion is compared with the others; the most important award criterion receives one point and the less important zero. These pair wised comparisons are filled out in a matrix, the scores are added and then normalised to one, which results in a weighing factor per award criterion.

Consideration

One of the most important aspects of the MCE is "tuning" the point scores (checking the realism of the point scores by the means of scenario analysis). Tuning comprises the activity of finding a realistic monetary value of one point, with the knowledge that extra points can lead to a more expensive bid winning. Once the value of one point is known, it helps to "tune" the parameters (weights, scoring ranges and scoring methods) in the MCE system.

The weights need to be set up in such a way that the resulting scores represent an economic reality. The procurer has to make sure that an aspect of minor importance does not get a major influence in the preference, or the other way around. The pair wised comparison can be used as a tool for ranking the award criteria.

6.9   Options for determining the Added Value

6.9.1   Decision 10: Added value

Figure 65 presents two options for expressing performance in money. Performance of bids can be expressed in money per criterium, or, if that is not that obvious, the performance on several criteria can be grouped into a single performance indicator first, which then can be expressed in money. It is also possible to express some of the criteria in money directly and to group some first, which is symbolised in the figure by the use of both the "and" gate and the "or" gate.
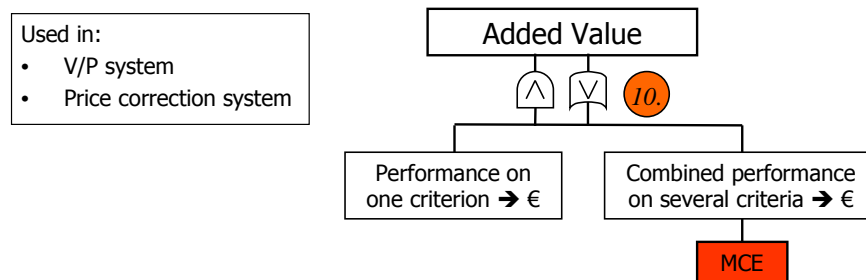
Figure 65   Options for determining the value of award criteria

In order to combine the performance on several criteria into a single performance indicator the Multi Criteria Evaluation (MCE) technique is used, see section 6.8.

Imagine for instance a MCE with three award criteria; process quality, aesthetics and durability, with weights of for instance 50%, 35% and 15% respectively. These weights determine the maximum amount that can be earned by maximum performance on the award criteria.

Establishing the amount of money that should be coupled to a performance can be done in several ways. In some cases the procurer exactly knows the worth of a certain performance. If that is not the case the procurer can use a percentage of an estimate or the budget. In practice, references to the prices of bids are done as well, but as described in section 6.5 that should be discouraged.

Theoretically performance can be expressed in money in several ways. Analogously to the price-point relationships mentioned in section 6.5, performance-money relationships could be linear, curved or discrete. In practice, only the discrete and the linear relationship were encountered.

The discrete performance-money relationship should be discouraged for same reason why the discrete price-point should be discouraged; when using a discrete performance-money relationship, a small performance difference can lead to a large difference in the evaluation, which could lead to legal appeals of losing suppliers, which could very well be successful on the ground of proportionality.

Examples of a linear coupling for one criterium are for instance "each extra parking lot that can be delivered amounts to x euro", or "each month earlier completion of the project generates x euro".

In practice there are many situations where a curved relationship would be more appropriate, since the extra performance does not necessarily mean extra money (analogously to the economical concept of "diminishing marginal utility"). An example from practice is for instance the bonus for earlier delivery; it is no use to reward a delivery that is so early that the surrounding infrastructure is not ready yet.

Consideration
The methodological reasons why some performances should be expressed in money directly while other performance should be grouped first is not clear. The main reason is probably practical; some performances, such as extra parking spaces or earlier delivery are easy to express in money, while others, such as ecology or aesthetics are not.

So if the procurer is able to express the willingness to pay for extra performance on a criterium, the performance can be expressed in money directly. If there are several criteria for which this ability is not present, the performance on these

criteria can be grouped into a single performance indicator first (using MCE technique), which then can be expressed in money.

6.10   Conclusion 4

The fourth key question "which EMAT award mechanism elements are suitable?" is answered by the configuration options presented in this section. Table 28 presents a summary of all the options and the result of the accompanying considerations. Refer to the main text of this section for an explanation of the abbreviations used in the table.

6.11   Main conclusion

The answer to the fourth key question identifies suitable and possible EMAT elements, which lead to the configuration tree presented in Figure 66. The tree forms the answer to the main question "which EMAT award mechanisms are suitable for the Dutch construction industry?"

6.12   Validation of the results

The results are validated by presenting them to several procurement specialists. The meeting was held on May the 20th, 2008. See Appendix H for more details of the validation meeting. The validation meeting led to some improvement of this thesis.

Table 28   *Summary of all EMAT configuration options*

Decision	Suitable options	Lesser suitable options	Discouraged options
1. Strategy	Price Value optimisation	Value maximisation	Price minimisation
2. P V opt.	* V-P * V/P		
3. V-P	PCS	Pt. Syst.	
Value max.	MCE		2 envelope system
4. V/P	$V = V_{ToR} + AV$	V ➔ MCE	* AV/P * AV/ΔP * $V_{Tot.}$/ΔP
5. PCS	P-AV	V-P	
Pt. Syst. P-Pt. rel.	Linear P-Pt. rel.		* Curved P-Pt. rel. * Discrete P-Pt. rel.
Pt. Syst. Price ref.	One price		Weighed price components
Pt. Syst. Valuation	Non Price Dependant		Price Dependant
6. Price	One price	* Price components * Unit prices	NPV (should not be nested; can be rewritten to V-P)
7. V_{ToR}	Estimate	Budget	
8. Award criteria	* Grade scale * Technical scale * Likert scale		
Scoring	* Using guideline * Measure/read		Grading of bids
9. Weights	* Summation * Weighed summ. * Mix		
Establishing weights	* Subjective method * Pair Wised Comp.		
10. Added value	* By criterium * Grouped * Mix		
Perf.-€ rel.	* Linear Perf.-€ rel. * Curved Perf.-€ rel.		Discrete Perf.-€ rel.
Valuation	Non Price Dependant		Price Dependant

Figure 66   The entire EMAT configuration tree

7   Conclusions and recommendations

The future is here. It's just not widely distributed yet. - William Gibson, US science fiction novelist in Canada (1948 -)

The answers on the key questions and the main question form the main conclusions of this research. Besides these main conclusions, this section points out the most remarkable observations. Furthermore, based on the research, several recommendations are made.

7.1 Conclusions

Conclusion 1. The result of the matching of the suitability requirements and the encountered cases is an overview of suitable EMAT award mechanism elements, from which suitable EMAT award mechanisms can be configured. The 'value minus price' system and the 'value price ratio' system are both suitable. The design contest system should be discouraged. If one chooses for a 'value minus price' system, then the price correction system should be applied instead of the point system, since the point system is error prone and more labour-intensive.

Conclusion 2. As a result of the matching of the suitability requirements and the encountered cases, lesser suitable EMAT elements have been identified. These are weighed prices, discrete price-point relationships, discrete performance-money relationships, comparative score determination and price dependant value determination. These EMAT elements should be discouraged because they can be tricky from a legal point of view or because they are not very practical.

Conclusion 3. The uncertainty about which requirements determine the EMAT award mechanism suitability is removed with the identification of several legal and practical requirements. Legal requirements are non-discrimination, proportionality and transparency. Practical requirements are 'sufficient bidding freedom', 'simplicity and elegance' and the safeguarding of traditional project management requirements.

Conclusion 4. With the collection of the properties of 24 EMAT award mechanisms it becomes clear how the EMAT award mechanism is applied in practice. Four main types are distinguished; the point system (6 cases), the price correction system (11 cases), the ratio system (2 cases) and the value maximisation system (1 case). Several developments are distinguished. The average bidding freedom is about 30% for cases from the civil sector and about 20% for the commercial sector, amounting to a combined bidding freedom of about 25%. Most used award criterion in the civil sector is 'quality of the project management plan', a process quality criterion. Most used award criterion in the commercial sector is 'functionality of the built object', a product quality criterion.

Conclusion 5. It has several advantages to present the results of an EMAT award two dimensionally in the value price model. Main advantage is that the distinguishing features of bids and their relative performance can be identified in a glance. This helps in analysing the bidding behaviour of the market. Also, relevant properties of the EMAT award mechanisms, such as the boundaries of the procurement space and the bidding freedom are easily identified. Furthermore it helps conveying the idea that it is not all about the lowest price and that adding value matters.

Conclusion 6. The sudden appearance of the value price ratio system in both the civil and commercial sector in the last months of 2007 is a remarkable observation. Even though the number of investigated cases is not that high, the appearance is quite significant. The appearances can be explained by the continuous attention for the ratio type of evaluation, as generated by De Ridder (2006:209) for instance. Another explanation is the progressing insight of procurers and their advisors as a result of good and bad experiences and knowledge sharing.

Conclusion 7. The considerations whether procurers should base their award decisions on the highest procurement profit (value minus price) or on the highest profitability (value price ratio) do not provide a clear conclusion. Practice shows a preference for the value minus price system (17 cases) over the value price ratio system (2 cases) but theory states that profitability should be the main guideline. The result is inconclusive: both systems are suitable.

Conclusion 8. The EMAT award mechanism has a bright future. The Dutch general directorate of public works has installed a policy to only use the EMAT award criterion (RWS 2004a). Furthermore, the application of integrated contracting methods requiring the EMAT award criterion, like negotiated procedure, competitive dialogue, PPP, PFI, framework contracts and concessions will probably increase. As a result, an increase in the demand of knowledge about the EMAT award mechanism is to be expected.

7.2   Recommendations

7.2.1   Recommendations for procurers

Procurer recommendation 1: Use the decision tree to formulate EMAT award mechanisms. The suitable EMAT elements identified by this research are structured in a tree. The tree can be used as a tool for formulating EMAT award mechanisms. The use of the decision tree indicates there are several possibilities for formulating the EMAT award mechanism. Main contribution of the decision tree is that the legally questionable or unpractical configuration options are excluded, which helps procurers in preventing mistakes.

Procurer recommendation 2: Use the value price model to present results. As shown in section 3.7, the value price model is very suitable to present the results of EMAT awards. It quickly provides an overview of the most important

parameters. For instance it quickly answers questions like "which bid wins?", "how does the winner distinguish itself from its competitors?", "what was the bidding behaviour?", "what was the bidding freedom?", "is the procurement a success or a setback?" etc. If published, it gives the suppliers a clear insight into the positions, increasing the chance they will accept the result. All in all, using the value price model should reduce the transaction costs considerably.

Procurer recommendation 3: It becomes rewarding very quickly to give extra attention to the elegance of the EMAT award mechanism, for instance by improving its presentation, because the problems arising from an unclear award mechanism increase exponentially. The suppliers will have to invest extra time to understand the mechanism in order to determine their bid, which in turn will cost extra effort for the procurer because of extra requests for information. Also the procurer will have to spend more time conducting the assessment of the bids. Finally, the chance of not obtaining the bid with the optimal possible value price combination increases by an unclear award mechanism. The elegance of the mechanism is not only increased by improving the presentation, but also with putting a limit to the number of award criteria and not stacking technique upon technique.

Procurer recommendation 4: As described in section 3.6 and Figure 24, a bid with a high added value and a relatively high price can win the contract. Although practice (Otto 2009) shows that this situation rarely occurs, the budget must be large enough to accommodate it. It is not clear whether that is taken into account sufficiently in the current situation. If current estimates are 'tight' (based on minimum requirements) then the budget should be increased with the amount of the bidding freedom. However, if current estimates are 'loose' (based on maximum requirements) then current budgets are sufficient. As described in section 5.5.1, the average bidding freedom in the encountered cases is about 25%. Procurers could also consider stating the maximum amount of money they are able to spend in advance.

Procurer recommendation 5: As mentioned in section 6.9.1, in practice there are many situations where a curved relationship would be more appropriate than the much used linear relationship, since the extra performance does not necessarily mean extra money (analogously to the economical concept of "diminishing marginal utility"). An example from practice is for instance the bonus for earlier delivery; it is no use to reward a delivery that is so early that the surrounding infrastructure is not ready yet.

Procurer recommendation 6: Public authorities that procure regularly should set up a knowledge management framework. This is not only for the main setup of the EMAT award mechanism, but especially for aspect evaluation methods. For each aspect, i.e. aesthetics, availability, etc., they should list how that aspect was

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evaluated. This enables learning, development and reuse of knowledge. If during a procurement, disagreement or discussion about an aspect evaluation mechanism occur, it should be registered in the knowledge management framework so it will lead to refinement of the evaluation method, which could also be input for the development of national standards or norms.

Procurer recommendation 7: As seen in some cases (Dreschler et al. 2006, Vedder & Vermeulen 2008), the phases and choices preceding the award phase have a large influence on the effectivity of the award phase. The choices on the area of the procurement strategy, intention of the market approach, scope definition, organisational task allocation, type of procurement procedure, selection criteria and terms of reference should be attuned to awarding on EMAT.

7.2.2   *Recommendations for suppliers*

Supplier recommendation 1: Be ready for integrated contracting. In order to remain competitive, traditional construction companies will need to develop themselves towards integrated suppliers. In order to be able to make a competitive bid, the integrated supplier will have to have a well-thought out production system in place and the tools and methodologies to quickly generate bids, based on the production system. There are quite some challenges for traditional construction companies before they can call themselves an integrated supplier, but practice shows it can be done. CPI (2009) describes a case and many more cases can be found in practice.

Supplier recommendation 2: Investigate the possibilities of advanced ICT applications such as BIM (Building Information Model) (CPI 2008). The generation of bids in an EMAT award is more labour intensive than the generation of bids based on a lowest price award. Having a product configuration tool could help suppliers to quickly generate competitive bids. As such, a product configuration tool, geared towards the production system, could form an important competitive advantage for suppliers.

7.2.3   *Recommendations for further research*

Research recommendation 1: For many researchers in the construction industry the research into factors that explain project success is one of the most interesting and relevant topics. When measuring project success there are several problems, but the research presented in this thesis gave some ideas of how it can be done. It would be interesting to see whether there is a correlation between project success and properties of the EMAT award mechanisms. Based on the cases, there is the impression that the application has a positive influence on the project performance.

Research recommendation 2: One of the aspects of the theory of integrated contracting is that suppliers can and will make more reliable bids in an EMAT award than in a lowest price award because they do not have to comply to the design imposed by the client anymore, but can base their bid on their own optimised production system. That should produce bids that are more reliable in terms of the promises made during the award and the realised project performance. It would be interesting from a scientific point of view to test this hypothesis and it would be interesting from a practical point of view as well.

Research recommendation 3: In certain cases, a considerable effort is invested in developing the award criteria and accompanying evaluation methods. As the maturity of these award criteria and interpretation methods progresses, also as a result of structured evaluations carried out by the procurers themselves, it becomes interesting to see whether they could be used in other phases of the life cycle, such as feasibility or the design phase. Another application could be to estimate the financial value of assets during the lifetime of the object. Motivation for this investigation is that using one methodology throughout the lifecycle of a product could create economies of scale. In the future that could lead to a reversed situation as well; design parameters and methods becoming input for the award mechanism.

Research recommendation 4: Assessing the bids in an EMAT award is more labour intensive than assessing the bids in a lowest price award, which consisted of simply opening the price envelope. However, because of knowledge of advanced ICT technologies such as BIM (Building Information Model) (CPI 2008) and automated guideline checking tools, the impression exists that the proposal assessment process could be streamlined considerably. If the product proposals would be submitted in (or transformed to) a digital format, the performance of the proposals could (partially) be determined automatically, lowering the barrier for the application of the EMAT award mechanism, which in turn would empower the desired developments in the Dutch construction industry.

Appendices

Science is facts; just as houses are made of stones, so is science made of facts; but a pile of stones is not a house and a collection of facts is not necessarily science - Henri Poincare, French mathematician & physicist (1854 - 1912)

Appendix A   Glossary

This glossary elucidates the meaning of the central concepts used in this thesis, lest these concepts can be used in a consistent and coherent manner. It does not intend to suggest universal definitions of words. Also the Dutch translation of the concepts is given, firstly to connect to specific juridical jargon and secondly for Dutch readers.

6⁻ Estimate (Dutch: 6⁻ Raming): estimate of the cost of a bid that just barely meets minimum requirements and thus scores the minimum possible added value (negative added value is also possible). Please note that in the Dutch school grading system, a "6⁻" is barely sufficient.

Added value (Dutch: Toegevoegde waarde of meerwaarde): the reward for the performance on the award criteria.

Award (Dutch: Gunning): the decision of which tender gets the contract.

Award criteria (Dutch: Gunningscriteria): criteria that are used in order to determine the economically most advantageous tender, along with the price and a Terms of Reference conformance check.

Award mechanism (Dutch: Gunningsmechanisme): a mechanism that public clients use to determine their preference for tenders. It has to be known prior to the award phase by the potential suppliers.

Award phase (Dutch: Gunningsfase): the phase of a procurement in which the tenders are evaluated.

Award strategy (Dutch: Gunningsstrategie): the set of decisions for the configuration of the award mechanism. It plays a role in the procurement process. Not to be confused with the selection phase or the procurement strategy. Available selection strategies are price minimisation, value maximisation and value-price optimisation.

Bid (Dutch: Bieding): the legally binding proposal concerning price and performance a supplier submits in a procurement procedure.

Bidding freedom (Dutch: Biedingsvrijheid); the price difference between the '6⁻ estimate' and the 'budget tester' divided by the price of the budget tester.

Budget tester (Dutch: Budget tester): a fictitious bid that scores the maximum possible added value and is priced in such a way that it is just as attractive as the 6⁻ estimate.

Client (Dutch: Klant, vragende partij): a party that needs a construction product and related services, such as design, engineering, execution and maintenance. In this thesis the word is used to differentiate from the more traditional word principal.

Contractor (Dutch: Aannemer): traditional term for the builder of public works and utility buildings. With integrated contracts a contracting party will need to provide more services than construction, such as design and engineering, hence this thesis uses the term supplier. See also integrated supplier.

Criterion (Dutch: Criterium): an aspect, quantity, product dimension. Please note that in the relevant European regulation (European Parliament 2004) this word refers to the type of award mechanism as well. In this thesis that other meaning is excluded in order to prevent misinterpretation.

Designing (Dutch: Ontwerpen): the process of matching desires with possibilities and vice versa.

Economically Most Advantageous Tender (EMAT) (Dutch: Economisch Meest Voordelige Inschrijving, EMVI): the tender that, according to the contracting authority, is the best on various criteria linked to the subject-matter of the public contract in question, for example, quality, price, technical merit, aesthetic and functional characteristics, environmental characteristics, running costs, cost-effectiveness, after-sales service and technical assistance, delivery date and delivery period or period of completion (European Parliament 2004).

EMAT award mechanism (Dutch: EMVI gunningsmechanisme): a mechanism that grades tenders on more criteria than just the price and compliance with the terms of reference.

Efficiency (Dutch: Efficientie): the degree in which resources are being consumed. Aimed at "doing things right". Classical definition: the ratio of the actual consumption of resources and the estimated consumption (dimensionless, because it is a division of equal quantities).

Effectivity (Dutch: Effectiviteit): the degree in which a certain goal is reached. It is aimed at "doing the right thing". Classical definition: the ratio of the delivered performance and the estimated performance (dimensionless, because it is a division of equal quantities).

Functional requirement (Dutch: Functionele eis): a requirement that specifies a wanted behaviour or performance rather than a wanted solution. See also specifying functionally.

Integrated contracting (Dutch: Geïntegreerd aanbesteden): a way of contracting in which one or more project activities are contractually combined with the construction activity. This way of contracting is aimed at reorganising the construction industry into a more mature, responsibility taking, innovative and productive industry than is the case with traditional procurement.

Integrated supplier (Dutch: Geïntegreerde aanbieder): a set of cooperating companies and/or divisions, which takes the responsibility of delivering a bid.

Lowest Price procurement (Dutch: Laagste Prijs aanbesteding): a procurement in which the contract is awarded to the supplier with the lowest priced tender. See traditional procurement.

Performance (Dutch: Prestatie): the difference between the properties of a product and the requirements. See also criterion, property, quality, requirement and specification.

Point system (Dutch: Puntensysteem): an award mechanism in which the price and quality of a tender are being made comparable by expressing them both in points. More points mean a higher preference. For the price an inversed correlation is necessary so that a higher price receives fewer points.

Price (Dutch: Prijs): the price of a bid is the amount of money a supplier wants to receive for the performance promised in his bid.

Price correction system (Dutch: Price correctie systeem): an award mechanism in which optional value is expressed in monetary terms. This optional value then forms a correction on the price of a tender. This correction is not fictitious, because the optional value that was promised will be enforced by the contract.

Principal (Dutch: Principaal, opdrachtgever): traditional term for the client of public works and utility buildings. With integrated contracts the principal is required to allocate more responsibility towards supplying parties, hence in this thesis the word client or customer is used to indicate the demanding party.

Procurement (Dutch: Aanbesteding): the regulated search and selection process on the supplier market that a public client undertakes in order to fulfil its construction need.

Procurement strategy (Dutch: Aanbestedingsstrategie): the set of decisions for the configuration of the procurement process, aimed at getting an optimal result from the supplier market.

Product (Dutch: Product): usually an object or service. In this thesis it is a built object and all accompanying services, of which the scope is defined in contract documents.

Production technology (Dutch: Productie systeem): the combination of machinery, labour, knowledge and working processes aimed at producing products.

Productivity (Dutch: Productiviteit): the degree in which resources are being consumed for a certain goal. Aimed at "doing the right things right". The product of effectivity and efficiency.

Program of Requirements (PoR) (Dutch: Programma van Eisen, PvE): a list of all requirements the procurer wants that the construction product to comply with. These requirements are often specified in a technical way. Please note the difference with the more comprehensive concept 'Terms of Reference'.

Property (Dutch: Eigenschap): the actual behaviour of a product on a criterion. See also criterion, performance, quality, requirement and specification.

Quality (Dutch: Kwaliteit): the difference between the properties of a product and the requirements. Please note that this definition is slightly different than the international ISO definition, which defines quality as the degree in which the properties of a product meet requirements. See also criterion, performance, property, requirement and specification.

Requirement (Dutch: Eis): a prescribed property. The property is desired to such a degree that it is a deal-breaker if it is not met, hence it is prescribed. In this definition no distinction between functional requirements and "normal" requirements is made. See 'specifying functionally' for clarification on that issue. See also criterion, performance, property, quality and specification.

Resources (Dutch: Productiemiddelen): money, materials, environment, production technology and energy.

Services (Dutch: Diensten): the provision of services referred to in Annex II of (European parliament 2004:1.2d).

Selection phase (Dutch: Selectiefase): the phase of a procurement in which the suppliers that are eligible for submitting a tender are evaluated and selected.

Specification (Dutch: Specificatie): the meticulous description of either a requirement or a product, based on a criterion. Because of this ambiguity use of this concept is avoided in this thesis. See also criterion, performance, property, quality and requirement.

Specifying functionally (Dutch: Functioneel specificeren): prescribing a required behaviour rather than the required solution. This leaves open the possibility for several solutions. In practice this concept is often used to indicate a procurement which has considerable freedom of design for the supplier, which is erroneous, because even a bolt can be specified functionally. On the other hand a very precise requirement - note the difference between requirement and specification - can still leave many possibilities open, for instance the requirement that the product must have a certain colour.

Supplier (Dutch: Aanbieder): party that delivers construction products and related services, such as design, engineering, execution and maintenance. In this thesis this word is used to indicate the difference with the more traditional contractor. Synonyms: (service) provider, systems integrator.

Supply (Dutch: Leveringen): the purchase, lease, rental or hire purchase, with or without option to buy, of products. (European parliament 2004:1.2c)

System (Dutch: Systeem): A coherent collection of elements. Systems theory is used to describe reality as well as designs and other abstract constructs.

Systems Engineering: The interdisciplinary approach and means that is necessary to realise functioning systems. The approach focuses on 1. the early definition of client needs and the wanted functionality and 2. the documenting of the requirements, based on which the design process is performed and the system is validated in order to keep the top-level problem in mind (freely translated from (RWS et al. 2007)).

Tender (Dutch: Aanbieding; inschrijving): the written offer, bid, proposal, promise of a supplier to deliver a product for a certain price, within a certain timeframe, complying with the Program of Requirements.

Terms of Reference (ToR) (Dutch: Opdracht, contractvoorwaarden, vraagspecificatie): contract stipulations. Please note that this concept encompasses more than the product-oriented Program of Requirements.

Traditional procurement (Dutch: Traditionele aanbesteding): the procurement that takes place under the 'Bid-Build' task allocation type with accompanying organisation and contract forms. UAV/UAR are the administrative conditions and the tender package is made using the RAW methodology. Award is based on the lowest price. Typically, during the contract phase cost/time overruns and/or quality errors and other unwanted events occur because the contractor has gambled to still be able to make a profit due to contract clauses that can be interpreted in more than one way, which is almost always the case.

Value (Dutch: Waarde): the value of a bid is the performance of that bid, determined by the procurer and expressed in monetary terms.

Value aspect (Dutch: Waarde aspect): see award criteria.

Value based procurement (Dutch: EMVI aanbesteding, Gunnen op Waarde): a procurement in which the contract is awarded to the supplier with the economically most advantageous tender, rather than the lowest price.

Works (Dutch: Werken): either the execution, or both the design and execution, of works related to one of the activities within the meaning of Annex I (a list of various construction-related activities). A 'work' means the outcome of building or civil engineering works taken as a whole which is sufficient of itself to fulfil an economic or technical function. (European parliament 2004: 1.2b)

Appendix B   List of abbreviations

English abbreviations

BIM   Building Information Model

BOT   Build, Operate, Transfer

CBA   Cost-Benefit Analysis

CPI   Centre for Process Innovation in building & construction

CODP   Client Order Decoupling Point (Dutch: KOOP)

DTI   Department of Trade and Industry, a United Kingdom government department. Replaced by the Department for Business, Enterprise and Regulatory Reform and the Department for Innovation, Universities and Skills on 28 June 2007

EMAT   Economically Most Advantageous Tender (Dutch: EMVI)

INCOSE INternational Council of Systems Engineering

ISO   International Organisation for Standardisation

LP   Lowest Price

MCE   Multi Criteria Evaluation

OGC   Office of Government Commerce

OR   Operations Research

PCS   Price Correction System

PoR   Program of Requirements (Dutch: PvE)

PPP   Public Private Partnership

RIBA   Royal Institute of British Architects

SE   Systems Engineering

ToR   Terms of Reference (Dutch: vraagspecificatie; contractvoorwaarden)

VPC   Value-Price-Cost

Dutch abbreviations

ARTB   Adviesraad Technologiebeleid Bouwnijverheid (advisory board for technology policy in the construction industry)

ARW   Aanbestedingsreglement Werken (procurement regulation works)

ARN   Aanbestedingsreglement Nutssectoren (procurement regulation utilities sector)

AVBB   Algemeen Verbond Bouw Bedrijf (federation of contractor organisations)

AWT   Adviesraad voor het Wetenschaps- en Technologiebeleid (advisory board for science- and technology policy)

BASS   Besluit Aanbestedingen Speciale Sectoren (directive procurement regulation for public contracts in the utilities sector)

BAO   Besluit Aanbestedingsregels voor Overheidsopdrachten (directive procurement regulation for public contracts in the "classical" sector)

BAW '73 Besluit Aanbesteding Werken 1973 (procurement of works resolution 1973)

BNA   Bond Nederlandse Architecten (association of Dutch architects)

CBS   Centraal Bureau voor de Statistiek (central bureau of statistics)

CROW   Centrum voor Regelgeving en Onderzoek in de Grond-, Water- en Wegenbouw en de verkeerstechniek (centre for regulation and research in civil engineering)

DNR   De Nieuwe Regeling (the new regulation; client-consultant services agreement model)

EIB   Economisch Instituut voor de Bouwnijverheid (economical institute for the building and construction industry)

EMVA   Economisch Meest Voordelige Aanbieding (see EMAT)

EMVI   Economisch Meest Voordelige Inschrijving (see EMAT)

EZ   Ministerie van Economische Zaken (Dutch ministry of economic affairs)

ISO   Internationale Organisatie voor Standaardisatie (see ISO)

KC BPI   Kenniscentrum Bouwprocesinnovatie (Knowledge centre for construction process innovation)

KOOP   Klant Order Ontkoppel Punt (see CODP)

MINFIN	Ministerie van Financiën (Dutch ministry of finance)
MVO	Maatschappelijk Verantwoord Ondernemen (doing business in a societal responsible way)
NEVI	Nederlandse Vereniging voor Inkoopmanagement (Dutch assiociation for purchase management)
ONRI	Orde van Nederlandse Raadgevende Ingenieurs (Dutch association of consulting engineers)
OVIA	OVerheidsInkopen en Aanbesteden (governmental platform for purchasing and procurement)
PIANOo	Professioneel en Innovatief Aanbesteden, Netwerk voor Overheids-opdrachtgevers (a network for supporting government clients in professional and innovative procurement)
PSIB	Proces- en SysteemInnovatie in de Bouw (organisation for creating process and system innovation in the Dutch construction industry)
PvE	Programma van Eisen (see PoR)
RAW	Rationalisatie en Automatisering in de Grond-, Water- en Wegenbouw (rationalisation en automatisation in civil engineering)
RGD	RijksGebouwenDienst (Dutch government housing department agency, part of VROM)
RRB	RegieRaad Bouw (council for coordinating renewal initiatives in the Dutch construction industry)
RVOI	Regeling van de Verhouding tussen Opdrachtgever en adviserend Ingenieursbureau (client-consultant services agreement model)
RWS	Rijkswaterstaat (Dutch directorate-general for public works and water management, contracting agency of VenW)
SBR	Stichting Bouw Research (foundation for construction research)
SPO	Samenwerkende Prijsregelende Organisaties in de bouwnijverheid (cooperating price arranging organisations in the construction industry)
STABU	Standaard Bestek voor de Burger en Utiliteitsbouw (Dutch specification system for the residential and commercial sectors of the construction industry. Please note that this terminology is now outdated. Currently, STABU is the brand name of the specification system and the institute that maintains it.)
STT	Stiching Toekomstbeeld der Techniek (foundation for visions of the future of technology)

UAR '72 Uniform AanbestedingsReglement 1972 (uniform procurement regulations 1972)

UAV Uniforme Administratieve Voorwaarden (uniform administrative conditions for the execution of works)

UAVgc Uniforme Administratieve Voorwaarden voor geïntegreerde contractvormen (uniform administrative conditions for integrated contracts)

UPR '71 Uniform Prijsregelend Reglement 1971 (uniform price arranging regulation 1971)

V&W Ministerie van Verkeer en Waterstaat (Dutch ministry of transport, public works and water management)

VNG Vereniging van Nederlandse Gemeenten (association of Dutch municipalities)

VROM Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer (Dutch ministry of housing, spatial planning and the environment)

Other languages
CIB Conseil International du Bâtiment (International Council for Building)

FIDIC Fédération Internationale des Ingénieurs-Conseils (International federation of consulting engineers)

Appendix C   References

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Appendix D   Procurement regulation

D.1   The structure of Directive 2004/18/EC

The structure of Directive 2004/18/EC (European Parliament 2004) is as follows:

- TITLE I   Definitions and general principles (art. 1-3)
- TITLE II   Rules on public contracts
  - CHAPTER I   General provisions (art. 4-6)
  - CHAPTER II   Scope
    - Section 1 — Thresholds (art. 7-9)
    - Section 2 — Specific situations (art. 10-11)
    - Section 3 — Excluded contracts (art. 12-18)
    - Section 4 — Special arrangement (art. 19)
  - CHAPTER III   Arrangements for public service contracts (art. 20-22)
  - CHAPTER IV   Specific rules governing specifications and contract documents (art. 23-27)
  - CHAPTER V   Procedures (art. 28-34)
  - CHAPTER VI   Rules on advertising and transparency
  - Section 1 — Publication of notices (art. 35-37)
    - Section 2 — Time limits (art. 38-39)
    - Section 3 — Information content and means of transmission (art. 40-41)
    - Section 4 — Communication (art. 42)
    - Section 5 — Reports (art. 43)
  - CHAPTER VII Conduct of the procedure
    - Section 1 — General provisions (art. 44)
    - Section 2 — Criteria for qualitative selection (art. 45-52)
    - Section 3 — Award of the contract (art. 53-55)
- TITLE III   Rules on public works concessions
  - CHAPTER I   Rules governing public works concessions (art. 56-61)
  - CHAPTER II   Rules on contracts awarded by concessionaires which are contracting authorities (art. 62)

D.2   Cases justifying use of the negotiated procedure

Article 30 describes the cases justifying use of the negotiated procedure **with** prior publication of a contract notice:

a) In the event of irregular tenders or the submission of tenders which are unacceptable under national provisions compatible with Articles 4, 24, 25, 27 and Chapter VII, in response to an open or restricted procedure or a competitive dialogue insofar as the original terms of the contract are not substantially altered. Contracting authorities need not publish a contract notice where they include in the negotiated procedure all of, and only, the tenderers which satisfy the criteria of Articles 45 to 52 and which, during the prior open or restricted procedure or competitive dialogue, have submitted tenders in accordance with the formal requirements of the tendering procedure;

b) In exceptional cases, when the nature of the works, supplies, or services or the risks attaching thereto do not permit prior overall pricing;

c) In the case of services, inter alia services within category 6 of Annex II A, and intellectual services such as services involving the design of works, insofar as the nature of the services to be provided is such that contract specifications cannot be established with sufficient precision to permit the award of the contract by selection of the best tender according to the rules governing open or restricted procedures;

d) In respect of public works contracts, for works which are performed solely for purposes of research, testing or development and not with the aim of ensuring profitability or recovering research and development costs.

Article 31 describes the cases justifying use of the negotiated procedure **without** prior publication of a contract notice:

1) For public works contracts, public supply contracts and public service contracts:

    a) When no tenders or no suitable tenders or no applications have been submitted in response to an open procedure or a restricted procedure,

provided that the initial conditions of contract are not substantially altered and on condition that a report is sent to the Commission if it so requests;

b) When, for technical or artistic reasons, or for reasons connected with the protection of exclusive rights, the contract may be awarded only to a particular economic operator;

c) Insofar as is strictly necessary when, for reasons of extreme urgency brought about by events unforeseeable by the contracting authorities in question, the time limit for the open, restricted or negotiated procedures with publication of a contract notice as referred to in Article 30 cannot be complied with. The circumstances invoked to justify extreme urgency must not in any event be attributable to the contracting authority;

2) For public supply contracts:

a) When the products involved are manufactured purely for the purpose of research, experimentation, study or development; this provision does not extend to quantity production to establish commercial viability or to recover research and development costs;

b) For additional deliveries by the original supplier which are intended either as a partial replacement of normal supplies or installations or as the extension of existing supplies or installations where a change of supplier would oblige the contracting authority to acquire material having different technical characteristics which would result in incompatibility or disproportionate technical difficulties in operation and maintenance; the length of such contracts as well as that of recurrent contracts may not, as a general rule, exceed three years;

c) for supplies quoted and purchased on a commodity market;

d) for the purchase of supplies on particularly advantageous terms, from either a supplier which is definitively winding up its business activities, or the receivers or liquidators of a bankruptcy, an arrangement with creditors, or a similar procedure under national laws or regulations;

3) For public service contracts, when the contract concerned follows a design contest and must, under the applicable rules, be awarded to the successful candidate or to one of the successful candidates, in the latter case, all successful candidates must be invited to participate in the negotiations;

4) For public works contracts and public service contracts:

a) For additional works or services not included in the project initially considered or in the original contract but which have, through unforeseen circumstances, become necessary for the performance of the works or services described therein, on condition that the award is made to the economic operator performing such works or services when such additional works or services cannot be technically or economically separated from the original contract without major inconvenience to the contracting authorities, or when such works or services, although separable from the performance of the original contract, are strictly

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necessary for its completion. However, the aggregate value of contracts awarded for additional works or services may not exceed 50 % of the amount of the original contract;

b) For new works or services consisting in the repetition of similar works or services entrusted to the economic operator to whom the same contracting authorities awarded an original contract, provided that such works or services are in conformity with a basic project for which the original contract was awarded according to the open or restricted procedure. As soon as the first project is put up for tender, the possible use of this procedure shall be disclosed and the total estimated cost of subsequent works or services shall be taken into consideration by the contracting authorities when they apply the provisions of Article 7. This procedure may be used only during the three years following the conclusion of the original contract.

Appendix E Facts of the Dutch construction industry

E.1 Financial figures of the Dutch construction industry

The contribution of the Dutch construction industry to the entire Dutch economy is about 9.5%, see Table 29.

Table 29   Contribution of the Dutch construction industry to Dutch GDP

	2003	2004	2005	2006
Gross domestic product (GDP)	476,945	491,184	508,964	534,324
Production construction industry	46,549	46,452	48,162	51,795
Share construction industry in GDP	9.76%	9,46%	9.46%	9.69%
Source: Bouwend Nederland (2008:10)				

The Dutch construction industry is usually divided into the sectors civil, commercial and residential. These sectors can be divided by stage (development, construction, and use), actor (supplier, client), and type of actor (public, private), discipline (concrete, asphalt, installations, structure, façades, soil, etc.), market (product level) or project size. The division of the EIB ("Economisch Instituut voor de Bouwnijverheid", the economical institute for the building and construction industry) is depicted in Table 30, along with production volumes.

Table 30   Production of the Dutch construction industry

Sector, share of total production*	Production (M€)
Residential, 34%	**16,200**
Construction	10,250
Renovation and conversion	5,950
Commercial, 22%	**10,400**
Construction	6,600
Renovation and conversion	3,925
Maintenance, 19%	**8,850**
Buildings	8,850
Civil, 25%	**12,000**
Construction	7,425
Maintenance	4,575
Total production of the Dutch construction industry 2004	***47,450***
*: Excluding internal deliveries, machines and other investments, trading margins and balance export services, base National accounts; 2003 prices, excluding VAT. Source: EIB (2005)	

The numbers in Table 30 concern the turnover of contractors, and these represents mainly the stages of construction and use. The sizes of the design and development stage are indicated by the turnover of architects and engineering offices, see Table 31.

Table 31   Turnover of architects and engineering offices

Engineering discipline	Turnover (M€)
Residential and Commercial	2,059
Town planning, traffic planning	851
Civil (soil improvement, road construction, hydraulic engineering)	876
Environmental technology and consult	620
Remaining technical design	1,071
Total	**5,477**
Source: CBS (2005)	

E.2   Clients in the Dutch construction industry

The EIB (2005) distinguishes the following groups of clients in the Dutch construction industry:
- Residential
  - Government and housing agencies

- o Developers
- o Other private clients
- Commercial
  - o Agricultural buildings (8.2%)
    - Greenhouses
    - Others
  - o Industry en construction industry (13.8%)
    - Factory halls
    - Business buildings
  - o Trade and hotel and catering industry (16.8%)
    - Shops / shopping centres
    - Supermarkets / wholesale businesses / distribution centres
    - Hotels
    - Car branch
  - o Transport and communication (7.6%)
    - Post and telecom branch
    - (Air)port development
    - Transport branch
    - ICT organisations
  - o Business services (18.2%)
    - Financial institutions
    - Development around railway stations
    - Office market services
  - o Public administration (5.2%)
    - City halls, ministries, defence, justice (courthouses, prisons), police, fire departments, embassies, tax offices
  - o Education (9.9%)
    - Educational buildings (primary schools, secondary schools, universities, colleges, regional education facilities)
  - o Health- and welfare work (12.4%)
    - Hospitals, psychiatric hospitals, houses for the handicapped, nursing homes
  - o Other services (7.8%)
    - Swimming pools, sport- and recreational facilities (canteens, clubhouses)
    - Museums
    - Libraries
    - Procurer- and employee organisations
    - Religious, ideal en political institutions
    - Funeral homes
    - Hairdressers
    - Dancing schools
    - Movie theatres
    - Soccer stadiums

- ■ Theatres
- ■ Parking garages
- ■ Casinos
- ■ Event complexes
- Civil engineering: Soil-, road- and hydraulic engineering (total production in 2004: M€ 12,000)
  - o Central government (M€ 1,050 = just 9% of total civil engineering production)
    - ■ State highways (M€ 727)
    - ■ Seaways and water management (M€ 181)
    - ■ Dams, water-control structures (M€ 141)
  - o Decentralised government (M€ 3,775 = 31% of total civil engineering production)
    - ■ Provinces
      - • Roads
      - • Sea- and waterways
      - • Soil sanitation
    - ■ Municipalities
      - • Roads and streets
      - • Making ready for building
      - • Sewages
    - ■ Water-management authorities
      - • Dikes
      - • Pumping stations
      - • Earthworks
      - • Purification plants
  - o Enterprises (M€ 2,600 = 22% of total civil engineering production)
    - ■ Transportation companies
      - • National rail infrastructure (ProRail, construction works in 2004: M€ 286)
      - • Regional and city rail infrastructure: metro-, bus-, tram- and light-rail tracks
      - • High Speed Rail track (M€ 781 in 2004)
      - • Betuwe Rail track
    - ■ Utility- and telecommunications sector: cables and wires (electricity, ICT)
    - ■ Sea- and airports: 5th airstrip Schiphol, 2nd Maasvlakte
  - o Maintenance (M€ 4,575= 38% of total civil engineering production. M€ 1,558 (13%) from central government)
    - ■ Railways, roads, water- and seaways, sewages, electricity facilities

E.3   Historical overview of Dutch construction procurement regulation

RWS (2002a) gives a historical overview of Dutch construction procurement regulation. The development of regulation for competition illustrates the shaky balance of power between procurers and contractors in the Dutch construction market. In times of recession (for example the thirties of the previous century) the position of procurers was strong. In the post-war rebuilding the suppliers were in a dominant position. After that the development of European policy in the field of the competition (Treaty of Rome 1956, Directives for the award of public works contracts 1971) started to play a decisive role.

For the Netherlands this resulted in the following list of laws and regulations, in chronological order:

1958   Establishment of the "law economic competition" (Wet Economische Mededinging), based on the abuse scheme (dishonest competition) rather than the European prohibition scheme (prohibition on price agreements).

1963   Establishment of the "Cooperating Price arranging Organisations in the Construction industry" (Samenwerkende Prijsregelende Organisaties in de Bouwnijverheid, SPO), in which the construction companies organise themselves and start working on the preparation of price arranging regulation.

1971   First version of the "European Directive Works". Establishment of the "Uniform Price arranging Regulation" (Uniform Prijsregelend Reglement, UPR 1971) and the "code of honour for the entrepreneurs in the construction industry".

1972   Establishment of the "Uniform Procurement Regulations 1972" (Uniform AanbestedingsReglement, UAR 1972) in which procedures for procurement are arranged for the realm of central government.

1973   Establishment of the "Decision Procurement of Works 1973" (Besluit Aanbesteding Werken, BAW 1973), which arranges which procurement form must be applied; it obliges the use of the UAR 1972.

1975   Recommendation of the "Commission Economic Competition" concerning procurement arrangements, which are the beginning of a revision of the UPR 1971. The advice shows consideration for the arguments of contractors that want to protect their position in the pre-contractual phase; it recommends actualising components of the grown working method. This leads to the consultation group "Themes for restructuring the procurement scene".

1986   Establishment of the revised UPR (UPR 1986) and the revised UAR (UAR 1986).

1987   Resolution on competition arrangements in the Dutch construction industry.

1988   The European Commission starts a study into competition policy in the Netherlands.

1991   Effectuation of "UAR-EG 1991" (EG = Europees Genootschap = European Union) which implements the European Directive Works in the Netherlands.

1992   Decree of the European Commission as a result of which the Dutch procurement model must be adapted. The European decision leads to large commotion in Dutch politics. The feeling arises that the Netherlands are not at all taken seriously by the European Commission. The then Prime Minister Ruud Lubbers tries in vain to turn the tide by means of a letter to Jacques Delors, President of the European Commission.

1998   A wide administrative consultation finalises the concept-UAR. Main objectives of the new UAR are to improve procurement practices and to lower transaction costs.

2001   Effectuation of the UAR 2001 and uncovering of collusion in the Dutch construction industry.

Appendix F   Purchasing in general

Purchasing can be defined as the act of exchanging the ownership of an amount of money for the ownership of a product (service, tangible object or both), under a set of conditions. In this transaction at least two parties are involved; the supplier and the client. The transaction is often preceded by a process of orientation by the client and negotiation.

F.1   Types of purchasing relationships

Looking at the economy, globally three types of client-supplier relationships can be defined:

1.   Consumers – business: buying
2.   Business – business: acquisition
3.   Government – business: procurement

In the relationship between consumers and businesses, purchasing is simply referred to as buying. In order to find out more about this relationship one could turn to their own experience as a customer, or to consumer organisations for the customer perspective. In order to learn more from the business perspective, one could turn to marketing literature, i.e. Kottler & Keller (2006), which includes advertising and marketing strategies.

In the business to business relationship, purchasing is often referred to as acquisition. For this type of transactions, one could turn to management theories and literature about supply chain management, i.e. Porter (1980).

When a governmental organisation is the client, purchasing is called (public) procurement. Public is mentioned between parenthesis because procurement is, according to the definition used in this thesis (see section 2.2), always public.

Main distinction from the other two main types of purchasing is the extra regulation governments have to adhere to. Not only are they obliged to empower

competition amongst suppliers, they also have to take into account considerations such as integrity and accountability.

For suppliers the government can be an attractive customer, because often large contracts are involved. A drawback of doing business with governments is the need to comply with a lot of administrative procedures and bureaucracy. Advantage is that although government sometimes has a reputation as a slow payer, once they have promised to pay they are good for their money, as the government cannot go bankrupt.

There are several authoritative sources that can be consulted regarding procurement. Besides the knowledge present at several individual organisations, such as the individual public authorities, consultancy firms or knowledge institutes, one could turn to general platforms such as NEVI, the Dutch association for purchase management, VNG, the association of Dutch municipalities or to PIANOo, a network for supporting government clients in professional and innovative procurement. These platforms focus at government purchasing and procurement in general. Although not explicitly mentioned as their main goal, the construction industry procurements cover a large area of their work field.

F.2   Customer approach strategies

This section presents abstracts of the work of Porter (1980) and Johnson and Scholes (1993:209–216) regarding customer approach strategies.

In his well known work, Porter (1980) provides a framework for industrial and other firms to analyse their business processes, in order to increase their competitive advantage. He identifies three successful business strategies, namely the Cost Leadership Strategy, the Differentiation Strategy and the Focused Strategy. The Cost Leadership Strategy emphasises efficiency. By producing high volumes of standardised products, the firm hopes to take advantage of economies of scale. The Differentiation Strategy involves creating a product that is perceived as unique. The unique features or benefits should provide superior value for the customer if this strategy is to be successful. In the Focused Strategy the firm concentrates on a selected few target markets. It is hoped that the needs of that target market can be met better by this specialisation.

Porter emphasises that firms should choose one of these strategies; if they want to pursue two or all three strategies, the danger exists of getting "stuck in the middle" and ending up nowhere.

Johnson and Scholes (1993) presented the "strategy clock", see Figure 67.
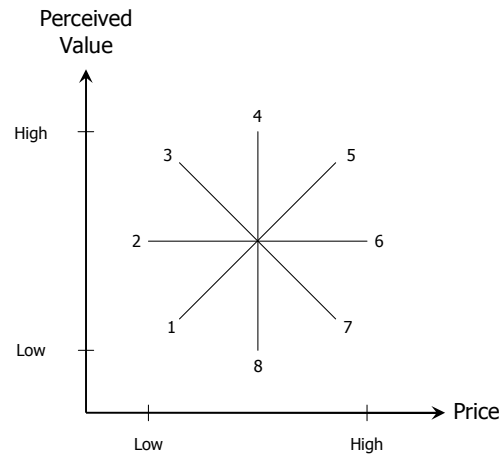

Figure 67   Strategy clock, Johnson and Scholes (1993)

The numbers in Figure 67 correspond with possible strategies for suppliers:

1. 'No finery' strategy, just the basics; low price and a low perception in a price-sensitive market segment.
2. Low price strategy; offer products with the same perceived value as products of competitors, for a lower price.
3. Hybrid strategy (for fast changing markets); try to differentiate and optimise on price as well.
4. Differentiation; try to find unique products, based on own competences. Strategy based on uniqueness and marketing. The product has to be difficult to imitate and for that there are several possibilities.
5. Focused differentiation; try to find products with a high perceived value (by customer), that justifies a good price in the selected market segment. Example: luxury cars.
6. Raise the price while keeping the perceived value fixed. Example 1: "stealth pricing"; introduce extra charges over the (competitive) base price. Example 2: lower the quantity of the product, while keeping the price the same. Example 3: raise the price for a product that was "underpriced", i.e. had a higher quality than the perceived quality.
7. Raise the price and lower the perceived value.
8. Lower the perceived value, while keeping the price fixed.

According to the authors, strategies 6, 7 and 8 are bound to go wrong, unless there are special conditions, such as Giffen-goods or a monopoly situation.

Appendix G   Considerations for formulating a procurement strategy

There are several extensive and well documented sources on this subject.

Griffith & Sidwell (1995:43) state: "Essentially, clients are looking for a 'best buy' procurement package and they focus therefore on a strategic overview of the benefits that may be available to them in using any particular approach. Moreover, they seek to examine the implications of the procurement form across the total building process to assess overall balanced benefits and advantages. Choice of procurement by most clients will be based, without doubt, upon their range of knowledge and experience and their resource base."

PSIB (2005b) distinguishes several factors to be relevant in the choice for a certain task allocation/organisation/contract, from the perspective of the procurer:
- Internal context (properties of procurer)
    - o   Organisation structure
    - o   Finances
    - o   Policy
    - o   Knowledge, experience and capacity
- External context (properties of the environment)
    - o   Market
    - o   Politics and society
    - o   Laws and regulation
- Project context (properties of the project)
    - o   Money
    - o   Time
    - o   Quality
    - o   Influence on the project
    - o   Complexity
    - o   Risks

They distinguish the following goals of public procurers:
- Societal responsibility;
- Value for money;

- Own core responsibilities.

For the procurers it is furthermore important to take into account:
- Relationship with other procurements;
- Adequate role description (and fulfilment), especially in the context of changing roles;
- Own knowledge/experience/competences on the area of procurement;
- Length of permit procedures.

The Dutch foundation for construction research SBR (2006) also has done an extensive study into the relevant aspects in the decision for the client supplier task allocation. First of all they summarised the procurer interest by formulating the following central questions:
- How to choose the right construction project organisation form?;
- How to choose the best way of procuring?;
- How to get value for money?

They distinguish the following types of task allocations, on an increasing scale of procured activities:
1. Traditional (Build)
2. Team variants (Design Team)
3. Integrated (Design and Build, known as Design and Construct in the Netherlands)
4. Strategic cooperation (PPP, Alliance, BOT)

This allocation corresponds with the one mentioned earlier in this section and the list in section 2.3.3.

They found the following aspects to be of importance in the choice for a project development process:
- Procurer aspects
  - Wishes, in terms of functionalities
    - Need for value for money (several types)
    - Need for certainty and guarantees (low-high)
    - Need for authority and control (low-high)
  - Abilities; need for hiring consultants
    - Time available for supervision
    - Professionalism; ability to specify wishes, to manage the regulated processes, to manage and to evaluate technical aspects
    - Internal decision processes, ability to cooperate internally as well as externally, specific prior obligations
    - Environment, adjacent real estate, other projects/developments
    - Financing and availability of building lot
  - Allowances; (procurement)regulation

- o   Permits, other actors
- Project aspects
  - o   Size
  - o   Complexity (organisation, technology)
  - o   Uniqueness
  - o   Maintenance and use
  - o   Finances
  - o   Specific risks
  - o   The importance of speed
- Market aspects
  - o   number of suitable contractors/suppliers
  - o   market situation, local market position contractors/suppliers
- Other aspects: legal, societal, political (policies, for instance aimed at a certain contract form), environmental.

Not only do they provide the relevant aspects in the decision for the client supplier task allocation, but they provide two decision methods as well:

Method 1 – Matching profiles
First the procurer needs and properties are established, using a 1 to 5 point scale, where a 1 stands for a not so important consideration and where a 5 corresponds with a very important aspect. The project properties are determined in the same way. For each type of task allocation, a suitability profile exist, where a score of 1 indicates that the task allocation is not suitable for the corresponding aspect and where a score of 5 indicates that the task allocation is very suitable for the corresponding aspect. The task allocation profile that provides the best match with the client & project profile determines the most suitable task allocation.

Method 2 – Matrix
The second method is a matrix, with on the horizontal axis the type of procurer and on the vertical axis the type of the project; for each cell an indication is given for the most suitable task allocation. The types of procurers are:

1. The company (incidental, private);
2. The private home builder (incidental, private);
3. The collective (incidental, public);
4. Building for the market (professional, private);
5. Building for own use (professional, private);
6. The government (professional, public).

These procurer profiles were drafted by the BNA, the association of Dutch architects.

The types of construction tasks are:
A. Difficult: large, complex and unique
B. Prestigious: large, simple, unique
C. Efficient: large, simple, repetitive
D. The villa: small, simple, unique
E. The residence: small, simple, repetitive
F. Maintenance: simple and complex

Other methods to establish a suitable task allocation and corresponding organisation and contract exist as well, i.e. Linthorst (2004).

Appendix H   Details validation meeting

Date: Tuesday, May 20th, 2008, 10:00-12:00.
Location: room 03.270, TU CiTG, Delft.

Attendees
B. Oosterom, public works Rotterdam, procurement specialist; H. Wijnen,
Pianoo, senior procurement advisor; H. Crucq, RWS, senior procurement advisor;
M. Polet, RWS, project manager, contract manager; M. van der Knaap, Twijnstra
& Gudde, senior advisor; M.A. Mooiman, DMS, specialist procurement/legal
affairs; R. Reedeker, Adjunct manager Royal Haskoning BM, procurement
specialist; S. Roetman, former national coordinator engineering and
standardisation at Grontmij, currently freelance advisor; T. van Reeuwijk,
CROW, national coordinator procurement; H. de Vree, TU Delft, section Design
and Construction Processes; H. de Ridder, TU Delft, chairman section Design and
Construction Processes; R. Beheshti, TU Delft, UHD; J. Verlaan, TU Delft; M.
Dreschler, TU Delft.

Absent with notice
H. Teigeler, RGD + Procurers forum construction industry, procurement
specialist, R. Sebastian, TNO, procurement specialist.

Agenda
- Introduction
- Goal of the meeting
- Part 1: Results PhD research
    o Introduction PhD research;
    o Qualitative result: configuration options EMAT award mechanisms;
    o Quantitative results;
    o Conclusion & recommendations.
- Part 2: Feedback
    o 9 propositions;
    o Other items.

Introduction

See attendance list. At the reactions, names have been left out of for the sake of privacy.

Goal of the meeting

Primary: validation of 1) need and necessity 2) the contents and 3) the scientificity of the research.

Secondary: sharing of knowledge, interaction and knowledge development.

Reactions on Part 1: Results PhD research

Introduction PhD research

At slide 6, the procurement space and procurement strategies:

• Idea: Take 'worst possible solution' (intersection minimum value, maximum price) as reference point.

• Is there an upper limit for value? Response 1: In the case of EMAT, the upper limit is determined by the award mechanism. Response 2: Preconditions determine the optimum solution.

Qualitative results: configuration options EMAT award mechanisms

At slide 10, the choice between Value minus Price of Value divided Price system:

• V - P is often used for design work. V / P (value per euro) is more suitable for works. V - P delivers higher profits, but not per euro.

At slide 12, price correction mechanisms:

• Bonuses and penalties should not only be taken into account fictitiously in the award phase, but should actually be applied in the execution phase, otherwise suppliers would have no incentive to keep their promises.

Quantitative results

At slide 19, "type in time":

• Did the application of V / P in 2007 have to do with the new standard?

At slide 22, overview of value aspects:

• It would be nice to see whether certain combinations of values aspects per project occur more often.

Conclusion & Recommendations

• In the event of bids ending equal, the tie-break criterion should consist of working from coarse to fine; first look at how the equal ending bids perform on the most important aspects, then at the second most important and so on.

• In response to the term "decision tree": in practice, the decisions are not taken in the suggested neat Top-Down manner. For instance, it might happen a lowest price award is converted into EMAT at the last moment, for example when the quality of the plan of works suddenly needs to play a role.

• At the discussion on V – P or V / P: V - P can be called procurement profit, V / P could be called societal return on investment. For that reason V / P should almost always be chosen.

Reactions on Part 2: Feedback
Feedback on nine propositions
General remark: some of the propositions and some of the used concepts could have been formulated sharper and in less ambiguous wording. Although discussion of the concepts used in propositions is always part (and sometimes even purpose) of discussing propositions, there was sometimes a little too much space for different interpretations. Apparently those concepts did not become clear during the presentation preceding the propositions.

Propositions concerning the need and necessity of the research

1. Continuous award on lowest price is a problem.
• All: yes. In many cases the lowest price award mechanism is still suitable, but the exclusive use of the lowest price award mechanism causes problems in the market.
• The lowest price award, but the fixated value is the problem!

2. We need more clarity on how to set up EMAT awards.
• Yes. But it is questionable whether the proposed "variant tree" (that would be a better name than decision tree, see the second remark at conclusions and recommendations) provides that clarity.
• Some simple examples would have been enlightening.
• There should be a greater uniformity in EMAT award mechanisms, because reinventing the wheel for each project leads to much confusion, for procurers as well as suppliers.
• In reaction to the use of the word uniformity: standardisation has a more positive association than uniformity. Explanation: Standardisation is created by leaders in the market (best practices). Uniformity is created by compromising ("we take some properties of all suggested solutions") or by imposition from outside the market.

3. Application of EMAT puts more responsibility on suppliers.
• Turn that proposition around: "EMAT is needed to put more responsibility on suppliers".
• It might not give supplies more responsibility, but at least it gives them more (design) freedom.
• The responsibility for procurers increases as well. Perhaps that is why EMAT remains difficult to sell to politicians, why spend more budget? For municipalities that is difficult to explain to the province. It is difficult to explain why more quality is worth the money.

Propositions concerning the contents of the research

4. The mentioned quantitative results are consistent with my view of the EMAT practice.
• Yes, but is that relevant? It is about the view on the future!

5. "The EMATs I know can be grouped into the decision tree"
• Yes. However 'variant tree' or 'classification tree' would maybe be a more apt name, because it does not yet meet the criteria that need to be met in order to be called 'decision tree'.

6. More standardisation of value criteria, scoring methods and weighting factors is required (please explain).
• Yes.

Propositions concerning the scientificity of the research

7. Reproducibility: if the research methodology would be followed again, it would not result in a substantially different decision tree.
• The quantitative part would probably lead to slightly different conclusions, but it is doubtful whether these differences would be significant. The qualitative part (the tree) would probably be the same in a new study. Variant tree is a better name.

8. Transparency: the research method and the results are understandable.
• Not quite, for example the creation of the term "added value" is currently insufficiently clear. Response: the presentation of the research method and the results will be improved.

9. Falsifiable: if something would be wrong, that would be demonstrable.
• In order to answer that question, the "document management" of the research is of interest as well. Can it be demonstrated why certain decisions are taken? Can the basis for results be retraced? Response: yes, all information and documentation is available and accessible.

Other items
• RWS is busy analysing about 30 EMAT procurements.
• From a legal point of view, the value maximisation strategy is also EMAT.
• EMATs for Design & Build contracts are clearly different in scope than "Bouwteam" EMATs.

Curriculum vitae

Name: Marco Dreschler
Born: 10 February 1976, Jayapura, Indonesia

Education
- PhD research at Delft University, June 2004 – June 2009
- MSc study Civil Engineering & Management, September 1994 – November 1999, University of Twente at Enschede. Specialisation: Integrated design and construction processes. Master thesis: *Conceptual design with Design^{++}*
- Atheneum (Secondary school), September 1988 – July 1994, 'Marcus College' at Grootebroek

Work experience
- PhD researcher at Delft University, June 2004 – June 2009
- Quality management at High Speed Rail track South, Rotterdam, March 2004 – June 2004
- Directorate-general for public works and water management, civil engineering division, Utrecht, December 2000 - November 2003
  - General supervisor, division execution of projects, project 'renovation Ketel bridge' at Swifterbant, October 2003 – November 2003
  - Project engineer, tunnelling division, subdivision project management, March 2003 – September 2003
  - Project advisor information and automation, staff division building informatics, December 2000 – March 2003
- Project secretary contract affairs bored tunnel at High Speed Rail track South, Utrecht, February 2000 – November 2000
- Graduation assignment at Ballast Nedam Engineering, division construction techniques, Amstelveen, February 1999 – November 1999
- Training assignment at Grontmij, the Bilt, division water management & public works. Sub assignment: R&D project. September 1998 – December 1998

Extras
- Best paper award at the CIB world meeting, 2005, Helsinki
- Organisation of international symposium about project management, 2007
- Workshop about EMAT in collaboration with Twijnstra & Gudde, 2008
- Consultancy about EMAT and procurement in general, 2006-2009