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## 5.

# ***Case Study Report: Valuing Business Transformation using Real Options Analysis***

*Using a standard ROA implementation process, we will apply Real Options Analysis to a real-life situation and calculate the business value for the business transformation scenarios. The first step describes the situation and the objectives, step two implements the option valuation model and step three describes the results. Next, we review the whole process and describe the benefits of Real Options Analysis with regard to factors whose value is difficult to assess in more traditional valuation methods. The chapter finishes with a comparison with other business transformation valuation methods, a discussion of critical arguments on using ROA and overall conclusions.*

### ***5.1 Approach***

In their book *Real Options: Managing Strategic Investment in an Uncertain World*, Amram and Kulatilaka (1999) describe an approach to apply real options in practical situations. They advise the following four-step solution process:

- (1) Frame the application
- (2) Implement the option valuation model
- (3) Review the results
- (4) Redesign?

When applying *Real Options Analysis* to practical situations, Amram and Kulatilaka comment: “While an option in the financial contract is clearly identified, the option

in the real options application is sometimes much harder to spot. In the real options approach there is much more need to think through the application frame, making sure that it covers the right issues and achieves the right balance between a simplicity that preserves intuition and richness that delivers realistic and useful results. As a result, implementation of the real options approach requires the integration of a fair amount of detailed material, from the construction of inputs to number crunching.”

They emphasize adequate content knowledge, combined with a balance between simplicity and richness. Content knowledge is important to frame the problem. When framing the problem one has to consider, among others, relevant decision points, options to be calculated and relevant timeframes for the sequencing of decisions. Content knowledge is required to identify these items.

Simplicity allows intuition to validate the results, or, in other words, to use the statistical instruments for supporting human decision-making capabilities. Too much complexity may obscure the underlying rationales and make them unavailable for human analysis. We will apply these guidelines when working out the case.

## **5.2 Case study**

The applicability of real Options Analysis for the implementation of Enterprise Architecture will be illustrated using this case study. The case study was conducted in the second half of 2007. The purpose of the case study was to help management to understand the value, costs and risks of implementing enterprise architecture.

### **5.2.1 Description**

A large Dutch financial institution has formed a domain named *Input Handling*. The objective of this domain is to receive and handle all customer-related, non-interactive input. The types of documents that the domain handles are various. Examples are *Proofs of Identity*, *Contracts*, *Letters*, documents from the *Chamber of Commerce*, etc. Basically, when the domain receives a document, it checks the authenticity of the document, it scans and stores it and makes the electronic image accessible for a target business process. The paper original may be archived or disposed. The *Input Handling* domain is not responsible for further processing of the scanned document; this is done by the target process. For instance, documents of the business processes *Mortgages*, *Savings* or *Insurances* are scanned and processed by *Input Handling*. Currently, only paper documents are handled. In the future, other forms of input documents may be included, such as e-mail and Inter-

net forms. Interactive channels, such as telephone or chat, are out of scope, because they are handled by the customer contact centre.

### **5.2.2 Current situation**

The institution distinguishes between individual scanning and bulk scanning. Individual scanning is used at branch offices, where employees have direct contact with a customer and may scan, for instance, a proof of identity document. Individual scanning in branch offices is at present only of limited value. Only a few branches have a scanner and branch employees use it to scan documents to the network drive of their computer. In most cases, the scanned documents are printed and the paper copy is used in the business process. Branch offices that do not have a scanner just make a photocopy of the document and this copy is used for further processing. In the actual situation, it may happen that customers are asked to provide – within a short time span – the same documents several times, because earlier scans cannot be retraced. This is, of course, undesirable. The desired situation is to enable individual scanning in branch offices, combined with central storage and accessibility of the scanned document, across branch offices and across channels.

Bulk scanning is used for documents, which are sent by mail to a central address in the Netherlands. The central scan room scans the documents, and either archives the document or makes it available for further processing within a business process. A problem with the current solution is the retraceability of the documents from the archive by the business processes. Depending on the amount and type of the meta-information that is stored with the document, retraceability of the scanned documents within the business processes varies between 40 and 100%. In addition, reusability of the scanned documents across business processes is limited and only a few business processes are enabled to receive a scanned document directly. For the majority of the business processes, documents are scanned to the electronic archive and retrieved for operational usage from the archive.

### 5.2.3 Key-figures

See Table 5-1 below for some key figures about the scanning processes.

Item	Volume
Number of documents in the Electronic Archive	2.3 billion documents
Annual increase of the Electronic Archive	400 million documents
Number of documents bulk scanned annually	6.9 million documents
Different types of documents bulk scanned	1061 document types
Percentage of bulk scanned documents directly entered into the electronic archive	87 per cent
Number of paper sheets used annually in branch offices	54.5 million sheets
Expected annual number of documents scanned individually	10 million documents

Table 5-1. Key figures of the scanning process

### 5.2.4 Business architecture

To bring focus in the development of the *Input Handling* domain, the domain owner has requested the development of the business architecture. The purpose of this business architecture is to provide a clear vision on a generic approach for input handling, future-proof and in accordance with the business vision and strategy. It is also important that it can easily fit in the current business process and application landscape of the institution. See Figure 5-1 for an overview of this architecture.

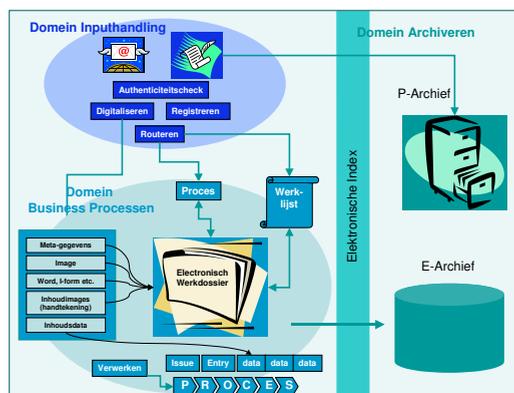


Figure 5-1. Overview of the business architecture for the domain Input Handling (picture courtesy of the case study institution)

At the upper left corner of Figure 5-1 the business functionality of the domain *Input Handling* is described. The domain has to execute the following functions:

- (1) Authenticity check (Authenticiteitscheck) of the incoming document
- (2) Registration (Registreren) of the document
- (3) Digitization (Digitaliseren) of the document
- (4) Complement the scanned image with metadata (Meta-gegevens)
- (5) Routing (Routeren) of the document to an target environment

The original paper document is either discarded or moved to the paper archive (P-Archief). The electronic document is either routed to a process (Proces), to a task list (Werklijst) or to the electronic archive (E-Archief). The architecture describes the required business behavior of the solution; it does not describe the technical solution. The architecture covers the existing and foreseen future business requirements, is independent of a specific technology or the specific procedures of a particular business process and, hence, generally applicable. The business architecture is approved by the domain owner and chosen as the preferred direction for the development of the domain.

Because of the required scan volumes and the complexity of linking the scan processes to various target environments, it is found that the approach for realizing the business architecture is not trivial. Before starting the implementation, a good understanding of benefits, costs, options and risks was necessary.

### 5.3 Implementation Scenarios

There are two possible implementation scenarios for the implementation of this business architecture. The first one is doing the implementation in-house; the second one is to source the development of the architecture out to a contractor. Therefore, together with null scenario, we compare three business transformation implementation scenarios:

1. **Null Scenario** – the current, actual situation will not be changed. No implementation of the business architecture will take place.
2. **Standard Scenario** – the business architecture will be implemented in-house, with internal procedures and approaches.
3. **Contract Scenario** – the implementation of the business architecture will be outsourced to a contractor, based on a fixed-price contract. This means that the risk for budget overrun is carried by the contractor.

We will compare the benefits, costs and risks of the Standard Scenario and the Contract Scenario to the Null Scenario, using Real Options Analysis. The benefits these scenarios are calculated as a delta to the Null Scenario (the current situation).

The timeframe for implementing these scenarios is three years. In the next paragraphs, we will illustrate the use of applying Real Options Analysis for the full scenario, without (yet) considering the intermediary phases. ROA can also be used to calculate the value of individual phases and combined it in one overall scenario value. This phased approach is worked out in appendix 1 (page 128).

## **5.4 Solution Process**

The solution process of Amram and Kulatilaka is used for our case study for applying Real Options Analysis in an Enterprise Architecture environment. An overview of the four main steps of the solution process:

### ***Step 1. Framing the Application***

The purpose of the first step *Framing the application*, is to structure the application in mathematical terms. Financial benefits and costs and the related probability distributions will be determined.

### ***Step 2. Implement the Option Valuation Model***

The purpose of the second step is to establish and value the options. In this step, we will calculate the option value of the Contract and the Standard Scenario.

### ***Step 3. Review the Results***

In this step, the results from the previous step are reviewed and various strategies for decision-making\* can be considered. Based on the decision-making strategy, recommendations can be given for the optimal implementation strategy.

### ***Step 4. Redesign?***

Based on the reviewing of the results, a redesign may be possible. Example questions to consider in this step are: Can the set of investment alternatives be expanded? Can the investment strategy be reconfigured or redesigned to increase value? Are their options that can be added by staging or modularity?

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\* See for the various decision-making strategies § 4.5 (page 29).

## 5.5 Step 1. Framing the Application

The purpose of the first step, *Framing the application*, is to identify transformation scenarios and identify for each scenario the benefits, costs and risks. We will first consider the benefits, then the costs and based on the resulting cash-flow probability density distribution, we can derive the associated implementation risks of the scenarios.

### 5.5.1 Benefits

Architecture facilitates the execution of strategy. Strategic objectives of the domain *Input Handling* are\* :

1. Maximize business value for sponsors<sup>†</sup>
2. Optimize strategic alignment with overall business goals like customer intimacy and satisfaction and operational excellence.

There are two types of benefits for implementing the business architecture: (1) benefits that maximize the business value for sponsors; i.e., revenue increase because of higher customer intimacy or improved commercial opportunities, and (2) benefits because of improved operational excellence; i.e., lower operational costs or reduced operational risks.

#### *Effects on the Business*

Implementing the business architecture has several types of effects on the business. To understand these effects, an expert panel was created, consisting of the domain owner and specialists in the area of business operations and digitization. With the expert panel a workshop was conducted, where a first solution outline was drafted, which was refined in several rounds. The following two main effects are identified:

- Improved quality of information
- More efficient and faster information handling

These main effects translate to the benefits described in Table 5-2.

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\* From an internal strategy document of the financial institution, November 2007.

† With “sponsors” are meant the internal clients of the domain input handling; i.e., the departments that make use of the services of the domain.

Benefit	Explanation
<b>Quality improvement of the information used within business processes</b>	Part of the (customer) information is currently stored at various places on paper and some is already available electronically. When all the information will be available electronically at one central storage location, the quality of the information within the processes will improve, because there will be one common source of information. For instance, in the current situation it may happen that different employees of the institution base their decisions on different versions of the same document.
<b>Quality improvement information provisioning to the customer</b>	The supply of information to the customer will improve because of the general quality improvement of information within the processes.
<b>Documents need to be provided only once by customers</b>	Some documents, like extractions from the Chamber of Commerce, or identification documents, may be asked several times from the same customer, because the copy is kept on paper controlled by one employee. With the new system, documents are scanned once, stored centrally, and can be reused across business processes.
<b>Shorter elapsed time for process handling, because of elimination of transport of physical paper documents</b>	Many of the business processes are executed at various locations throughout the Netherlands. If the business process stops at one location and needs to continue at another location, then the paper documents are transported between locations. Transport of documents to another location takes one or two days. In a typical business process, several locations are involved and, therefore, execution of a business process may need up to 10 days for just the transport of paper documents. This delay is eliminated when using only electronic documents.
<b>Improved customer satisfaction</b>	Because of shorter processing times, improved quality of information and less need to issue the same documents several times, customer satisfaction is expected to rise.
<b>Ability to facilitate one Electronic Customer File</b>	Implementation of the business architecture provides basic building blocks for creating a central electronic customer file. This is a long-term goal associated with the current business architecture.

Table 5-2. Overview of benefits that improved customer intimacy and commercial opportunities

### Effects on the Efficiency of Internal Operations

The expert panel approach was used also to understand the effects of the business architecture on operational efficiency. Replacing paper with electronic documents improves the efficiency of business processes. The main effects are: less searching for documents, better availability of documents across channels, decrease of process cycle times and increased manageability of the information within a process. Furthermore, several existing ad hoc procedures for document handling can be removed and will be replaced by one standard way of working.

Benefit	Explanation
<b>Improved document handling</b>	It is expected that the time it takes to handle paper documents (i.e., printing, copying, scanning, archiving) will decrease.
<b>Less use of paper</b>	The use of paper for copying and printing will decrease.
<b>Transport reduction</b>	The effort needed for transporting documents will decrease.
<b>Less documents stored in the Central Paper Archive</b>	It is expected that more documents will be destroyed after scanning and, therefore, that the effort it takes to run the central paper archive will be less.
<b>Linking output documents to input documents (e.g. contracts)</b>	Many incoming paper documents are printed by the institution first, then sent to a customer, who has to sign or approve the document, and then sent back to the institution. The main example of this type of document is a contract. Part of the functionality described in the business architecture is to mark these types of documents before they are sent to the customer, so that they can be identified easily when received back.
<b>Up-to-date customer info</b>	In the past, the institution has conducted several initiatives to improve the quality and consistency of their customer data, to comply to legal requirements. The expectation is that the quality of the customer info improves, so that these projects for customer file reparation are unnecessary anymore.

Table 5-3. Overview of benefits that improve operational excellence

## 5.5.2 Quantification of Benefits

### Benefit Drivers

To understand the value of the architecture implementation scenario, the benefits described in the previous paragraphs were quantified in financial terms. When determining the benefits, special attention was given to the quantification of the operational efficiency benefits, because they were much easier to quantify, than customer intimacy or commercial opportunity benefits. For each of the benefits described in Table 5-3, several activities were undertaken to understand the impact on the size of the benefits. For instance, for the benefit *Less use of paper*, the total cost of paper purchases for copiers and printers was requested. Based on the total cost, an estimation was made of the impact of the benefit and the resulting financial consequences. Comparable activities were undertaken to estimate the financial impact of the other benefits.

Because of uncertainties in estimating the size of the benefits, the quantification of the individual benefits was described in terms of a lower and an upper estimate. For each of the benefits described in this table we were able to quantify the expected benefits and an estimation of the probability that this benefit would be realized.

#	Benefit	Estimated Savings		Rationale
		Lower estimate	Upper estimate	
1	Improved Document handling	€4M	€5M	Efficiency of the document handling will be improved, i.e. accessing information, the speed of finding specific documents will be increased, etc. The estimation is that the time needed to handle paper decreases with 30 to 50%.
2	Less use of paper	€ 500K	€ 2M	Less cost of paper, copier maintenance, etc.
3	Transport reduction	€ 2.5M	€ 3.5M	The estimation that the paper transport between various locations can be reduced by 30 to 50%.
4	Less documents stored in the Central Paper Archive	€ 0.75M	€ 1.25M	The estimation is that the number of paper documents that are archived will decrease, in the long term, with 25 to 50%.
5	Linking output documents to input documents (e.g. contracts)	€ 400K	€ 600K	Many documents that the financial institution receives are documents that are sent earlier, an example being financial contracts. By providing the printed documents with a unique identification code, which is recognized during scanning, handling of these documents can be improved.
6	Up-to-date customer info	€ 800K	€ 1.2M	Digitization of information leads to efficiency improvements of the information management for customer files. For instance, it is expected that customer file repair will not be necessarily any more.

Table 5-4. Estimation of individual benefits of implementing the business architecture

These estimations were based upon and validated with the volumetrics described in Table 5-1.

### Probability Density Function for Benefits

To describe these figures in mathematical terms, we will apply two assumptions.

1. The probability of the benefits is normally distributed (see § 4.4, page 24).\*

\* Because of motivation described in § 4.4, we selected a normal distribution. The characteristics of the expected savings did not give indication that another distribution type would be more appropriate. Also note that the validity of the calculation method is not dependent on the selected distribution type (see § 4.6).

2. The a priori probability that the actual savings are indeed within the bounds specified – as the results of the discussion in the expert panel and the outcome of the underlying research – is 75%\*.

Based on these assumptions, we are able to create a probability density functions that describe the benefits. If the probability is 75% that the actual outcome is between the lower and the higher estimate, this means in mathematical terms that:

$$\int_{le}^{he} N(x, \mu, \sigma) dx = 0.75 \quad (5-1)$$

where:

$x$  = Savings

$\sigma$  = Standard Deviation

$\mu$  = Mean

$N(x, \mu, \sigma)$  = Normal Probability Distribution Function

$le$  = Lower Estimate

$he$  = Higher Estimate

Based on this calculation the value of the Standard Deviation can be calculated. This leads us to the following figures:

Benefit	Lower Estimate	Higher Estimate	Expected value	Standard Dev.	Variance
1	4	5	4.5	0.4351	0.1893
2	0.5	2	1.25	0.6526	0.4250
3	2.5	3.5	3	0.4346	0.1889
4	0.75	1.25	1	0.2174	0.0473
5	0.4	0.6	0.5	0.0870	0.0076
6	0.8	1.2	1	0.1738	0.0302
<b>Total</b>			<b>11.3</b>	<b>0.942</b>	<b>0.8891</b>

Table 5-5. Expected value (EV) and standard deviation for benefit savings (EV in € x 10<sup>6</sup>)

This table shows the expected value and standard deviation values for the identified benefits (Lower, Upper and EV in € 1.000.000). The total Expected Value and Variance is calculated by the sum of the individual Expected Values and Variances.

\* We will challenge this value later on and conduct a sensitivity analysis to understand the effect of this value on the final result (See page 55.)

The total Standard Deviation is calculated as the square root of the total Variance. This is because the expected value of the convolution of several normal distribution functions is the sum of the individual expected values. The standard deviation of the convolution is the square root of the sum of the variances (see ( 4-18 ) and ( 4-19 )). The following probability density function describes the combined benefits.

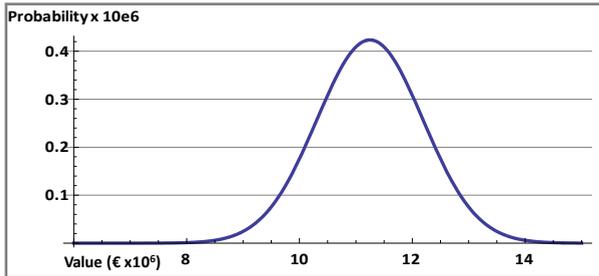


Figure 5-2. Probability distribution function for expected benefits

### 5.5.3 Quantification of Costs

#### Cost drivers

The cost of the architecture can be determined by calculating the cost of the implementation and operation of the various elements of the business architecture. The following cost elements are identified.

Type of cost	Factor	Cost								
Development cost (one-time investment)	The cost of implementation of the architecture functionality	<p>Based on the business architecture, twenty <i>Business Services</i> were identified. A Business Service describes a discrete part of the functionality of the total business architecture. See for the description of the Business Services</p> <p><i>Appendix: An Overview of Business Services for the Financial Case Study</i> (page 144). The cost of implementing the business services was calculated, by splitting up the business services into general categories, which describe the complexity of implementing the service. Three categories are used: Simple, Medium and Complex.</p> <table border="1"> <thead> <tr> <th>Category</th> <th># Services</th> </tr> </thead> <tbody> <tr> <td>Simple</td> <td>9</td> </tr> <tr> <td>Medium</td> <td>9</td> </tr> <tr> <td>Complex</td> <td>2</td> </tr> </tbody> </table> <p>The cost of building a simple, medium or complex service is estimated to be respectively € 50.000, € 100.000 or € 200.000. The categorization of the services and the estimated cost per category is based on the judgment of an expert panel. Total cost is therefore € 1.750.000. (= <math>9 \times 50K + 9 \times 100K + 2 \times 200K</math>)</p>	Category	# Services	Simple	9	Medium	9	Complex	2
	Category	# Services								
	Simple	9								
Medium	9									
Complex	2									
Cost of fitting the architecture within the existing environment	The cost of fitting the architecture within an existing environment is € 450.000. This estimation is based on the judgment of an expert panel.									
Cost for implementing the architecture within the sponsor's business process	The cost of connecting the business architecture to the business processes of a sponsor is estimated to be € 150.000. Six business sponsors will implement the architecture within their processes. The connecting cost will be therefore € 900.000.									
Annual maintenance cost	Operational costs to maintain the architecture	The cost of operating the implemented business architecture (including license costs, etc.) is estimated to be € 2.000.000 annually.								

Table 5-6. Cost of implementing the business architecture

### PDF Parameters

As we have seen (on page 31) the probability density function for cost follows a lognormal distribution. The lognormal distribution is characterized by three parameters: the location, scale and threshold parameters. We need to estimate the value of these three parameters, based on past performance of this institution,

with regard to budget overrun of IT projects. We were able to analyze 70 IT projects. The actual cost of the project was compared with the planned cost. The actual cost of the project was taken from the financial administrative systems. The planned cost of the project was taken from the initial, formal project-budget request document. See the results in the figure below.

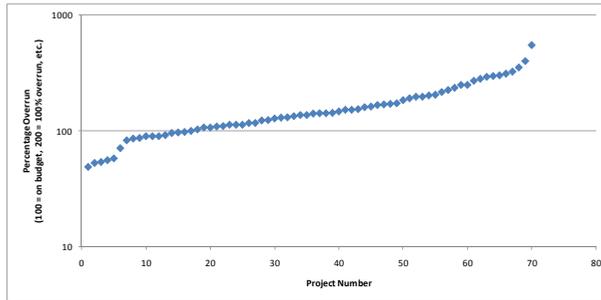


Figure 5-3. Overview of budget overrun for 70 IT projects

Figure 5-3 depicts 70 project results using a logarithmic scale. A project score of 100 means that the project has finished on budget. Scores above one hundred means that the project has overrun. For instance, a project score of 120 means that it has 20% overrun. A score below 100 means that the project has underrun: the initial budget was higher than the actual costs. We can analyze these figures to find out the corresponding probability distribution. Using Minitab®, we found out that these results follow a 3-parameter lognormal distribution.

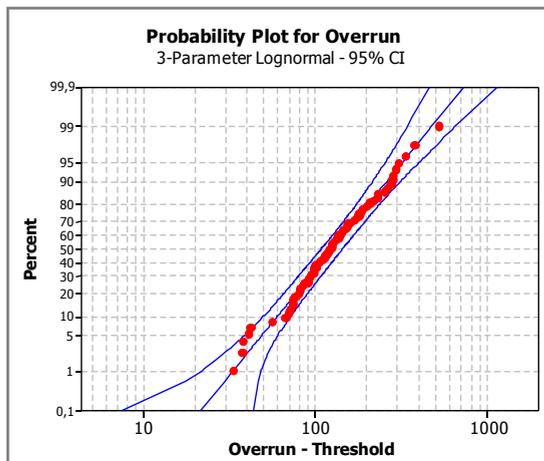


Figure 5-4. Lognormal analysis for project budget overrun

This analysis compares the frequency of the actual figures with a theoretical distribution, while trying to minimize the error between the theoretical value and the actual frequency. A red dot describes the results of one individual project. The middle line is the "ideal" lognormal distribution and the higher and the lower lines denote the 95% confidence intervals.

The parameters of the corresponding lognormal distribution are:

Location	4.8	Planned Cost	Set to 100
Scale	0.57	Most often occurring (Mode)	103
Threshold	15.3	Expected Cost	158

Table 5-7. Parameters project overrun lognormal distribution

These parameters give rise to the probability distribution function depicted in Figure 5-5, where the planned cost of implementing the business architecture is set to 100. From the distribution follows that the most likely (most often occurring) overrun is 3%, while the average overrun is 58%.

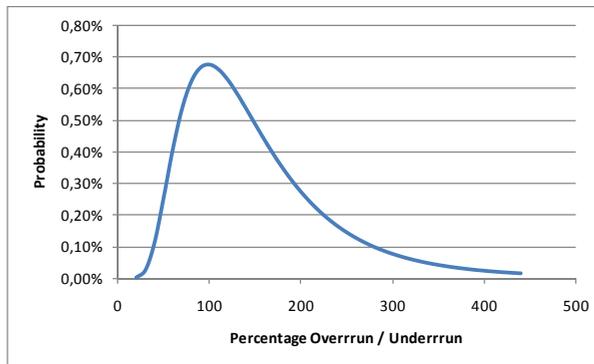


Figure 5-5. Lognormal distribution for project budget overrun

### ***Relationship of the Probability Density Function to the Planned Cost***

It is interesting to note that the planned cost is virtually the same to the most likely occurring actual cost – the mode. The planned cost is 100, while the mode is 103. This demonstrates that the planning for the cost of projects is based upon the most likely outcome of the project, instead on the average cost of projects. Indeed, the general understanding of project management within this institution was that the average project cost was substantially higher than the planned cost, although exact

figures on this were not available. Based upon the analysis of the previous paragraph we can conclude that the average overrun is 58%.

**Probability Density Function for Cost**

Figure 5-5 depicts the general characteristics of projects within this financial institution. To apply these figures to our case we will need to convert these generic results to the actual figures. This means that the norm value of 100 will be replaced by the planned cost for this project. The planned costs for implementing the business architecture are (based on Table 5-6):

The cost of implementation of the architecture functionality	€ 1.750.000
Cost of fitting the architecture within the existing environment	€ 450.000.
Cost for implementing the architecture within the sponsor’s business process	€ 900.000.
<b>Total</b>	<b>€ 3.100.000</b>

*Table 5-8. Total implementation cost for realizing the business architecture*

Scaling the probability density function of Figure 5-5, to a value where 100 equals € 3.1, gives a probability density function with the following parameters:

<b>Location</b>	1.36	<b>Mode</b>	€ 3.3M
<b>Scale</b>	0.57	<b>Expected Value</b>	€ 5.1M
<b>Threshold</b>	0.47	<b>Median</b>	€ 4.4M

*Table 5-9. Parameters of the lognormal distribution for development cost*

These parameters give rise to a lognormal probability distribution function that is shown in Figure 5-6.

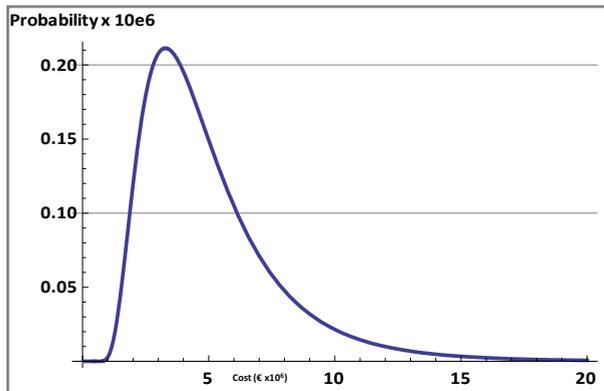


Figure 5-6. Probability density function describing the cost of the business architecture

This figure shows the probability density function of the actual cost for implementing the business architecture within this financial institution, based on an analysis of overruns and under runs of 70 projects.

### **Operational Cost**

The annual, operational cost of the solution is € 2M (see Table 5-6). The operational cost has to be subtracted from the expected benefits. Consequently, the expected benefits decrease from € 11.3M to € 9.3M.

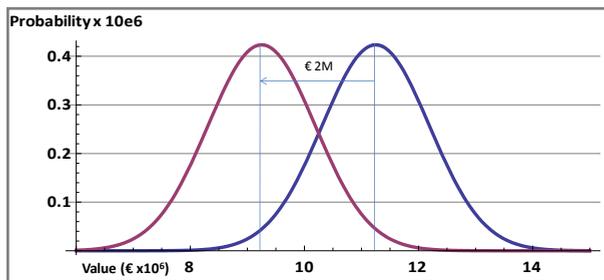


Figure 5-7. Probability distribution for expected benefits after operational costs.

### **5.5.4 Standard Scenario – Cash Flow Probability Functions**

At this point, we have developed a probability density function for both the benefits and the costs. This means that we have an understanding of the probability for a certain actual outcome with regard to the benefits and to the costs. To determine the relationship between costs, benefits for implementing the business architecture, the revenue and cost probability density function are combined, using the approach for convolution of two probability distribution functions as described in

( 4-14 ). This convolution provides a probability density function describing the cash flow.

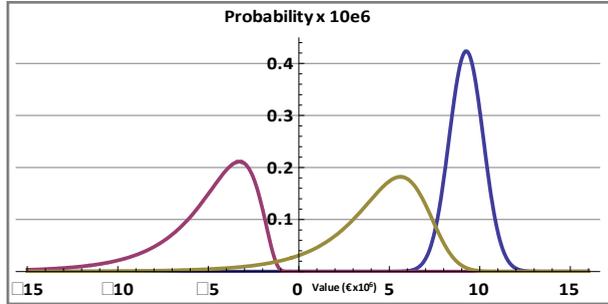


Figure 5-8. PDF's of cost, cash flow and revenue of the Business Architecture

The left probability density function (red) describes the cost. The right function (blue) describes the expected benefits. The middle function (yellow) is the convolution of these two functions and describes the resulting cash flow probability density function, for the standard scenario. The cash flow function in cumulative format is shown below.

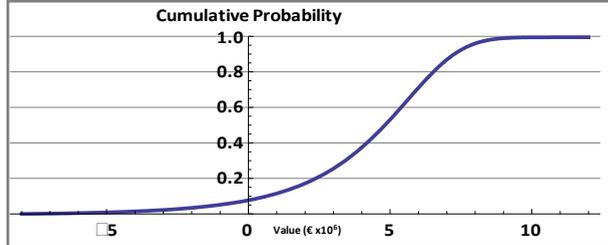


Figure 5-9. Cumulative probability function of the cash flow

From this cash flow function, we can derive some key-figures:

Figure	Value
Expected Value	€ 4.3M
Median – 50% Value	€ 4.8M
Mode – Most likely outcome	€ 5.6M (18%)
Probability of Negative outcome	8%
Probability of high revenue (>€6M)	29%

Table 5-10. Key-figures of the cash flow

The expected revenue of implementing the business architecture is € 4.3M. We can conclude that implementing the business architecture will most probably be a revenueable initiative; the probability of a positive outcome is 92%. However, the expected value of € 4.3M is € 1.3M less than the most likely outcome of € 5.6M. If we assume that management calculates the benefit of the program based on the most likely cost (as is discussed on page 55), then the resulting value of the implementation of the business architecture will be less than expected.

### 5.5.5 Sensitivity Analysis

The results of Table 5-10 are based on the assumption that the probability of the actual benefits to be within the estimates described in Table 5-4 is 75%. This 75% is a rather arbitrary choice. To understand the impact of this choice, we will revisit our results, based on different assumptions. This gives an indication of the sensitivity of the results to the assumption. To challenge the assumptions we will recalculate the benefit probability density function, using the value of respectively 75%, 50% and 25% as probability values for the confidence of the bandwidths described in Table 5-4. The benefit probability function (as described in Figure 5-2) becomes for these three values:

Key-figure	Confidence estimates	Value		
		25%	50%	75%
Expected value		€ 11.3	€ 11.3	€ 11.3
Standard Deviation		3.401	1.606	0.943

Table 5-11. Sensitivity analysis key figures for benefits

When the confidence of the estimates decreases, then the standard deviation of the probability density function increases. Increase of the standard deviation means that the possible outcome spread out. This is illustrated in the figure below.

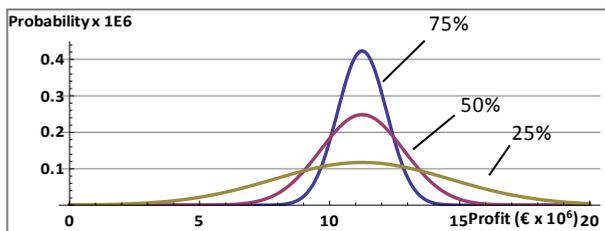


Figure 5-10. Sensitivity analyses for benefits

Figure 5-10 shows three probability density functions for benefits, the first one based on 75% confidence, the second one based on 50% confidence and the third one based on 25% confidence. Each successive function is more ‘flat’, reflecting the increasing uncertainty of the outcome.

To understand the effect of the flattening of the benefit probability density function on the cash flow function, these benefit functions are convoluted with the cost function (Figure 5-6). This results in the following cash flow functions:

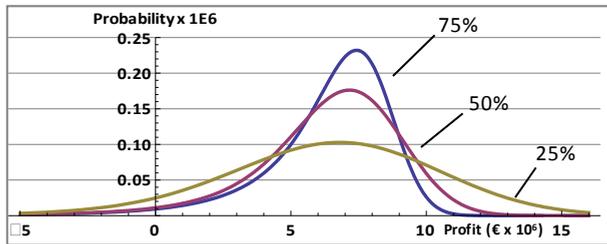


Figure 5-11. Results of sensitivity analysis for the cash flow function

An overview of the key-figures for the cash flow functions:

Key-figure	Value		
	Cash Flow Function: 25%	50%	75%
Expected Value	€ 6.3M	€ 6.4M	€ 6.4 M
Median – 50% Value	€ 6.6M	€ 6.7M	€ 6.9M
Mode – Most likely outcome	€6.8M	€7.1M	€ 7.4M
Probability of Negative outcome	5%	2%	2%
Probability of high revenue (>€8M)	34%	28%	24%

Table 5-12. Sensitivity analysis Key-figures for the cash flow

When inspecting these figures we find that the Expected Value hardly changes. At the lower end (the probability of a negative outcome), the changes are also limited: the probability of a negative outcome only increases slightly from 2 to 5%, and then only for the 25% confidence level. At the high end (probability of an outcome above € 8M) the differences are more explicit: the probability of a high outcome increases from 24%, via 28% to 34%; an increase of 10%, while the lower end changes only 3%. We can say that the effect of the assumption on the confidence level of the bandwidths of Table 5-4 is limited. Specifically, the differences between the 75% estimate and a 50% estimate is limited. If anything, an increase in uncertainty about the expected benefits has a positive, beneficiary net effect on the financial out-

come. The finding that an increase of uncertainty increases the value of a real option is a common finding for researchers working with real options (Amram, et al., 1999). Because of the fact that the effect of the choice of confidence level is limited and the resulting cash flow functions are not very sensitive to the assumptions, we have chosen to continue our calculations with the 75% confidence level.

## 5.6 Step 2. Implement the Option Valuation Model

The risk of cost overrun in developing the enterprise architecture is substantial. For instance, if we look at Figure 5-6, which describes the cost for implementing the business architecture, the planned cost is € 3.1M, the most likely cost (the mode) is € 3.4M, but the expected cost is € 4.9M, which is equal to 58% overrun. The probability of more than 100% overrun – the probability that the cost increases from the planned value of € 3.1M to more than € 6.2 – is almost 20%, 1 out of 5. From these figures, it is evident that risk mitigation of the cost has a significant impact on the total profitability of the program. To limit the risk of the development, part of the risks of developing the architecture can be passed-on to an external developer.

The option to contract allows the financial institution to contract out the development of the enterprise architecture, against a fixed-price. The fixed price can be seen as in insurance premium against high overrun. In effect, this eliminates the cost uncertainty; only the revenue remains. For instance, if the contractor decides to undertake development of the business architecture for a fixed-price of € 4M, this creates a new cash flow probability density function.

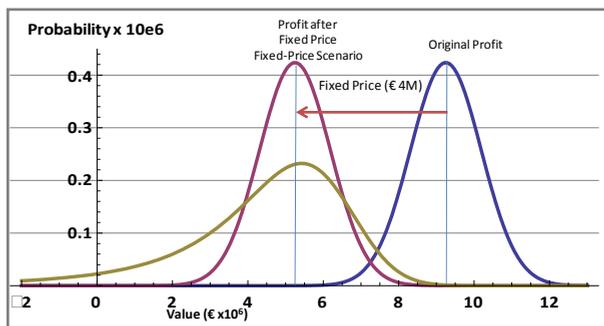


Figure 5-12. Comparing cash flows with and without contracting option. Example for fixed price of € 4M.

The right (blue) graph describes the revenue function, which is also described in Figure 5-7. The left (red) probability density function describes the probability density function for the *Contract Scenario*. The Contract PDF is equal to the original

revenue PDF, shifted to the left over four units, because the fixed-price example of developing the business architecture is € 4M. The lower (yellow) PDF describes the standard scenario.

The key question is of course, which choice is the best one? Is it better for the financial institution to go for fixed-price (red, upper left) or to go for standard development (yellow, lower)? Clearly, the answer to this question depends on the investment strategy of the financial institution. Table 4-6 mentions four feasible strategies. These are:

1. Maximization of likely value
2. Maximization of expected value
3. Minimization of loss
4. Maximization of option value

We will discuss the application of these strategies in the following paragraphs.

### 5.6.1 Maximization of Likely and Expected Value

#### Analysis

The likely value of the standard PDF is € 5.6M, while the expected value is € 4.3 (according to Table 5-10). For the revenue PDF, the expected value and the likely value are both equal to € 11.3M (see Table 5-5). Therefore, the likely and the expected value of the Contract PDF is equal to € 11.3 minus the operational costs (€ 2M) minus the value of the fixed-price. See the Figure below.

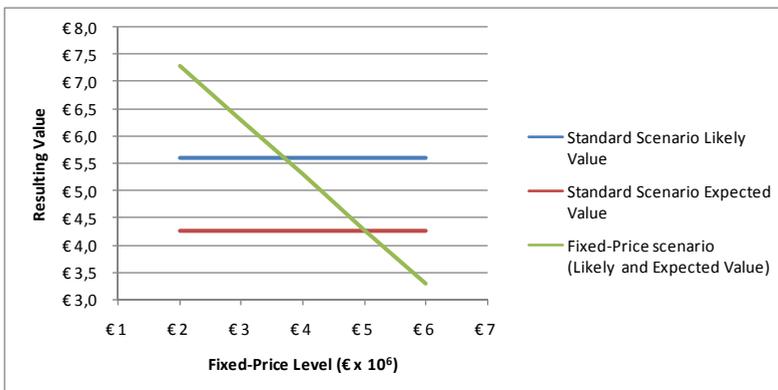


Figure 5-13. Likely and Expected Value of the Standard and the Contract Scenario

### Conclusion

When opting for the strategy of maximization of *Likely Value*, the Contract variant is preferable when the price is below € 3.7M. In practice, this strategy is mostly used, because planned and most likely values are virtually the same (see the paragraph *Relationship of the Probability Density Function to the Planned Cost* page, 55). However, this is not a very sensible strategy, because the likely value does not say much about the expected value and it does not consider the risks of negative outcome. Other strategies may be more suitable.

When opting for the strategy of maximization of *Expected Value*, the Contract variant is preferable when the price is below € 5.0M.

### 5.6.2 Minimization of Loss

#### Analysis

Management may set a lower limit for the expected outcome of the cash flow of the implementation of the business architecture. The objective of this selection strategy is to minimize the probability that the cash flow resulting from the implementation of the business architecture is below this lower limit. The probability that the standard PDF delivers a result below a specific threshold is equal to:

$$S_p = \int_{-\infty}^T p_s(x) dx \quad (5-2)$$

where:

$p_s$  = Probability Density Function of the standard cash flow

$T$  = Threshold value

$S_p$  = Prob. of outcome below  $T$ , for the standard PDF

Figure 5-9 demonstrates this function graphically.

For the Contract PDF, the probability that the cash flow outcome is below the threshold is equal to:

$$F_p = \int_{-\infty}^T p_p(x + A) dx \quad (5-3)$$

Where

$p_p$  = Probability Density Function of the profit

$T$  = Threshold value  
 $A$  = Fixed Price value  
 $F_p$  = Prob. of outcome below  $T$ , for the fixed price PDF

The strategy is to minimize the probability that the outcome will be below the threshold. This indicates that the Contract solution will be chosen if the probability of an outcome below the threshold for this solution is smaller than for the standard solution. Mathematically, this means that  $F_p < S_p$ . If the standard probability is smaller ( $S_p < F_p$ ) then the standard solution will be chosen. Figure 5-14 shows the values of  $S_p$  and  $F_p$  as a function of  $A$  and  $T$ .

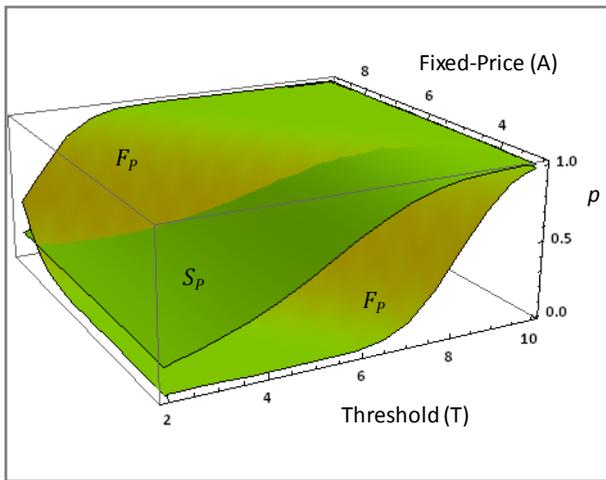


Figure 5-14. Values of  $S_p$  and  $F_p$  as function of  $A$  and  $T$ .

The intersection line between  $S_p$  and  $F_p$  is shown in Figure 5-15.

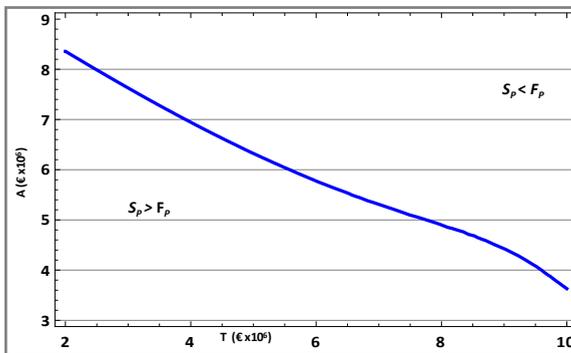


Figure 5-15. Intersection line between  $S_p$  and  $F_p$ .

The horizontal axis of Figure 5-15 denotes the threshold value  $T$  and the vertical axis denotes the value of the fixed-price value  $A$  (in € x 10<sup>6</sup>). In the area *below* the blue line, the probability that Contract Scenario delivers an outcome below the threshold, is smaller than for the Standard Scenario.

### Conclusion

Below the blue line, it is favorable to select the Contract Scenario. Vice versa, above the blue line it is favorable to select the Standard Scenario. For instance, assuming the fixed-price ( $A$ ) to be € 6M, then selecting the Contract Scenario is favorable when the threshold value is below € 5.6M.

### 5.6.3 Maximization of Option Value

#### Analysis for the Contract Scenario

The option value incorporates the additional value created by the uncertainty about future outcomes (see § 4.5.4, page 38). The value of the option is calculated by the Black-Scholes formula given by ( 4-2 ). This formula is repeated here:

$$O = N(d_1)S_0 - N(d_2)Ae^{-r.T} \quad (5-4)$$

The following table gives an overview of the Black-Scholes parameters within the context of our case.

Parameter	Explanation	Usage of the parameter in the context of our case	Value
$S_0$	Current value of the asset	The current value of the asset is not known, because the asset will be created by the project. Therefore, we only can use the estimated future value of the asset, which is given by Table 5-5. We subtract the operational cost.	€ 9.3M
$A$	Cost of fixed-price	This is the cost of the fixed-price project.	(variable)
$r$	Interest rate	The standard interest rates used for investment decisions within the financial institution is 10%.	10%
$T$	Time to expiration (in years)	The planned time for realization of the architecture is three years.	3
$\sigma$	Volatility of the asset	The volatility over three year of the assets is based on the calculation of Table 5-5.	0.94

Table 5-13. Usage and value of Black-Scholes parameters

Filling in the parameter values of this table into the Black-Scholes equation, we find the relationship between the option value and the fixed-price cost.

$$O = 4.65(1 + \text{Erf}(3.5 - 1.3 \ln(A))) - .37A(1 + \text{Erf}(3.1 - 1.3 \ln(A))) \quad (5-5)$$

where:

$O = \text{Option Value}$

$A = \text{Fixed Price value}$

$$\text{Erf}(x) = \text{Error Function} = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt$$

This gives the following relationship between the option value and the fixed-price value.

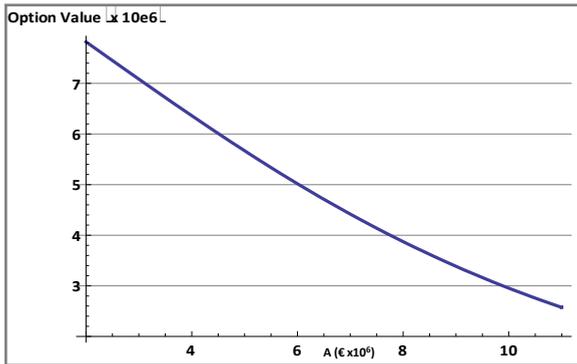


Figure 5-16. Relationship between option value and fixed-price

The horizontal axis denotes the value of the fixed-price, while the vertical axis denotes the value of the option. For instance, if the fixed-price is € 4M, then the resulting option value is € 6.4M.

### Analysis of the Standard Scenario

The option value of the standard scenario cannot be calculated with Black-Scholes, because it deals with two sources of uncertainty, i.e., uncertainty with regard to the cost and uncertainty with regard to the revenue. To calculate the Option Value, we use formula ( 4-27 ), with the cash-flow probability density function of the standard solution (as is shown in Figure 5-8).

Figure	Value
Expected Value	€ 4.3M
Option Value	€ 4.4M
Median – 50% Value	€ 4.8M
Mode – Most likely outcome	€ 5.6M
Probability of Negative outcome	8%
Probability of high revenue (>€6M)	29%

Table 5-14. Key figures of cash flow function including Option Value

Table 5-14 is a copy of Table 5-10, but includes the Option Value. We find that the option value of the standard scenario is almost identical to the expected value. The reason for this is that the probability of a negative outcome is relatively small; approximately 8% (see Table 5-10 and Figure 5-9). A small probability of negative outcome means that Real Option Analysis has not significant added value, compared to NPV.

### 5.7 Step 3. Review the Results

And so, what is the best option; to contract or not to contract? Figure 5-17 gives a summary of the findings:

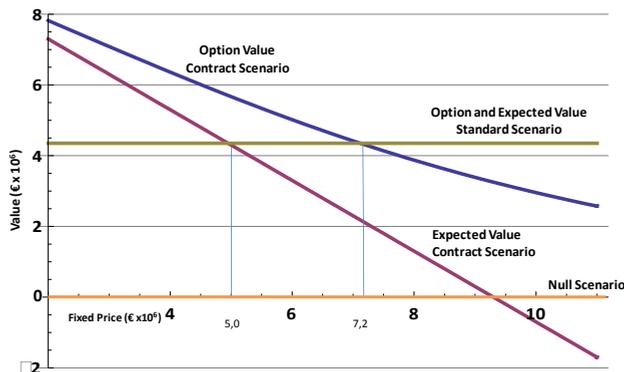


Figure 5-17. Comparison of standard option versus the contract option

Figure 5-17 is a combination of Figure 5-13 and Figure 5-16. We compare the *Expected Value* of the Standard Scenario to the *Expected* and the *Option Value* of the Contract Scenario. (For the Standard Scenario, the *Expected Value* is virtually identical to the *Option Value*, so these are treated together). These scenarios are compared to the Null Scenario (do nothing; continue the status quo).

The conclusion is, that the *Option Value* of the Contract Scenario is significant higher than the *Expected Value* of the Contract Scenario and that the difference between them increases if the fixed-price increases. This is understandable, because the *Option Value* is equal to the partial, positive *Expected Value*. In other words, the *Option Value* only considers the positive outcome of the *Expected Value* and ignores the negative outcomes. When the fixed-price increases, then the *Expected Value* becomes more negative and, consequently, the difference between the *Option Value* and the *Expected Value* of the Contract Scenario increases.

Based upon this analysis, it is advisable to choose for the Contract Scenario, if the total contracting cost is € 7.2M or less, otherwise the Standard Scenario would be advisable. If we compare this result with the analysis of § 5.6.2, which minimizes the probability of a negative outcome, then we see that the Contract Scenario for a cost of € 7.2M is also viable on the condition that the threshold value is set to € 5.3M or lower.

## **5.8 Step 4. Redesign?**

In Step 4, the analysis is considered holistically, within the complete context of the question and the proposed solution. It allows the owner of the problem to take another angle or go for a different solution direction. For instance, in this case we considered only one type of contract option, namely the fixed-price contract. In the analysis, also other types of contracts might be included, such as: time and material with ceiling, or a shared risk approach between the contractee and the contractor. All these options have their own value that can be calculated separately.

## **5.9 Comparison with Other Valuation Approaches**

Various methods for valuing architectural and IT investments have been developed. We will discuss a number of these methods and compare it to the Real Option Analysis approach that has been discussed in this thesis.

### **5.9.1 SAAM**

Software Architecture Analysis Method was developed to analyze the properties of software architectures (Kazman, et al., 1994). The approach considers three perspectives for understanding and describing software architectures---functionality, structure and allocation. SAAM, therefore, is an approach to value qualitatively the various properties of software architecture and does not aim to quantify the busi-

ness benefits of the software. In this respect, the purpose of the method is quite different from the Real Options Analysis that was described in this thesis.

### 5.9.2 ATAM

Kazman, Klein and Clements (2000) developed ATAM: *Architecture Trade-Off Analysis Method*. The purpose for ATAM is: “[...] to assess the consequences of architectural decisions in light of quality attribute requirements.” ATAM, therefore, is an approach to value qualitatively the various architectural decisions that can be made during the development of an Enterprise Architecture. It does not aim to quantify the benefits of architectural decisions, but to improve and demonstrate the alignment of architectural quality attributes with the objectives of the users of the enterprise architecture. The method is aimed at increasing the *fit for purpose* of the resulting architecture.

### 5.9.3 CBAM

The purpose of the Cost Benefit Analysis Method (CBAM -- (Moore, et al., 2003; Asundi, et al., 2001; Kazman, et al., 2002)) is to structure the decision-making process for implementing an enterprise architecture, in order to maximize the benefits that the architecture provides, while minimizing cost. CBAM analyses architectural decisions from the perspective of cost, benefit, schedule and risk. As such, it is comparable in purpose and perspectives to the Real Options Analysis that was described in this thesis. CBAM does not use ROA for this analysis, but a combination of scenario thinking and *utility levels*. A *utility level* valuates various qualities of the final solution with regard to the objectives of the users of the architecture. The utility levels are defined qualitatively by expert users or management. This method does not incorporate the value of future decision-making and as such, it is an approach, which depends on subjective estimations by key users. The reliance on the opinion of expert users and senior management makes the approach difficult to apply. The advantage of the method is that it makes the intuition and understanding of the value of the architecture explicit and traceable.

### 5.9.4 Other ROA approaches

There is a sizeable literature on using option valuation for IT investments. Dos Santos (1991) was one of the first authors to value IT investments using Real Options Analysis. More recently see Hilhorst (2004) and (2005). In the 2004 study, a combination of *Multiattribute Decision Analysis* (MADA) and Real Option Analysis was used, to incorporate both financial and non-financial elements in the decision-making process. The reason for including ROA is because to “include risk as a

measure of uncertainty with respect to specific consequences of an investment, adds to the reliability of the outcome of the decision.” The reason for using the combination of ROA and MADA is to address one of the major arguments against using ROA, that is “its lack of transparency for decision-makers. Using real Options Analysis in the multi-attribute approach gives a better insight in different implementation scenarios.” (Hilhorst, et al., 2004).

### ***5.9.5 Critics on Using ROA for IT Investment Evaluation***

De Jong, Ribbers and Van der Zee (1999) assert that real Options Analysis is not a useful instrument to value IT investments. Their three main objections are:

- (1) It is difficult to estimate the input values (the Variance and Net Present Value) for subsequent projects*
- (2) ROA -- in its closed Black-Scholes form -- is too simplistic, because too many assumptions are being made*
- (3) This form is too complex to communicate to management.*

Indeed, estimation of input values is a critical activity when performing Real Option Analysis. However, this activity is critical for any valuation method, be it ROA, Decision Tree Analysis or other methods. We have tried to overcome this objection by splitting up the analysis in the two main components (i.e., revenue and cost expectations) and measuring separately the expected value and variance for each of the components. For the cost component, we were able to measure the actual variance, which gives us confidence that this value is correct.

We support the statement that the basic Black-Scholes formula is too simplistic for many situations. That is why we adapted the basic method by calculating separately the revenue and cost probability distributions.

It might be that the basic Black-Scholes formula is too complex to communicate. After all, the formula is more or less a ‘black box’ with a number of input parameters that delivers an output value, which is not necessarily intuitively related to the input parameters. However, we find that the adaptations that we have added to the basic approach (that is calculating separate revenue and cost probability distributions and combining them) are easily explained to management. Management is experienced to think in revenue and cost factors, and instead of having one revenue and cost estimation value, this approach builds on this thinking in describing revenue and for cost distributions. Combining the revenue and cost distributions in one overall distribution is very much comparable to the process that is performed with single revenue and cost factors.