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## 7.

# *Results of the Solution Architecture Case Study*

*This chapter discusses the results of the null-hypothesis ( $H_0$ ) tests. Each of the project variables is tested against every  $H_0$  statement. This provides understanding of the correlations between the project and success variables. Of the 80 possible correlations, 19 proved to be significant. For each of the identified correlations, the size of the effect, an interpretation of the underlying mechanism for the correlation and the consequences of the correlation are given. In addition, the limitations of the analysis are discussed, together with a comparison of findings by other researchers. The chapter ends with overall conclusions.*

### **7.1 Significant Correlations**

Table 7-1 shows a summary of null hypothesis testing results. In the previous chapter, ten architecture-related project variables were identified and eight  $H_0$  statements were defined. Each of the project variables is tested against every statement; this gives 80 possible correlations. Of these 80 correlations, 19 correlations proved to be significant. The table below shows the corresponding p-values of the significant correlations. A correlation is significant if the statistical test delivers a probability value (p-value) that is equal or smaller than the chosen significance level of 5%. For the significant correlations, the  $H_0$  statement is rejected, which means that the outcome of the statistical test indicates that the project variable and the success variable are correlated.

		H <sub>0</sub> Statement							
		I	II	III	IV	V	VI	VII	VIII
		EV Project Budget	Var. Project Budget	EV Project Time	Var. Project Time	Customer Satisfaction	Percentage Delivered	Functional Fit	Technical Fit
Project Variables	1 Technical Calculation	-	0.2%	-	-	-	-	-	-
	2 Certification Architect	-	-	-	-	-	-	-	-
	3 Certification w.r.t. Project	-	-	-	-	0.0%	-	-	-
	4 Specific Experience Architect	-	-	-	-	5.0%	1.5%	-	-
	5 Project Architecture	-	2.4%	0.2%	-	0.8%	0.2%	-	0.3%
	6 Domain Architecture	-	-	3.6%	-	1.9%	0.6%	-	-
	7 Enterprise Architecture	-	-	1.8%	3.5%	0.1%	2.6%	-	-
	8 Architecture Governance	0.3%	-	-	-	-	1.8%	-	-
	9 Controlling Architect	-	-	-	-	-	-	-	-
	10 Architecture Compliancy	-	-	1.0%	-	-	-	-	-

Table 7-1. Overview of p-values of the significant correlations

The table shows the resulting p-values for testing a project variable against the H<sub>0</sub> statements. For those correlations that are found to be significant, the resulting p-values of the H<sub>0</sub> tests are shown in the table. For example, project variable 7 (Quality of the Enterprise Architecture) correlates significantly with the H<sub>0</sub> statements III, IV, V and VI, with a p-value of respectively 1.8%, 3.5%, 0.1% and 2.6%. Because of these correlations, the H<sub>0</sub> statement is rejected. A dash means that the relationship between the project variable and the H<sub>0</sub> statement is not significant (e.g. the p-value from the test is larger than the significant level of 5%) and, consequently, the H<sub>0</sub> statement cannot be rejected.

We find that most of the H<sub>0</sub> statements are correlated to project variables. In the following paragraphs we will discuss the correlations that are identified and the real also discuss some correlations which might be expected but are not found in our survey. Especially, we will have a look at project variable 2 and H<sub>0</sub> statement VII, because for this variable and statement we did not find correlations.

## 7.2 Description method

In the following paragraphs, the significant correlations are interpreted and explained. The following structure will be used to describe the finding and the interpretation.

1. *Statement* – The formulation of the  $H_0$  statement
2. *Findings* – The actual findings of the analysis
3. *Conclusion* – Conclusions that can be drawn from the findings
4. *Significance* – Significance level. This level is equal or below the significant threshold of 5%
5. *Interpretation* – Interpretation of the findings and the conclusion, which may provide additional reasoning or foundations for the conclusion
6. *Consequences* – The size of the effect is explained, in terms of the effect on the success variable.

## 7.3 Overview of the results

### 7.3.1 $H_0$ statement I – Expected value of Budget Overrun

<b>H<sub>0</sub> Statement</b>	<i>Application of enterprise architecture is not significantly correlated with the expected value of the actual project budget (as percentage of the planned budget).</i>
<b>Finding</b>	Project variable 8 ( <i>Quality of the customer's architecture governance process</i> ) tests significant. The other variables are non-significant. $H_0$ statement I is rejected.
<b>Conclusion</b>	The presence of an architecture governance process (either fully functional or limited in scope and responsibilities) is significantly correlated with a lower expected value of budget overrun, compared to a situation where there is no architecture governance process in the customer's organization present. The difference in expected value is 19% (3% versus 22%).
<b>Significance</b>	P = 0.3%
<b>Interpretation</b>	The presence of an architecture governance process implies that the organization is working with architecture and, therefore, is using project architectures and higher-level architectures. The reverse situation is not necessarily the case; an organization may be defining project architectures without having an architecture governance process. This finding shows that the presence of an architectural governance process has its own additional value.
<b>Consequences</b>	The average project size is € 700.000. A decrease in the overrun with 19% will save on average € 130K per project, or about € 6M for the 49 projects that we have examined. If we set the upper limit for budget overrun on 20% (i.e., any project with 20% or more overrun is defective) then the Six Sigma process capability (see § 6.3.2) of the custom software development process is 1.6 if projects

are run without architecture governance and 2.7 for projects with governance.

Table 7-2. Results for expected value of Budget Overrun

### 7.3.2 H<sub>0</sub> Statement II – Variance of Budget Overrun

<b>H<sub>0</sub> Statement</b>	<i>Application of enterprise architecture is not significantly correlated with the variance of the actual project budget (as percentage of the planned budget).</i>
<b>Finding</b>	Project variable 1 ( <i>Presence of architect during calculation of the technical price</i> ) and project variable 5 ( <i>Quality of the project architecture</i> ) tests significant. The other variables are non-significant. H <sub>0</sub> statement II is rejected.
<b>Conclusion</b>	The presence of an architect during the calculation of the technical price is significantly correlated with a lower variance of the actual project budget, compared to a situation when there is no architect present during technical price calculation. The difference in the standard deviation is 21 (13 versus 34). The presence of a high-quality project architecture is significantly correlated with a lower variance of the actual project budget, compared to a situation when there is only a medium or poor quality or no project architecture present. The difference in the standard deviation is 18 (13 versus 31).
<b>Significance</b>	P = 0.8% (variable 1). P = 2.4% (variable 5)
<b>Interpretation</b>	Presence of an architect during the calculation of the planned cost and the quality of the project architecture is correlated with an increase of the reliability of the cost planning significantly. Reduction of variance is a major goal of the Six Sigma methodology (Pyzdek, 2003). When process variance is reduced, then the process becomes more predictable and overrun decreases. A major problem for custom software development process is the lack of predictability of the actual cost. Both project variables <i>Presence of an architect during the calculation of the technical price</i> and <i>High-quality project architecture</i> are correlated with a significant improved reliability of the project budget planning.
<b>Consequences</b>	Piselo (2003) states that only 16% of custom software development projects deliver according to plan, or – in other words – the sigma level of software development projects is 0.5 (see Table 6-6). Reduction of the process variance improves the process quality. For instance, we can calculate from Figure 4-7 that only 13% of the projects of answer 1 have more than 20% overrun, versus 38% of answer 2. In Six Sigma terms, this improves the process quality one full level, from 1.8 to 2.8 for the success variable <i>Budget Overrun</i> (see § 6.2.3, page 74).

Table 7-3. Results for variance of Budget Overrun

### 7.3.3 H<sub>0</sub> statement III – Expected Value of Project Timeframe

<b>H<sub>0</sub> Statement</b>	<i>Application of enterprise architecture is not significantly correlated with the expected value of the actual project timeframe (as percentage of the original timeframe).</i>
<b>Finding</b>	Project variables 5, 6, 7 and 10 ( <i>Quality of the project architecture, Quality of the domain architecture, Quality of the enterprise architecture and Architecture</i>

	<p><i>compliance testing</i>) test significant. The other variables are non-significant. <math>H_0</math> statement II is rejected.</p>
	<p>Application of Enterprise Architecture is correlated with a significant decrease in time overrun for projects. Four of the 10 project variables test significant, which makes the project timeframe one of the success variables that correlates with multiple aspects of the use of architecture.</p> <p>The presence of a high-quality project architecture correlates with a decrease in time overrun of the project, compared to a situation where there is a medium or poor quality project architecture present. The difference in overrun is 55% (71% overrun versus 16% overrun).</p> <p>The presence of a high-quality domain architecture correlates with a decrease in time overrun of the project, compared with situation where there is medium or poor quality domain architecture present. The difference in overrun is 44% (49% versus 5% overrun).</p> <p>The presence of a high-quality enterprise architecture correlates with a decrease in time overrun of the project, compared with situation where there is medium or poor quality enterprise architecture present. The difference in overrun is 46% (51% versus 5%).</p> <p>The presence of informal architecture compliance testing procedure correlates with a decrease in time overrun of the project, compared to the situation where there was no compliance testing between architecture design and implementation. The difference in overrun is 56% (66% versus 10%).</p>
<b>Conclusion</b>	
<b>Significance</b>	<p>P = 1.9% (variable 5)                  P = 3.6% (variable 6)                  P = 1.8% (variable 7)                  P = 1.0% (variable 10)</p>
<b>Interpretation</b>	<p>It is interesting to note that 4 of the 10 project variables correlate with the success variable. Probably, the same effect is measured multiple times, but from different angles. For instance, presence of enterprise architecture and the presence of the domain architecture denote probably the same type of architectural maturity of the customer’s organization and both project variables may be an indication for a common underlying cause. Further indication of this is that variable 6 and variable 7 have almost the same expected values for time overrun. To understand this result more fully, it is necessary to analyze the interaction between project variables. However, the survey size is too limited to perform this type of analysis (see page 102). Consequently, we have to limit ourselves to the supposition that interaction between project variables plays a major role in this result, without being able to quantify this interaction.</p> <p>Overall, we can conclude that application of enterprise and architecture is correlated with a substantial decrease in project overrun.</p>
<b>Consequences</b>	<p>The average actual project timeframe for the projects that we have examined is one year – which includes on average 40% overrun. Consequently, application of architecture is correlated with a decrease of average project time of about four months.</p>

Table 7-4. Results for expected value of Project Timeframe

### 7.3.4 *H<sub>0</sub> statement IV – Variance of Project Timeframe*

<b>H<sub>0</sub> Statement</b>	<i>Application of enterprise architecture is not significantly correlated with the variance of the actual project timeframe (as percentage of the original timeframe).</i>
<b>Finding</b>	Project variable 8 ( <i>Quality of the enterprise architecture</i> ) tests significant. The other variables are non-significant. H <sub>0</sub> statement IV is rejected.
<b>Conclusion</b>	The presence of a high-quality enterprise architecture correlates significantly with a decrease of variance in the actual project timeframe, compared to a situation where there is medium or low quality enterprise architecture or no EA. The difference in the standard deviation is 108 (115 versus 7).
<b>Significance</b>	P = 3.5%
<b>Interpretation</b>	<p>The interpretation of this result is not very clear, because the difference in the standard deviation is quite large and we did not identify a mechanism – linked to enterprise architecture – that could be responsible for this large effect. In addition, the question is why no correlation is found for domain and project architecture. The p-value for domain architecture is 11%, which could indicate a trend. However, the p-value for project architecture is 74%, which is nowhere significant.</p> <p>Furthermore, the sample size for answer 1 is rather small (only 8). Because of these interpretation difficulties, we suspect that this result may be spurious and further research may be needed.</p>

Table 7-5. Results for variance of Project Timeframe

### 7.3.5 *H<sub>0</sub> statement V – Customer Satisfaction*

<b>H<sub>0</sub> Statement</b>	<i>Application of enterprise architecture is not significantly correlated with the expected value of customer satisfaction.</i>
<b>Finding</b>	Project variables 3, 4, 5, 6 and 7 ( <i>Match of certification level of the architect to the level of the project, Specific experience of the architect, Quality of the project architecture, Quality of the domain architecture and Quality of the enterprise architecture</i> ) test significant. Project variables 2 and 8 ( <i>Certification level of the architect and Quality of the customer’s architecture governance process</i> ) are close. H <sub>0</sub> statement V is rejected.
<b>Conclusion</b>	<p>Application of Enterprise Architecture is correlated with a significant increase in customer satisfaction. Five of the ten project variables test significant, which makes customer satisfaction one of the success variables that correlates with multiple aspects of the use of architecture.</p> <p>Matching the level of the architect with the level of the requirement correlates significantly with an increase of customer satisfaction, compared to a situation where the certification level of the architect was under project level. The difference is an OTACE score of 4.1 versus 2.8 (on a scale of 1 to 5 – a score of 3.5 or higher is considered satisfactory). This project variable explains 51% of the total variance in the OTACE score.</p> <p>Broad experience of the architect with the type of engagement correlates significantly with an increase of customer satisfaction, compared to a situation</p>

where the architect has only some experience with the type of engagement. The difference is an OTACE score of 4.0 versus 3.6. This project variable explains 8.5% of the variance in the OTACE score.

The presence of a high-quality project architecture correlates significantly with an increase of customer satisfaction, compared to a medium or low quality or no project architecture. The difference is an OTACE score of 4.1 versus 3.5. This project variable explains 16.8% of the total variance of the OTACE score.

The quality domain architecture correlates significantly with an increase of customer satisfaction. The OTACE score is 4.2, 3.8 and 3.4 for respectively a high-quality, medium quality or low quality domain architecture. This project variable explains 12.5% of the total variance of the OTACE score.

The quality of the enterprise architecture correlates significantly with an increase of customer satisfaction. The OTACE score is 4.4, 3.9 and 3.4 for respectively a high-quality, medium quality or low quality enterprise architecture. This project variable explains 24.3% of the total variance of the OTACE score.

**Significance**

- P = 0.0% (variable 3)
- P = 5.0% (variable 4)
- P = 0.8% (variable 5)
- P = 1.9% (variable 6)
- P = 0.1% (variable 7)

Our supposition is that Customer satisfaction is the outcome of the comparison between the expectation of the customer and the actual results of the project. If the outcome of the project is only mediocre, but customer expectation is low, then the outcome of the project may still exceed customer expectation, and, therefore, customer satisfaction can be high. Customer satisfaction is the perceived discrepancy between expectation and realized results.

To understand the effect of perceived realized results to the customer, we analyzed the relationship between budget and time overrun with customer satisfaction. We find that budget overrun is not correlated with customer satisfaction

**Interpretation**

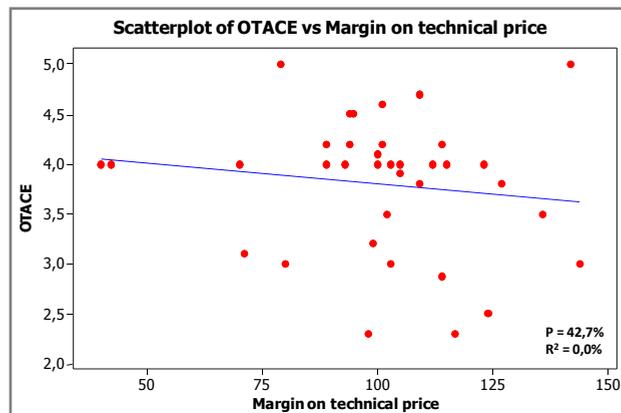


Figure 7-1. Customer satisfaction as function of budget overrun

A p-value of 42.7% does not indicate a correlation. This lack of correlation can be explained, when we realize that budget overrun is not necessarily a problem for the customer. In the case of a fixed-price construction, the IT service provider is fully responsible for the budget overrun. In this situation budget overrun may be causing an increase of customer satisfaction, because the customer receives the required functionality, while the overrun costs are paid by the provider. Budget overrun can be correlated with both high or with low customer satisfaction, and is therefore not related to the perceived value of the project for the customer. See below for similar analysis of time overrun and customer satisfaction.

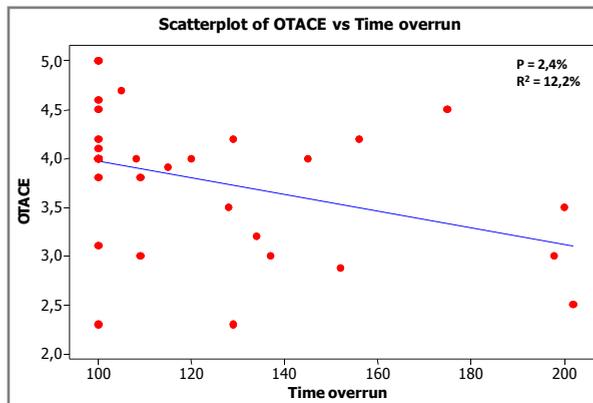


Figure 7-2. Customer satisfaction as function of time overrun

We find that this correlation is significant and is described in the following formula:

$$OTACE = 4.84 - 0.0086 * Time\ overrun \quad (7-1)$$

Increasing time overrun decreases customer satisfaction. Contrary to budget overrun, time overrun is always directly experienced by the customer. When a project encounters obstacles that delays it, then the customer is forced to adapt business project schedules, adapt the resource planning, adapt interdependencies with other projects, etc.

A further indication that time overrun and customer satisfaction are correlated is also given by the correlations with the project variables 5, 6 and 7 (respectively quality of the project, domain and enterprise architectures) and customer satisfaction, because these three project variables also correlate with the expected value of the project timeframe (success variable 3).

The finding that time overrun and customer satisfaction are correlated, confirms the supposition at the beginning of this paragraph that customer satisfaction is related to the actual outcome of the project. Can we also find correlations that customer satisfaction is correlated to the expectation of the customer? Interes-

	<p>tingly, project variable 3 (<i>Match of certification level of the architect to the level of the project</i>) does not correlate to budget or time overrun – but correlates with customer satisfaction. Our interpretation is that an architect, whose level is matched with the level of the project, manages the expectations of the customer in such a way that it improves customer satisfaction, while less experienced architects do not have this ability.</p> <p>Therefore, the correlation between customer satisfaction and both time overrun and certification level of the architect (project variable 3) supports our supposition. We can conclude that there are indications that customer satisfaction is influenced by the ability of the architect to manage expectations of the customer and by the time overrun of the project.</p>
<b>Consequences</b>	<p>Customer satisfaction is the result of the comparison of customer expectation and actual outcome of the project. The subjective elements of the customer satisfaction are co-determined by the experience of the architect. If the experience of the architect is too low compared to the level required by the project, then we find that this is correlated with the lower customer satisfaction. The difference is 0.4 point, on a scale from 1 to 5. The objective elements of customer satisfaction are co-represented by the time overrun. The effect is a 0.2 point decrease in customer satisfaction for every 20% overrun.</p>

*Table 7-6. Results for customer satisfaction*

### 7.3.6 *H<sub>0</sub> statement VI – Percentage Delivered*

<b>H<sub>0</sub> Statement</b>	<i>Application of enterprise architecture is not significantly correlated with the expected value of the percentage delivered.</i>
<b>Finding</b>	<p>Project variables 4, 5, 6, 7 and 8 (<i>Specific experience of the architect, Quality of the project architecture, Quality of the domain architecture, Quality of the enterprise architecture and Quality of the customer's architecture governance process</i>) test significant. H<sub>0</sub> statement VI is rejected.</p> <p>Application of Enterprise Architecture is correlated with a significant increase in percentage delivered. Five of the ten project variables test significant, which makes percentage delivered one of the success variables that correlates with multiple aspects of the use of architecture.</p> <p>Broad experience of the architect with the type of engagement correlates significantly with an increase of percentage delivered compared to a situation where the architect has only some experience with the type of engagement. The difference is 8% (92% versus 100%). This project variable explains 11.6 % of the variance in the percentage delivered.</p>
<b>Conclusion</b>	<p>An increase in the quality of the project architecture correlates significantly with an increase of percentage delivered. The difference is between low quality and high-quality project architecture is 12%. Respectively 100% , 95% and 88% for high, medium and low quality project architectures. This project variable explains 16.9% of total variance of the percentage delivered.</p> <p>An increase in the quality of domain architecture correlates significantly with an increase of percentage delivered. The difference between low quality and high-quality domain architecture is 13% (92% versus 105%). This project</p>

	<p>variable explains 13.8% of the total variance of the percentage delivered.</p> <p>An increase in the quality of enterprise architecture correlates significantly with an increase of percentage delivered. The difference between low quality and high-quality enterprise architecture is 9% (49% versus 103%). This project variable explains 8.6% of the total variance of percentage delivered.</p> <p>Improved architecture governance correlates significantly with an increase of percentage delivered. The difference between no governance and formal governance is 10% (94% versus 104%). This project variable explains 10.2% of the total variance of percentage delivered.</p>
<b>Significance</b>	<p>P = 1.5% (variable 4)</p> <p>P = 0.2% (variable 5)</p> <p>P = 0.6% (variable 6)</p> <p>P = 2.6% (variable 7)</p> <p>P = 1.8% (variable 8)</p>
<b>Interpretation</b>	<p>Five of the ten project variables correlate with the success variable percentage delivered. It can well be that the same underlying effect is measured multiple times, but from different angles. For instance, presence of enterprise architecture and the presence of the domain architecture may be linked by the architectural maturity of the customer's organization. To understand this result more fully, it is necessary to analyze the interaction between project variables (however, see page 102). We can conclude that application of enterprise and architecture is correlated with a substantial increase in percentage delivered.</p>
<b>Consequences</b>	<p>Analyzing the differences in percentage delivered for the five project variables, we can conclude that application of enterprise architecture is correlated with an increase of the percentage delivered of the project with approximately 10%.</p>

Table 7-7. Results for Percentage Delivered

### 7.3.7 H<sub>0</sub> statement VII – Functional Fit

<b>H<sub>0</sub> Statement</b>	<p><i>Application of enterprise architecture is not significantly correlated with the expected value of the functional fit.</i></p>
<b>Finding</b>	<p>None of the variables tests significant. H<sub>0</sub> Statement VII is not rejected.</p>
<b>Conclusion</b>	<p>The functional fit delivered by projects, is not correlated with application of enterprise architecture.</p>
<b>Interpretation</b>	<p>This result can be explained by considering the mechanisms of IT project development. It is the business decides on the functionality of the project; i.e., business answers the <i>What</i> question. IT is responsible for building the solution; in other words, IT is responsible for the <i>How</i> question. It is therefore understandable that architecture is correlated with the quality of the transformation (as indicated by the other success variables), but not with delivered business functionality.</p>

Table 7-8. Results for Functional Fit

### 7.3.8 $H_0$ statement VIII – Technical Fit

<b>H<sub>0</sub> Statement</b>	<i>Application of enterprise architecture is not significantly correlated with the expected value of the technical fit.</i>
<b>Finding</b>	Project variable 5 ( <i>Quality of the project architecture</i> ) tests significant. H <sub>0</sub> statement VIII is rejected.
<b>Conclusion</b>	An increase in the quality of the project architecture correlates significantly with an increase of technical fit.
<b>Significance</b>	P = 0.3%
<b>Interpretation</b>	This result is in line with the interpretation for statement VII. Architecture is correlated with the quality of the transformation, which includes the technical fit (performance, security, availability, etc.).

Table 7-9. Results for Technical Fit

### 7.3.9 Project variables without significant correlations

In our survey, there are two project variables (Variable 2: Certification of the Architect, Variable 9: Controlling Architect) for which no significant correlations were found. We will discuss this lack of results and try to find an explanation for it.

#### **Project Variable 2. Certification of the Architect**

Architect can be certified at four levels:

- Level 1** – Architect
- Level 2** – Senior Architect
- Level 3** – Enterprise Architect
- Level 4** – Global Architect

Architects are certified to provide visibility to the customer about the capability and experience level of the architect and to award the architect for his or her ability in the architecture craftsmanship. The reason for including this variable into the survey, was the assumption that more experienced architects provide a better architecture processes and deliverables, which – consequently – would provide better results for the projects. However, no such relation was found.

When investigating this lack of result, it was found that many experienced architects (who would be eligible for some higher architecture certification level) actually were not certified at their experience level. Because of this, the certification level of architect became meaningless in relation to project results, because the certification level is not clearly linked to the experience of the architect. Therefore,

it is not surprising that we did not find correlation between Certification of the Architect and project success.

### ***Project variable 9. Controlling Architect***

With the term *Controlling Architect* a solution architect is meant which is present during the execution of the project and his or her as main role is to control whether the actual implementation of the project is executed according to the design described in the solution architecture. If discrepancies occur between the actual implementation and the design, then the role of the controlling architect is to signal this discrepancy. He will discuss this with the project manager and the enterprise architect. If there is no solution found at this level, then the discrepancy can be escalated to respectively the program manager, the steering committee or the business sponsor. As a solution, the discrepancy may permanently or temporarily be allowed or, when the decision is negative, the project manager may finally be required to change the actual implementation according to the solution architecture. When we included this project variable into the survey, our assumption was that the presence of a Controlling Architect would have measurable impact on project success.

This variable is closely related to project variable 8 and 10 (*Architecture Governance Process* and *Architecture Compliancy*). Variable 8 asks whether an escalation process is in place and variable 10 asks whether there is an architecture compliancy process in place. Variable 8 and 10 are significant for three  $H_0$  statements. Variable 8 is correlated with a decrease in *Project Overrun* and an increase in *Percentage Delivered*, while Variable 10 is correlated with a decrease in project time overrun. So why do we not find a similar correlation with project variable 9?

There are multiple implementation solutions available for implementing the architecture governance and compliance processes. Using a controlling architect is one of the possible implementation choices. When investigating this issue, it was found that various organisations had different implementation mechanisms in place for implementing architecture governance and compliance processes. Sometimes, the concept of a Controlling Architect is used, but also in many situations other solutions are used.

As a consequence, the project variable became meaningless because the presence of a controlling architect as such was not a determining factor for the success of the project.

## 7.4 Limitations of the Analysis

### 7.4.1 The role of Second-Order Effects

Table 7-1 demonstrates that multiple project variables may correlate with the same success variable. For example,  $H_0$  statement III (Expected value of project timeframe) is correlated with the project variables 5, 6, 7 and 10 (*Quality of the project architecture*, *Quality of the domain architecture*, *Quality of the enterprise architecture* and *Architecture compliancy testing*). These variables are correlated with respectively 55%, 44%, 46% and 56% lower time overrun. Can we conclude from these figures that the project variable *Quality of the project architecture* (project variable 5) on its own is responsible for 55% decrease in time overrun? The answer is no, because there are multiple variables or combinations of variables responsible for the decrease in time overrun. See the example below.

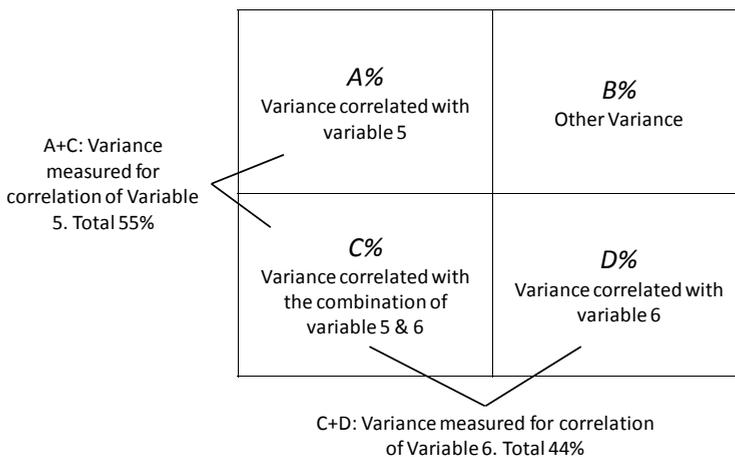


Figure 7-3. Analysis of Variance for Project Timeframe using Two Project Variables

Figure 7-3 shows a breakdown of the variance for the success variable *Project Timeframe* for the project variables 5 and 6. The total variance is split out into four components: variance that can be explained by the combination of variable 5 and 6, variance that can be explained by variable 5, variance that can be explained by variable 6 and remaining variance that cannot be explained by either 5 or 6. From our measurements, we know that A and C together is equal to 55% and that C and D together is equal to 44%. However, we are not able to determine the variance that results from the interaction between the two variables, which is represented

by the value of C. In other words, we can determine the total variance for variable 5 or the total variance for variable 6, but we cannot determine the combined effect of both variables, because this is equal to the measured variance of variable 5 (55%) plus the measured variance for variable 6 (44%) minus the combined effect (C%) which is unknown. In reality, we are not dealing with two variables, but with multiple variables, and the number of second-order interactions between  $n$  variables increases quadratic with increasing  $n$ . (The number of second-order interactions between  $n$  variables is equal to  $n(n - 1)/2$ .) On top of this, there are third-order interactions, fourth-order interactions, etc.

### 7.4.2 Measuring Second-Order Effects

In the paragraph *Minimum Sample Size* (page 81) is shown that the average sample size is approximately 16 projects. When testing simultaneously two project variables with a  $H_0$  statement, then the average sample size becomes  $49 / 3^2 = 5.4$  projects. However, the minimum sample size is 6 projects (see page 82), which means that the average sample size is less than the minimum sample size. In addition, variance in sample sizes means that some samples will be very small. For instance, a breakdown of the results of project variable 5 (Compliance Testing) and project variable 10 (Project Architecture) gives the following results:

		5. Compliance Testing Answer			Total
		1	2	3	
10. Project Architecture Answer	1	3	13	8	24
	2	1	3	11	15
	3	0	0	6	6
Total		4	16	25	45

Table 7-10. Sample sizes breakdown for project variables 5 and 10\*

Since five of the nine samples in this analysis are smaller than the minimum sample size, the results are unreliable. The size of the survey does not allow a test of two (or more) project variables simultaneously. The conclusion is that we are not able to measure second order (or higher order) effects. To test a  $H_0$  statement simulta-

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\* Four of the 49 project did not answer this question, therefore the number of projects in this analysis is 45.

neously for two project variables – with the same average sample size of 15 – we need a survey size of 135 projects.

### **7.4.3 Consequences of this Limitation**

The consequence of only being able to measure first-order effects is that we have to be careful when interpreting results. When drawing conclusions for a project variable, then we have to take into account that we are measuring not only a single variable, but we are measuring the effect of this variable combined with the interaction of this variable with other variables.

As a result, we cannot exactly determine which project variables are correlated with an effect. In the example of the previous paragraph, we cannot say that variable 5 is responsible for 55% decrease of time overrun. We can only say that variable 5, *in combination with the variables it interacts with*, delivers a combined effect of 55%. However, we do not know the variables it interacts with and we do not know the size of this interaction.

In addition, we are not allowed to combine the results or draw conclusions from the combination of project variables. For example, in the above example we cannot say that a combination of project variable 5 and variable 6, delivers a specific result, or that variable 5 without variable 6 will deliver a different result. The project variables that we have measured are not independent from each other and influence each other in ways we are not able to determine.

However, we must also realize that measuring (only) the first-order effects does not imply that these results are not reliable or not real. The results are real and can be trusted; the limitation of the measurement is that we are not able to determine the exact, individual correlation of project variables with a success variable. We need to keep this limitation in mind when discussing the results.

## 7.5 Results Summary

### 7.5.1 Main Results

Table 7-11 below gives an overview of the main results. Use of solution architecture is correlated with the following effects:

Statement	Paragraph
(a) 19% decrease in project budget overrun	7.3.1
(b) Increased predictability of project budget planning, which decreases the percentage of projects with large budget overruns from 38% to 13%	7.3.2
(c) 40% decrease in project time overrun	7.3.3
(d) Increased customer satisfaction, with 0.5 to 1 point – on a scale of 1 to 5	7.3.5
(e) 10% increase of results delivered	7.3.6
(f) Increased technical fit of the project results	7.3.8

*Table 7-11. Overview of Main Results*

These results demonstrate that using solution architecture is correlated with substantial, positive effects on project success variables. For instance, result (b) means that the percentage of projects with large overrun is decreased by 25%. This difference is substantial and this scale of improvement justifies the application of development of projects under architecture. The average project size in the survey is € 700.000. Result (b) indicates that the use of solution architecture is correlated with a saving of approximately € 140.000 for one out of four projects. On an average project portfolio, this will save annually millions of Euros. Comparable considerations can be identified for the other main results.

Of course, there is a cost associated with building up and maintaining the architecture processes and capability. These costs need to be balanced with the savings. Still, cost is only one of the aspects when taking the choice to implement an architecture function. There are other factors that are also positively influenced by architecture, which are not directly related to financial cost considerations, but are also important for the success of IT within an organization, such as increased customer satisfaction and decreased project time overrun.

### 7.5.2 Survey Conclusion

We can state that – for the projects part of our survey – solution architecture has a positive influence on project results. It is interesting to note that all the significant

correlations between project and success variables are positive; e.g., use of solution architecture is correlated with decrease in project budget overrun, increase in planning reliability, decrease in project time overrun, etc. A ‘better’ value of an architecture-related project variable correlates with a ‘better’ outcome of the success variable, *for all identified significant correlations*. We did not identify positive-negative correlations, where a ‘better’ value of an architecture-related project variable is correlated with a ‘worse’ value of a success variable.

This positive-positive trend gives an intuitive confirmation that the use of architecture is beneficial for projects; use of architecture does not counteract project objectives.

## 7.6 Relation to Other Research

### 7.6.1 Effect of Project Variables on Project Success

The finding that project variables can have correlations with multiple  $H_0$  statements is interesting. When tallying the number of  $H_0$  statements that correlate significant with a project variable we find:

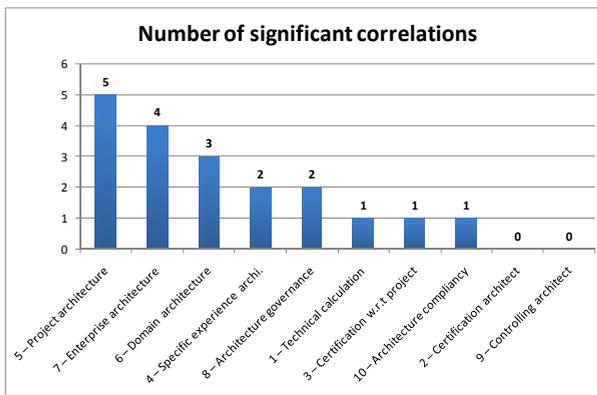


Figure 7-4. Number of significant  $H_0$  statement correlations for each project variable

Project variable 5 (*Quality of the project architecture*) has the highest score and correlates with the  $H_0$  statements II, III, V, VI and VIII (*Reliability of project budget planning, Project time overrun, Customer satisfaction, Percentage delivered and Technical fit of the project results*).

The fact that one project variable is correlated with five different success variables, implies that this project variable must describe some essential key-element of project success.

## 7.6.2 Comparison to Standish CHAOS Reports

### Top Ten Success Factors

The Standish group (1999; 2001) has published top 10 of project success factors. The 2001 version of the report mentions the following main success factors:

	Factor
1.	Executive support
2.	User involvement
3.	Experienced project manager
4.	Clear business objectives
5.	Minimized scope
6.	Standard software infrastructure
7.	Firm basic requirements
8.	Formal methodology
9.	Reliable estimates
10.	Other (Small milestones; Proper planning; Competent staff; Ownership)

Table 7-12. Overview project success factors (Standish report 2001)

Contrary to our findings, this list does not contain any design or architecture factor. An explanation for this is that at the time of this research (1995-2000), enterprise architecture was not widely used or known. The value of enterprise architecture was not a topic for IT executives, project managers or project staff and was obviously not identified by the Standish researchers. We feel that architecture should be on this list, because our research shows that architecture is a major project success factor.

Other researchers do value the constructive role of enterprise architecture. For example, the US National Research Council states in a review on FBI's Trilogy Information Technology Modernization Program that "if the FBI's IT modernization program is to succeed, the FBI's top leadership [...] must make the creation and communication of a complete enterprise architecture a top priority." (McGroddy, et al., 2004 p. 49). This statement acknowledges the value of enterprise architecture for system development initiatives and is in line with our conclusions.

### Project Size

One of the other conclusions from the original Standish Chaos report (1999) is that the success rate and the size of the project are linked. The lower the project cost, the higher the success rate. They provide the following figures:

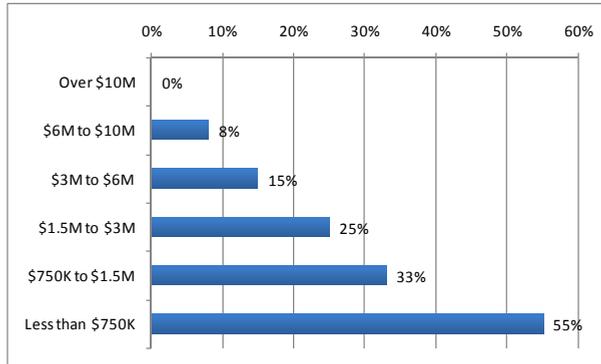


Figure 7-5. Project success rates (Standish Chaos Report, 1999).

If we correlate in our research the size of the project with the budget overrun, we find the following result:

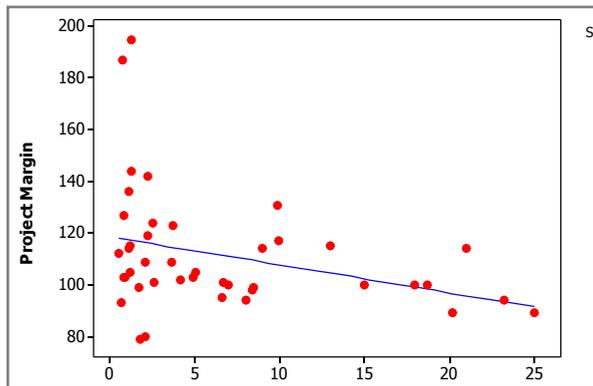


Figure 7-6. Correlation between project cost and margin

The vertical axis describes the percentagewise budget overrun or underrun. The horizontal axis describes the total cost of the IT project ( $\times 10^5$ ) in Euro's. Key figures of this correlation are:

Figure	Value
p	0.035
r <sup>2</sup>	8.4%
Correlation formula	$Project\ Margin = 118.6 - 1.1 \cdot 10^{-5} * Project\ Cost$

Table 7-13. Key figures for the linear correlation between project cost and margin

The correlation that we find between project cost and project margin is that projects become *more* successful with increasing projects size. This is a contradiction to the findings of the Standish report, because they find their projects become *less* successful with increasing project size. The figures are not exactly comparable, because Standish defines project success as a combination of on time, on budget and with sufficient functionality. Our correlation only considers cost overrun. Still, the trend is clearly contradictory.

In discussion with project and risk managers about the reason for our finding, the following explanations are given:

1. For small projects the initial planning effort in determining the project cost, is much smaller than for large projects. As a consequence, the project cost estimations for small projects are less reliable and the complexity of the project may be underestimated.
2. For small projects, it is very difficult to overcome a project setback within the existing budget. If a small two-month project has a setback which delays the project for one month, than the budget overrun in absolute terms may be small, but percentagewise the overrun is 50%. For large projects, this type of small setbacks can be absorbed within the existing project budget and the risk margins.
3. For large projects you have the time to rethink (part of) the solution and learn from lessons earlier in the project. For small projects, if you are halfway through the project and then find out that the original solution needs adjustment, there is no time or budget to redesign.

These arguments provide an explanation for finding that increasing project size correlates with higher project success.

## Conclusion

If we try to explain the discrepancy between our results and the findings from the Standish report with our results, then we must realize that our survey projects is limited to a project size of € 2.5M, while the Standish report examines projects up to and over \$ 10M. This may explain the difference. The arguments above describe the reasons why small projects (< € 1M) have high overruns; the arguments are not relevant for projects above € 2.5M. It is possible that the decreasing trend that we have identified will revert to an increasing trend for larger projects.

## 7.7 Applicability of the Results

The study that we conducted was carried out in a rather uniform context; the context of a commercial IT service provider. Are the conclusions from the current context also applicable in other contexts? To answer this question, we will look at some characteristics of the study and of results and see how this would fit in other contexts.

In § 5.5.3 (page 52) the probability density function for budget overrun for a Dutch financial institution is calculated (See Figure 5-5). We found that the cost overrun follows a lognormal distribution. On page 148 the probability density function for the budget overrun for the IT service provider is calculated. In this case, we found also a lognormal distribution but the parameters of the lognormal distribution differ substantially.

Parameter	Financial Institution	IT service provider
Threshold	15.3	64.9
Location	4.8	3.74
Scale	0.57	0.44
Mode	103	100
Mean	158	111
Median	137	107

Table 7-14. Comparison parameters lognormal distribution for budget overrun

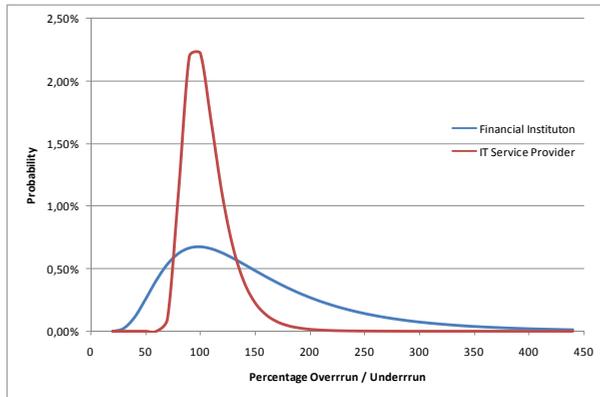


Figure 7-7. Comparison of normal distribution budget overrun

As can be seen in Table 7-14 and Figure 7-7, there are substantial differences in project budget overrun. The modes (most often occurring values) are virtually the same (100 versus 103), but the average budget overrun is in the situation of the Financial Institution considerable higher than for the IT service provider (58% versus 11%).

The conclusion from this comparison is that there are significant differences between various organizations, with regard to the variance in project budget outcomes and the resulting average budget overrun. Based upon this difference, it seems plausible that the figures we found for the architecture benefits (see Table 7-11) will be different too.