The Integration of an RE Method and AHP: A Pilot Study in a Large Swiss Bank

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***Abstract*—This paper reports on a pilot study of the integration between the Systemic Enterprise Architecture Method (SEAM) and the Analytic Hierarchy Process (AHP) in a requirements engineering project. The objective of the project, conducted in one of the major banks in Switzerland, was to select a common SOA tool that could satisfy the needs of two of the bank's main business units, investment and private banking. SEAM provided help in identifying stakeholders, eliciting their requirements, and analyzing these requirements. The resulting requirements were then grouped and translated into selection criteria for the alternative SOA tools. Based on these criteria, the stakeholders chose the tool to be purchased using AHP. We describe the project, the challenges we faced and the lessons learned. These relate to the nature and traceability of requirements, to the requirements elicitation process and to the relations between the bank's business units.**

***Index Terms*—Analytic Hierarchy Process (AHP), Banking, Requirements Engineering, SEAM, Service Oriented Architecture (SOA), Switzerland**

I. INTRODUCTION

The project described in this paper was done in Credit Suisse a bank headquartered in Zurich, Switzerland, hereafter referred to as the bank, from March to August 2011. The project lasted for six months during which one of the co-authors, Ms. Kyriakopoulou (referred to as the researcher in this paper), did her master thesis project in form of a research engagement in the bank. The goal of the project was to select a Service Oriented Architecture (SOA) tool for the bank. The bank needed methodological support to insure that the SOA tool, to be selected, will fit the requirements of both the Investment Banking and Private Banking business units. We took this opportunity to propose a pilot study in the use of SEAM, the Enterprise Architecture Method [1, 2] developed by our research group, and AHP [3] a well-known multi-criteria decision making method (MCDM). The application of AHP for requirements prioritization in requirements engineering dates back to 1990's, see for e.g. [4]. We have used SEAM in numerous projects in industry and have begun to use AHP as well. This project is the first time we tried to integrate both methods.

To report on the process the results and the findings of the pilot study, we have organized our discussions in the following way. In Section 2 we provide some background information about the bank and the context of the pilot study. Section 3 describes the process of the pilot study conducted to select the SOA tool. We present our findings and recommendations in Section 4 and Section 5 includes our conclusions and proposed future steps. Please note that the opinions and findings contained in this paper are those of the authors and do not reflect the views of Credit Suisse.

II. THE CONTEXT OF THE PILOT STUDY

The bank is a global organization with operations all over the globe, employing about 50,000 people. The project was conducted in its IT department in Switzerland. The IT department provides services to all the bank's departments, including two of its main business units, Private Banking and Investment Banking. Private Banking offers comprehensive advice and a broad range of financial solutions to private, corporate and institutional clients. Investment Banking provides a broad range of financial products and services, with a focus on businesses that are client-driven, flow-based and capital-efficient. The Investment Banking clients include corporations, governments, pension funds and international institutions.

To ensure agility and to achieve logical and operational decoupling, the bank implemented a component-based architecture in the late 1990's using CORBA [5]. This architecture was not homogeneously adopted by the Private Banking and Investment Banking business units. Whereas it was widely used in Private Banking, it was much less used in Investment Banking because Investment Banking believed that this architecture did not fit its needs. The Investment Banking culture is more oriented toward rapid implementation. CORBA was believed to induce lengthy development cycles, which are not compatible with the Investment Banking need for speed. On the technical side, CORBA was rapidly becoming obsolete being supplanted in most organizations. SOA in most organizations was built on CORBA. The challenge facing the bank was to sustain the SOA in light of the obsolescence of CORBA.

To overcome these two problems, the bank started planning to roll out a global modern SOA implementation project connecting all its local and international branches, in order to serve clients across business units with integrated

solutions via services. The bank had to choose a new technology fulfilling the requirements of its business units.

One of the main components of SOA with web services is known as the Web Services Description Language (WSDL) [6]. WSDL specifies a service and its interfaces. Recently, the web services concept was enhanced with the WSDL 2.0 standard, which addresses the "platform independent" aspects of SOA. The bank's initial assumption in the project was that adopting a WSDL 2.0 compliant tool would convince Investment Banking of the benefits of SOA via advanced web services. The aim of the project was therefore to select the SOA tool, preferably WSLD 2.0 compliant, that will fit the requirements of its both business units.

To help with the methodological aspect of the project, we proposed to use SEAM and AHP. SEAM is an enterprise architecture method that enables its users to model an organization from its position in a market segment down to the IT services and structure. The researcher followed our semester-long course titled "enterprise and service oriented architecture" [7, 8]. During the course the students learn to use SEAM for business-IT alignment, requirements engineering and enterprise architecture, implementing the results with an SOA tool. The content of the course equipped the researcher with the knowledge required for the pilot study such as familiarity with SEAM modeling technique, requirements engineering and SOA. This helped us with the development of the complete gamut of SEAM models during the project. These models helped to identify the stakeholders of the project and understand their pre-occupations, which led to capturing their requirements.

AHP is an MCDM that aids in the ranking and evaluation of alternatives based on a given number of criteria. MCDM methods are characterized by the evaluation of a finite set of alternatives based on multiple criteria. The main objective of an MCDM method is to measure the overall preference values of the alternatives. In the AHP process, after identifying the criteria and the alternatives, the decision makers conduct pairwise comparisons of criteria. This way, the weight for each criterion is calculated. Next, the decision makers do pair-wise comparisons of the alternatives based on each criterion. For an elaborate discussion of the algebraic calculations in the AHP process, refer to [3].
In the context of this project, SEAM models contributed to the identification of the decision makers who do the pair-wise comparisons (i.e., the project stakeholders) and the decision criteria (i.e., the requirements of the stakeholders). Thus, the information captured by SEAM models served as an input to the AHP.

III. THE SOA TOOL SELECTION PROCESS

Figure 1 depicts the steps taken in the project to define the selection criteria for the SOA tool. Later on in the project it became apparent that this process had to be amended. We elaborate on this in Section IV.

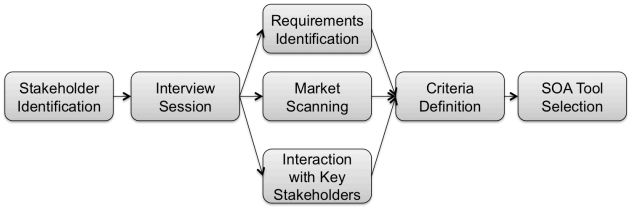

Fig. 1. The SOA Tool Selection Process

A. Stakeholder Identification

As illustrated in Fig. 1, the first step in the project was to identify the stakeholders. To this end, the IT systems of the Private Banking and the Investment Banking were modeled using SEAM.

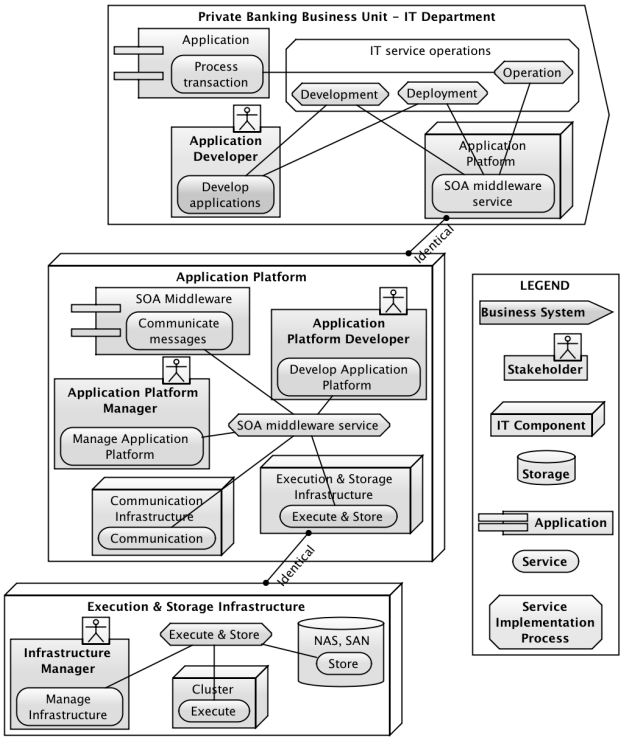

Fig. 2. SEAM model of the Private Banking Business Unit IT Department

Figure 2 is a SEAM model of the Private Banking business unit IT department. As illustrated in this model, the IT service operations process is composed of three sub-services: development, deployment and operations. To implement these sub-services, the application developer develops applications on the application platform. The application platform runs on the execution and storage infrastructure. SOA middleware service is mainly related to the application platform and the execution and storage infrastructure. Thus, we modeled the constituent elements of these two IT components. This representation helped us to identify all the stakeholders in the Private Banking IT department: application developer, application platform developer, application platform manager and infrastructure manager. The stakeholders in the investment banking IT

department were identified in the same way. Thirteen stakeholders were identified in total.

B. Interview Sessions

The thirteen stakeholders identified in the previous step were divided into three groups as illustrated in Table 1.

The key stakeholders had the highest stake in the project (i.e., directly affected by the project), a strong technical background in web services frameworks and were experienced in SOA implementation, but as we explained earlier they needed methodological assistance for the tool selection process. They were also well informed about the technical developments in the field. The primary stakeholders were indirectly affected by the project. Their interest, influence and knowledge of the subject were limited compared to the key stakeholders. Even though they were not the target of the project, they needed to be kept informed and their views incorporated into the requirements. The secondary stakeholders were those with low familiarity with the technicalities involved in the project that were unlikely to be closely involved in the project. Special efforts were required to ensure that their needs were met and their participation was meaningful.

TABLE 1. STAKEHOLDER GROUPS

Stakeholder Group	No.	Stake in the Project	Technical Knowledge
Key	4	High	High
Primary	4	Medium	Medium
Secondary	5	Low	Low -Medium

Semi-structured interviews were conducted with all stakeholders identified in the previous step. We adopted the seven-step interview design process (i.e., thematize, design, interview, transcribe, analyze, verify and report) in [9]. The questions were divided into five categories: platform independent level (i.e., the additional level of abstraction between the consuming application and the service provider); platform specific (i.e., interoperability with existing platforms, through language bindings.); transport level (i.e., routing, messaging, mediation and security services for runtime infrastructure); governance (i.e., defining, managing, monitoring and controlling services, registration and runtime endpoints), and product (vendors strategy for releasing, packaging and ease of initial product installation). For the stakeholders that were not based in Switzerland, the interviews were done over the phone. The level of the details discussed in the interviews depended on the group the stakeholder belonged to. The interview transcripts were sent to the interviewees for verification and getting their approvals.

C. Requirements Identification

We derived the beliefs and the goals of each stakeholder with respect to the prospective SOA tool from the verified interview transcripts. This was done by developing SEAM models that capture the goals and the beliefs of the stakeholders. In this modeling framework, goals are prescriptive statements that include a verb in imperative form to indicate a desirable or expected state, whereas beliefs are descriptive statements that reflects a stakeholder's understanding of itself and its environment. See [10] for more information. These models helped us in gaining a better understanding of the perspectives through which the stakeholder view and consider the prospective SOA tool. Fig. 3 shows one of the goal and belief models of the stakeholders identified in the IT department of the private banking business unit. It shows their perspective about the security of the prospective solution. As illustrated, the application platform developer and the application platform manager believe that security depends on the platform. As illustrated, this belief is originated and communicated by the infrastructure manager. Moreover, the application platform manager holds the belief "altering message headers weakens security" and thus formulates the goal "to instruct the developer not to alter message headers". For the application developer, this goal is translated to the belief "I am not allowed to alter message headers" and thus he formulates the goal "The code to preserve message headers in the code". These security issues however exist independent of the SOA solution that will be chosen. To capture the impact of SOA implementation, we need to understand the goals and beliefs of the application platform developer.

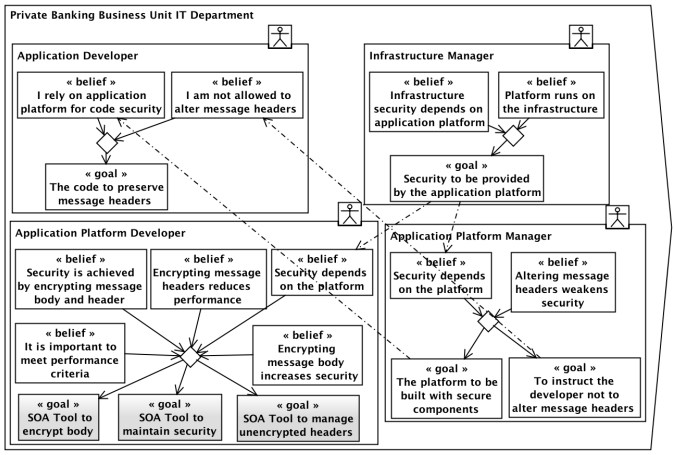

Fig. 3. Goals and beliefs of the stakeholders in the Private Banking Business Unit

Similar to the application platform manager, the application platform developer believes security depends on the platform. When it comes to communicating messages he believes encrypting message body increases the security, whereas encrypting message headers reduces the performance of the application platform. As he has to meet the security and performance criteria, he formulates the following three goals as his requirements for the prospective SOA tool: "SOA tool to encrypt message body", "SOA tool to manage unencrypted message headers", "SOA tool to maintain security".

This modeling procedure was followed iteratively to derive and cluster the goals and beliefs of all the stakeholders.

D. Market Scanning

A preliminary scanning of the market revealed seven tools to be potentially suitable for SOA implementation in the bank. Table 3 lists these tools and their key features.

Other tools were also identified that allow generating web services such as: gSOAP(C++), NuSOAP, Pear SOAP (PHP), etc. But as these tools do not offer functionalities broad enough with respect to the project scale, they were not considered as potential tools.

TABLE 2. SOA TOOLS AND THEIR KEY FEATURES

	Tool	Key Features
1	AXIS 2	Implementation is available in C/C++ and Java
2	CXF	Development of web services using frontend programming APIs, like JAX-WS.
3	WSO2	Implementation is available in C, C++, PHP, PERL, RUBY, PYTHON, JAVA.
4	METRO	Offers development of Web Services by using Java Technology APIs and tools powered by SUN JAVA. It consists of JAX-WS, JAXB, and WSIT.
5	JBossWS	It includes many specifications / standards implementations as well as tools to improve ease of use, endpoint management and monitoring.
6	Spring WS	Provides features such as configuration, transaction management, object-relational mapping, database abstraction, logging, etc.
7	WCF	It's based on .NET framework, can be developed using languages such as Visual Basic, C/C++, C# and Java.

E. Interactions with Key Stakeholders

Reviewing the SOA tools in the market revealed a number of other potential requirements that were not initially thought of and thus not discussed during the interviews. These requirements are described in Section IV. As it was not possible to re-interview all the stakeholders, we discussed these additional requirements with the key stakeholders.

F. Criteria Definition

The requirements driven from the interviews and the follow up interaction the key stakeholders were categorized in ten main decision criteria and over 30 sub-criteria, as listed in Table 3.

TABLE 3. CRITERIA AND SUB-CRITERIA

Service stack coverage - Java binding implementation of JAX-WS - .NET binding, compatibility with WCF C++ binding	**Name service lookup** - Group multiple endpoints against a single service instance - Look up capability of a physical endpoint - Service endpoint availability information
Service virtualization - Hiding the true location of services - Central or p2p functionality - Dynamic composition of endpoint address	**Protocols binding support** - SOAP over HTTPS - SOAP over JMS - SOAP over HTTP - COBRA
Decoupling of business - Physical endpoint lookup - Late transport and data binding	**Security** - Message body encryption - Managing unencrypted message headers
Routing and mediation - Bridge different transport technologies - Bridge different wire formats	**Service availability** - Notify of changes on availability - Metrics to measure the availability - Monitor active and inactive services
Message and wiring - Comma delimited wire encoding - JSON wire encoding - Non-SOAP XML encoding	**Service management** - Transport and context properties in metadata - Logging and auditing - Policy and SLA in metadata

Among the criteria listed, Service virtualization, Message and wiring, Protocols binding support and the details of Service stack coverage were added after the market scanning and the interaction with the key stakeholders.

G. SOA Tool Selection

Considering the decision criteria, we shortlisted the tools listed in Table from eight to three. For confidentiality purposes, we refer to these tools as solutions 1-3. We then proceeded with the evaluation of the alternatives applying AHP. As mentioned earlier the first step is to compare the decision criteria based on their relative importance. The alternatives will then be evaluated based on the criteria.

The stakeholders were given instructions on how to compare the criteria. Judgment is the key ingredient for stakeholders when evaluating the relative importance of one criterion over another. This subjective judgment is then translated into a numerical value, using a scale of 1-9 where 1 and 9 respectively denote equal and the highest degree of importance [3]. Table 2 illustrates the relation between the preferences, their corresponding value and the explanation.

In the pairwise comparisons, the underlying assumption is that if criterion 1 is absolutely more important that criterion 2, criterion 1 is rated 9. Thus criterion 2 must be absolutely less important and is thereby valued 1/9. The pairwise comparisons were carried out for all the criteria and sub-criteria outlined in Table 1.

TABLE 4. PREFERENCES, VALUES AND EXPLANATIONS IN AHP

Preference	Value	Explanation
Equal	1	Two criteria contribute equally to the objective.
Weak	3	Experience and judgment might favor one over the other.
Strong	5	Experience and judgment slightly favor one over the other.
Very Strong	7	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice.
Extreme	9	The evidence favoring one over the other is of highest possible validity.

Figure 4 presents the results for the criteria evaluation. As shown, the key and primary stakeholders participated in ranking the selection criteria.

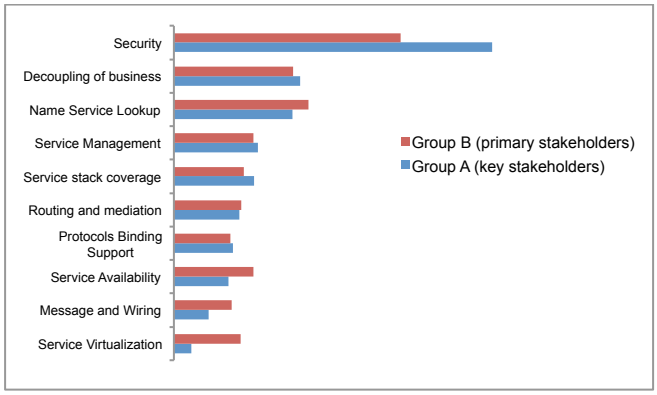

Fig. 4. Results of the stakeholders' comparison of criteria importance

Finally, the evaluation of the three SOA tools was done by the key stakeholders as they had the highest level of familiarity with the technical aspects of the tools. In Fig. 5,

we present the AHP results, comparing the performance of each solution based on the criteria outlined in section 4.1. As it can be seen Solution 2 was ranked first on the basis of meeting the ten decision criteria. This solution is not WSDL 2.0 compliant, despite the initial assumption that WSDL 2.0 compliance was an essential requirement of the future SOA tool. The reason for dropping the WSDL 2.0 compliance was the emergence of another criteria that entailed the choice of a tool that implemented an industry standard. There was no prospect for WSDL 2.0 support in the market.

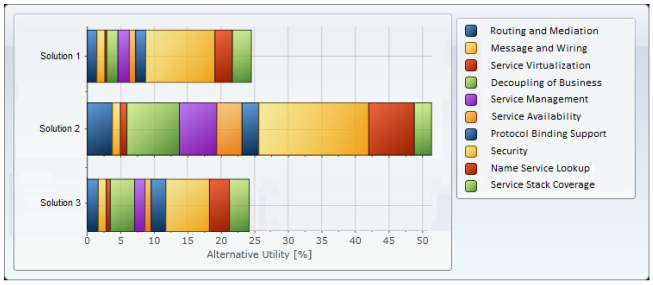

Fig. 5. AHP Results: ranking of the alternatives based on the criteria

IV. Finding and Recommendations

The findings of the pilot study relate to the selection process, the modeling, the use of AHP, the main objective of the project and the selected tool.

A. Amendments to the Tool Selection Process

In retrospect, it became apparent that the tool selection process shown in Fig. 2 was too simple to insure the traceability between requirements and criteria. Some of the detailed technical criteria that were used in the evaluation phase did not come from stakeholders requirements expressed in interviews. They came from an in-depth understanding of the features provided by the alternative tools in the phase we call "Market Scanning." It would have been very valuable to have this understanding before the interviews but at the same time simply experimenting with the alternative tools without interacting with the stakeholders would not produce an in-depth understanding either. We propose an iterative process where several phases of understanding the alternative tools are interleaved with stakeholder interviews. In Fig. 6, we show an example process with two-phase market scanning and stakeholder interviews. We believe that by following such a process, a better traceability will be maintained between requirements and selection criteria. Although not new, this finding is often glossed over in the practice of requirements engineering.

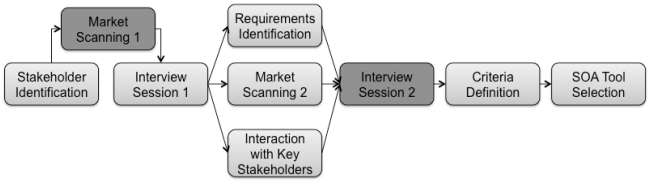

Fig. 6. The amended selection process

B. The Use of Models

The models made during the project were mostly done on paper, see Fig. 7 for example. Some of them have been transformed into electronic form. These models only partly adhered to the SEAM specifications. They were approximately correct models, but they were nevertheless useful to the stakeholders, not because they were correct but because the stakeholders could verify their understanding of the project with the help of the models. It is therefore important to note that we cannot expect industry people to do the same models that researchers do in the lab. Once the model is good enough for the stakeholders, it is a waste of time to make it "more correct".

Fig. 7. Models with stakeholders

C. The Merits of the Goal Belief Models

Goal belief models reflect the opinions that stakeholders express in interviews. These opinions are often very personal. It is quite difficult to put them verbatim in presentations and reports. To publish these models, even internally in a company, it is necessary to make them impersonal by removing the names of the stakeholders and sometime toning down what they expressed. Surfacing these opinions in the form of beliefs requires deep listening skills as well as attention to the social context.

One of the added values of the models is for the requirements engineer to acquire a better understanding of the stakeholders. Each model corresponding to an interview can be validated one on one with the stakeholder. So even though the models are not presentable as-is, they can still be useful. We have noticed this aspect in many other projects.

To the best of our knowledge, traditional requirements and software engineering methods do not provide the means for modeling stakeholders' beliefs. As a result, people's deeply held but often unstated preoccupations are not sufficiently surfaced. Based on our experience, these models are especially useful in the early stages of the requirements engineering phase, as shown in [10].

D. The Use of AHP

We had previously applied the analytic hierarchy process (AHP) in a project with a watch manufacturing company that involved selection of a workflow engine from the solutions available in the market. Our experience in this project showed that it is necessary to identify where the criteria used in AHP come from and to trace these criteria

back to the stakeholders and their requirements. The SEAM model helped us in identification of the stakeholders and their requirements and thereby served as an intermediary layer that linked the stakeholders and their requirements to the AHP criteria.

To aggregate the stakeholder's views and judgments in the evaluation and prioritization of alternatives by AHP, we calculated the geometric mean of the individual stakeholder's judgments and preference values. An alternative method for applying AHP in the group decision making process is that the stakeholders reach consensus on the importance of the criteria and the pair-wise comparisons of the alternatives. These two methods are the most well-established methods for applying AHP with groups [11]. This requires the simultaneous presence of all the stakeholders in the selection of the alternative. More importantly, in cases of conflict that are inherent in the organizational decision making process, the stakeholders have to compromise on their perception of the importance of a criteria or an alternative and thus their views may not be adequately reflected and incorporated in the selection process. We recommend the geometric mean as a better means of involving the stakeholders in the selection process in large-scale projects with multiple stakeholders that are geographically dispersed. We intended to utilize a web-based decision making software called MakeItRational [12] to gather the stakeholder's values for the pairwise comparisons and to do the AHP calculations online. However, as the computers in the bank did not support a certain application framework, the stakeholders were not able to open the link prepared for gathering their preference values. Thus the information was gathered by mailing Excel sheets to the stakeholders and the data was then entered manually in the Makeitrational web-based tool. A recommendation for future application of such web-based tools is to check the technical requirements and the compatibility with the existing applications within the organization.

E. The Main Goal and the Selected Tool

Recall that the main assumption of the project was that selecting a WSDL 2.0 compliant tool would convince Investment Banking of the benefits of SOA. The main goal was therefore to select a WSDL 2.0 compliant tool. As we described above, the final tool that was selected is not WSDL 2.0 compliant. Investment Banking was nevertheless convinced of the benefits of SOA. The reason is thought to be the involvement of Investment Banking in the project, more than the selection of WSDL 2.0. This shows that a project can be successful even if its basic assumption and therefore its main goal are not met, mainly because the necessary stakeholders are involved.

V. CONCLUSIONS AND PROPOSED FUTURE STEPS

It is often quite difficult to transfer methods developed in academia from the laboratory to industry. The case reported in this paper is one where several aspects were not conducted as straightforward as the theory suggests. The process followed should have been more iterative. The models were not as clean as when they are done for a research project but still useful. The result was somewhat surprising because the stated objective was not achieved but the project was nevertheless successful.

The lessons learned throughout this pilot study contribute to a better understanding of the issues of applying research results in industry practice. Researchers and practitioners should accommodate the expectations of one another, because as we have seen in this project, often times it is impossible to directly apply the methods developed by a research lab in an industrial context. Likewise, by taking the risks associated with applying a method that is not industry grade, practitioners may be able to benefit from the potential added value such methods can provide. In the case of this pilot study, we combined a well-known decision making method implemented by an off-the-shelf tool with a requirements engineering method developed in our research lab. This combined application of multiple methodologies is referred to as multimethodology [13].

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