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ISEBA – A Framework for IS Evolution Benefit Assessment

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Abstract: Decisions regarding information system evolution strategy, including modernization or replacement, are economically significant. Selection of a proper method for analyzing potential options, acquisition of suitable metrics or follow-up data, and evaluation of the results are major challenges in the evolution strategy decision making. In order to address these challenges, a framework for Information System Evolution Benefit Assessment (ISEBA) was developed. ISEBA provides assistance in the selection of a benefit-evaluation method for the investment situation at hand. It is based on empirical research on industrial decision making and co-operation projects, and examination of existing research results from information technology investment-evaluations. Based on the experiences from real world industrial cases, it can be alleged that ISEBA suits its purpose. It makes a decision maker take note of relevant issues in evolution investment decision making, leads to the selection of suitable appraisal method, and promotes discussion of the value of the results. Among the results of the industrial cases, the following was found. Firstly, resources are an important factor influencing the selection of an investment assessment method. Secondly, the appearance of both tangible and intangible benefits is scattered with respect to time and organizational structure. Thirdly, a dichotomy exists between upper management decisions and lower level organizational goals. The benefit appraisal was focused on an operative level while real project objectives were set on a strategic level. It is concluded, that a need for a practical framework, such as ISEBA, exists.

Keywords: IS evolution strategy, benefit assessment, industrial decision making, investment options evaluation

1. Introduction

Maintenance has a significant role in the information system (IS) life cycle. Depending on the publication time and scope of studies, 50-90% of the total IS expenses are caused by operation and maintenance activities (Lientz and Swanson, 1981; Erlikh, 2000). According to Lehman's first law, maintenance is necessary because software needs to be continuously improved or its ability to respond to the requirements of its environment decreases in time (Lehman et al., 1998). The inability to modify software rapidly may cause difficulties in exploiting new market opportunities (Bennett, 1995).

The amount of resources used on system evolution activities increases as information systems age. This creates the so called "legacy dilemma" (Bennett, 1995). On one hand, a legacy system is often business critical and has accumulated vital information during time. On the other hand, it is typically large in size, uses out-of-date technology and is laborious to maintain. Yet, it remains in operation because user organization cannot manage without it. There are three elementary strategies (Bennett, 1995; Seacord et al., 2003: 8-10) to deal with a legacy system: 1) continuing maintenance, 2) replacing the existing system, or 3) modernizing it. Modernization means improving the system in such a radical manner that it cannot be classified as traditional maintenance while a significant proportion of the legacy system is conserved (Seacord et al., 2003: 9). Replacement implies that existing legacy system is deserted and a substituting system is either purchased or developed (Seacord, 2003: 10).

Modernization and replacement are significant economical investments. Consequently, decisions regarding these should be made carefully. IT investment options can be analyzed with respect to their value, cost, and risks (Parker et al., 1988: 5) or the benefits that they yield (Ashurst and Doherty,

2003). In this paper, the term benefit is defined as the *overall benefit* of system evolution investment, i.e. the sum of positive and negative impacts, which can be either tangible or intangible or both.

In a literature survey, two frameworks that support the selection of benefit evaluation methods were found (see Farbey et al., 1992; Andresen 2002). In this paper, the existing models are re-developed and fitted into the IS evolution context. As a result, a model for IS Evolution Benefit Assessment (ISEBA), is presented. The rest of this paper is organized as follows. In chapter 2, current state of IT investment evaluation is discussed. Chapter 3 presents the ISEBA framework. Chapter 4 reports on the experiences when applying ISEBA in real world IS evolution cases. Finally, a summary and conclusions are given in chapter 5.

2. Evaluation of IT Evolution Investments

Recent research results show that there is an increasing pressure to show return on IT investments but IT executives and decision makers feel unable to compute it accurately (Verhoef, 2002; Koskinen et al., 2005). This is not due to a lack of evaluation methods but rather due to their oversupply. Andresen (2002) found in his literature survey 82 IT investment evaluation methods, each of which is suitable for specific type of investment situation. These include methods for measuring both tangible (i.e. quantitative or financial) and intangible (i.e. qualitative) benefits. The selection of a proper method from such a variety can be seen as a major challenge. Andresen's list of evaluation methods was delimited and supplemented with the methods that were recognized useful in real life IS evolution evaluation cases described in chapter 4 (see Table 1).

Table 1: IS evolution evaluation methods (Adapted from Andresen 2002).

Tangible methods	Intangible Methods
Accounting rate of return (ARR)	Critical success factors (CSF)
Capital investment appraisal	Delphi approach
Cost estimation	Exit of problems
Cost-benefit analysis (CBA)	Expectations analysis
Cost-effect analysis (CCA)	Experimental methods
Cost-revenue analysis (CRA)	Multi objective – multi criteria (MOMC)
Critical success factors	Portfolio analysis
Discounted cash flow analysis (DCF)	Present state analysis
Discounted payback method	Favored functionality analysis
Information economics (IE)	User satisfaction survey
Internal rate of return (IRR)	Value analysis
Net present value (NPV)	
Payback method	
Profitability index (PI)	
Real options method	
Return on investment (ROI)	
Return on management (ROM)	
Savings in employee-work-years	
Total cost of ownership (TCO)	

Dehning and Richardson (2002) conducted a literature review on studies covering the impacts of IT on firms' performance in 1997-2001. In most of these studies, IT investments have been evaluated with the means of direct performance measures or accounting measures. Financial investment evaluation methods, however, are not uniformly suitable or sufficient (if used alone) for every situation. If a method is selected carelessly, the results may recommend a refusal of a potential investment proposal simply because the selected method ignores a relevant factor (Ross et al., 1998). Respectively, an unprofitable investment may appear attractive if improper analysis methods are used. The fundamental ideology that influences the judgment of IT investment options is that the benefits should be greater than the costs. This leads the decision makers quite naturally to a situation where they try their best to measure the benefits in terms of money even if it does not seem quite possible. In the context of IS evolution, the impact of modernization or replacement may appear in form of intangible benefits, which cannot be detected by financial measures. In those cases, value can be used as a substitute of benefit (Parker et al., 1988: 64). On the other hand, modifying the intangible benefits into monetary terms may be so resource consuming that evaluation itself becomes unprofitable.

Besides the method selection, the acquisition of suitable metrics or follow-up data and evaluation of the results are major challenges in the evolution strategy decision making. In order to conduct a

benefit assessment for investment options, a company needs to gather IT-related data concerning its own activities to support management decision making (Verhoef, 2002). This presumes the existence of a proper metrics program and follow-up. A related risk is that selected metrics do not capture the value of IT (Verhoef, 2002). Metrics and follow-up data are to be conversed in a commensurable format before a cost-benefit or other analysis can be carried out (Erdogmus et al., 2004). Data conversion may be tricky if benefits appear as soft issues, which are difficult to express in terms of money. In order to avoid confusion with data conversion, the expected benefits should be identified before data acquisition.

A careful consideration of operational environment and organizational context is a prerequisite for a successful IS migration (Bergey et al., 1997). Issues to be considered are: role of the evaluation, decision environment, role of the system, characteristics of the organization, and cause and effect relationships (Farbey et al., 1992).

As a solution to the first challenge, Farbey et al. (1992) developed a model for matching an IT project with an evaluation method. A suitable method for a project is defined by locating the situational factors into a matrix and comparing the result to the "techniques matrix". A decade later, Andresen (2002) continued Farbey's work and presented an extended framework on how to select an IT evaluation method in the context of construction industry. What is missing in Andresen's model, however, is transparency regarding the suggestion of a suitable evaluation method. Also, Andresen's model gives one an impression that after method selection, most of the work is done. In real life though, application of the selected method and executing related tasks are the most labour intensive activities in benefit assessment. A method may suit the evaluation purpose perfectly but the needed input data is not available or its acquisition requires work hours beyond limits. Additionally, Andresen's model does not provide guidance or instructions about the required data as an input for the suggested method. It does not take into consideration unsuitable methods but instead focuses only on finding suitable ones.

An interview study of 29 decision makers representing software supplier and user organizations showed that the problems in decision making are mostly related to a non-systematic and narrow-viewed approach. The interviewees were, in general, unsatisfied with their informal decision-making process and thought that estimates of benefits were difficult to achieve. They were hoping to be provided with tools to systematize the process and means to widen the scope of thinking and to acquire a new perspective. In this way, fabricated arguments for or against evolution options could be minimized. Also, information about the previous decisions was considered important if it was available. A prerequisite for a support method is that it is transparent in order to enhance the thinking process. A "black box" method is of no use. The complete results of the interview study are reported by Koskinen et al. (2005).

3. Framework for IS evolution benefit assessment

ISEBA is a framework for IS evolution benefit assessment. It is based on empirical research consisting of an interview study of industrial co-operation projects, and examination of the challenges of benefit estimation for IS evolution options. ISEBA provides assistance in selecting suitable, and ruling out improper methods, for an investment situation. Also, it obliges instructions about the metrics and follow-up data that the selected method requires as input. ISEBA consists of four phases: 1) Determination of method applicability, 2) Selection of methods, 3) Implementation of the benefit assessment, and 4) Decision making (see Figure 1).

Phase 1 consists of the following activities: Evaluation of investment characteristics and environment, identification of investment type (Schwartz and Zozoya-Gorostiza, 2000) and defining investment assessment emphasis, i.e. evaluation criteria. As a result of the activities in phase 1, the unsuitable methods for selected criteria are excluded from the pool of potential methods. A method is classified unsuitable if there is a risk that it produces misleading results on the investment proposal in the defined context or is unable to measure selected criteria. If there is a method that measures the selected criteria better than others, then this method gets a "mark of recommendation", which increases the odds of remaining in the pool of potentially suitable methods. A method is classified suitable if evidence of the suitability exists or if the method has no clear reason to be unsuitable. The classification of "suitable" or "unsuitable" is based on literature and real life experiences using ISEBA.

In phase 2, the selection of suitable benefit assessment method(s) takes place. The amount of recommendations provides reference of the suitable methods per evaluation criteria. The excluded criteria cannot appear in the group of recommended methods. Additionally, instructions on required metrics and follow-up data for recommended methods are given. In Phase 3, data acquisition is carried out and benefit assessment of selected evolution options is performed. Use of a systematic measurement planning method, such as GQM (Basili, 1992), is recommended. Finally, in phase 4 the results of benefit assessment are analyzed and valuated in compliance with organization's strategies. A decision is made regarding the most fit option. If more than one investment proposal is to be evaluated, it is defined in Phase 1. It is assumed, that prior to use of ISEBA, the potential evolution options have been identified. If there is uncertainty about the possible evolution options, use of a scenario tool, such as SABA (Bennett et al., 1999), is recommended.

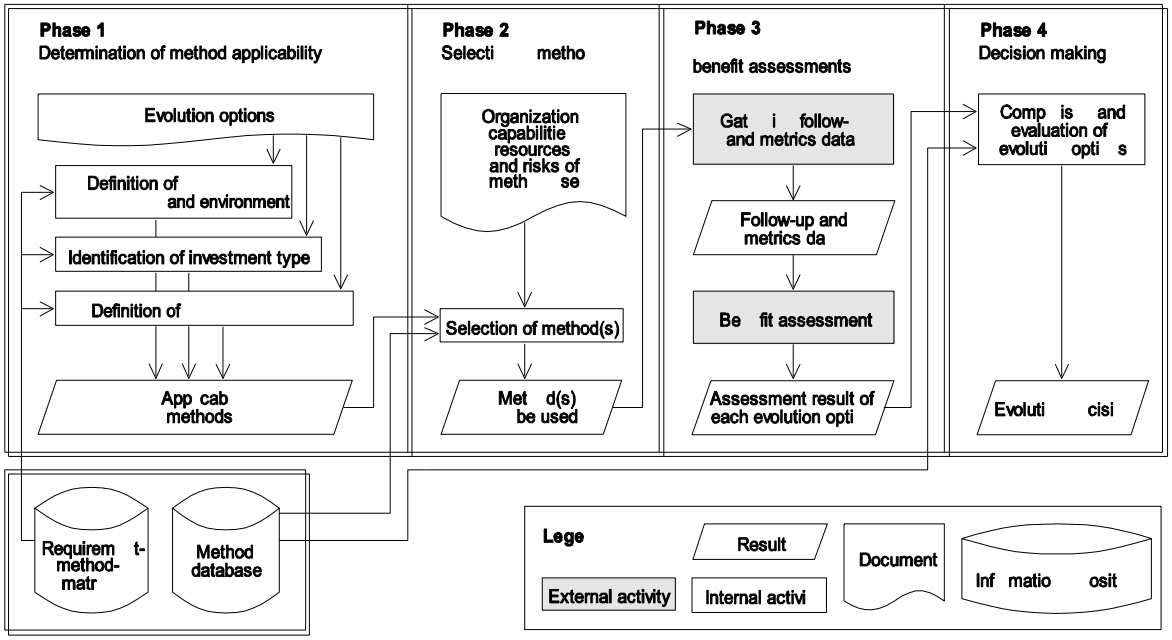

Figure 1: Structure of ISEBA.

ISEBA includes a method database consisting of the following information to support the framework: a requirement-method-matrix, description of required inputs, resources, and skills per method, and general guidelines for the interpretation of the results. As a result of phase 1, evaluation criteria form a "requirements profile" against which the suitability of methods is reflected. The requirement-method-matrix provides a listing of suggested (S) and not recommended (N) methods per evaluation criteria. Presently, it consists of 13 tangible evaluation criteria, 8 intangible evaluation criteria, and 19 criteria concerning the evaluation method, which can be related to 29 evaluation methods. The list of criteria and methods is up-dated on a regular basis as the research proceeds. An example of the requirement-method matrix is described in Table 2.

Table 2: An example of requirement-method-matrix.

Criteria	Attributes	AAR	CBA	IE	ROI	Value analysis
Use of resources	Evaluation should not use much resources. Inexpensive.	S	N			N *(Farbey et al., 1993)*
	Organization is prepared to allocate resources on the evaluation. Fairly expensive.			S *(Farbey et al., 1993)*	S *(Farbey et al., 1993)*	
	Carried out by professionals, involves various stakeholders or senior management. High cost.		S *(Farbey et al., 1993)*			S *(Farbey et al., 1993)*
Complexity of evaluation method	Simple and easy to use	S *(Ross et al., 1998: 245)*		N	S *(Curley, 2004: 70)*	
	May require professionals skills				S *(Farbey et al., 1993)*	
	Evaluation method can be complex			S *(Farbey et al., 1993)*		

A description of required inputs, resources, and skills per method, and general guidelines for the interpretation of the results are similarly parameters that are maintained as more methods and information become available.

The structure of ISEBA is described in more detail in Table 3. Description, prerequisites, tasks, and results are provided for each activity depicted in Figure 1.

Table 3: ISEBA, detailed description.

Phase	Activity	Description	Prerequisites	Tasks	Results
Phase 1	Evaluation of investment characteristics and environment	Investment characteristics and environment are defined.	Evolution options have been identified.	Consider • pressure for evolution investment • related uncertainty • relationship between evolution options	A preliminary elimination of unsuitable methods.
	Identification of investment type	Defines the post-investment evaluation timing.	Evolution options have been identified and agreed upon.	Identify the investment type • development project • purchase project	A preliminary estimate of the post-implementation benefit assessment timing.
	Definition of evaluation criteria	Evaluation criteria is defined and valuated with respect to the project goals.	Evolution options have been identified and agreed upon.	Consider • Which factors in an organization are most likely to reflect the potential benefits? • Are the potential benefits tangible or intangible? • On what business level will the benefits appear (operational or strategic level)? • Which criteria are more important than others?	Requirements profile. A list of suitable and not suitable evaluation criteria.
Phase 2	Selection of method(s)	The selection of potential methods takes place against requirements profile defined in phase 1. Information about input requirements of potential methods is provided by method database.	Evaluation criteria have been agreed upon and selections of phase 1 have been accomplished. List of potential methods is formed and available.	• Risks related to the evaluation methods are acknowledged. • The required inputs are assessed. • Complexity of methods is evaluated and compared to organizational skills. • Resource consumption of methods is assessed and compared to the available resources.	A list of evaluation methods to be applied.
Phase 3	Gathering follow-up and metrics data	The required input data for selected method is collected and processed.	Evaluation method(s) have been agreed upon.	• Data collection is planned. • Data collection and carried out.	A collection of processed data in the required format.
	Benefit assessment	Benefit assessment is carried out in accordance with the selected method.	The required data is available in required format.	• Benefit assessment is carried out. • Results of benefit assessment are summarized.	A summary of the evolution options benefit assessment.
Phase 4	Comparison and evaluation of evolution options	Decision about the potential evolution options is made. Attention should be paid to the reliability, accuracy and timing of benefit assessment results, and political interests of different stakeholders.	Sufficient amount of information of the potential evolution options is available and in commensurable format to support decision making.	• Results are analyzed with respect to the evaluation criteria and project goals. • Options are compared.	Organization is able to select the most beneficial evolution option that suits the organizational situation.

4. Experiences with using ISEBA

In this chapter, experiences of two real world industrial cases are discussed. The phase of ISEBA is referred with phase number (1-4) in the beginning of corresponding columns. Three parties were involved in the use of ISEBA: the user organization, the system vendor and the independent, external research group. Background information is provided as much as possible within the limitations of confidentiality.

Case 1
In case 1, the user organization was in the process of decision making concerning the evolution strategy of their invoicing system that was developed in the late 80's. The usability and maintenance of the system caused problems in everyday work. The existing invoicing system was originally tailored to comply with the organization's complex and unique business process. The introduction of a corresponding commercial off-the-shelf product was considered but it was discarded due to difficulty and high cost. Replacement with off-the-shelf product would have caused serious changes to the business operations and development of a new replacing system would have been extremely expensive. Hence, the possible evolution options were modernization or continuing the maintenance of the existing system.

(1) The organization was particularly interested in the potential benefits of modernization. The goal was to evaluate the potential effects of modernization from business value perspective and to produce information to support decision making. The emphasis of the evaluation was on intangible benefits appearing within a short period of time (c. 2 years). User satisfaction and system's suitability to organization's business processes were identified as important valuation criteria. In order to make a justified decision, project introducer needed more information on these issues. The criteria were a result of a meeting where representatives of user organization, vendor and independent researchers were present.

(2) Use of company resources was a central selection criterion for benefit assessment methods. The organization had a limited amount of work hours allocated on the benefit estimation. However, the participation of external researchers enabled the use of resource consuming methods. On the basis of these requirements, the analysis of user satisfaction and problem situations was selected as benefit assessment methods.

(3) Data gathering took place in two intervals. At first, user satisfaction was charted by an internet-based questionnaire with 30 respondents. After that, 25 employees took part in a four week problem situation follow-up. Data processing and analysis, and reporting of the results formed a significant portion of the total work hours.

(4) The results of data gathering and analysis indicated the current level of user satisfaction and problems related to system use. The representatives of user organization were surprised by the results of the user satisfaction questionnaire. Contrary to expectations, most of the system users were relatively satisfied and happy to use the current system. When analyzing the results of the benefit assessment, the results were compared to the overall organizational goals and strategies. As a result of the evaluation of modernization option, the organization decided not to modernize the existing system at the time being. Instead, a renewal of user interface in the future was suggested by the researchers.

Case 2
A decision concerning the strategy of a customer register developed during the early 80's was agreed upon. This legacy system was a central tool in the organization's business and had nearly 200 users. Maintenance was difficult and the system did not meet with the organization's present data requirements. Also, it was restricting company's future development options. Replacement was considered extremely costly. Modernization seemed as a natural option because the organization had a well established, long-term relationship with the system supplier.

The purpose of the evaluation was to verify the benefits achieved by the modernization on operative level. In the long run, the aim was to develop the organization's decision making process and adopt new working practices. A secondary goal was to assure system users of the positive impacts of modernization and by doing so minimize possible resistance of change. Top management had a

vision that modernization of their customer register would enable new business opportunities in the future, and even more importantly, would ensure company's survival in the rapidly changing markets. Measurement of these benefits, however, was considered difficult and resource consuming. Therefore, it was agreed that the benefits were not to be measured on a strategic level.

(1-2) Evaluation criteria were discussed in several meetings with the representatives of user organization, system supplier and independent researchers. As result, the technical quality and business value of the system, including user satisfaction, exit of system use related problems, preserving of system's good qualities, were selected as evaluation criteria. Tangible, i.e. financial benefits, were also considered interesting. It was soon realized, however, that data needed for financial calculations was only partially available and completing it afterwards would have required a significant amount of work. Expected benefits were only partially transformable into monetary units. Nevertheless, it was agreed that the available financial data should be utilized. On the basis of the requirement profile, it was concluded that present state and expectations analysis combined with a free form cost-effect analysis were the most suitable benefit assessment methods.

(3) For data collection, two measurements were planned, one before and one after modernization. In this way, the changes caused by the modernization could be detected. The focus of the evaluation was on system users. Data collection methods partially were chosen and developed on the basis of the previous industrial cases. As in case 1, user satisfaction was measured by a web-based questionnaire. System use related problems were charted by interviewing end users and following system use for a one week period. The favored qualities of the current system were studied by interviewing end users. The technical and business values of the customer register were discussed during interviews with technical and business experts representing both user and supplier organizations. After the completion of the project, the same measurements will be repeated. Approximately 100 employees took part in the data collection.

(3) Collected data complemented the previously made present state analysis by the user organization and vendor. A significant innovation was that in addition to problems and faults, also the good qualities of the current system should be charted. The identification of preferred features would enable the vendor to preserve them in the modernized system. Without this realization, there would have been a risk that those well functioning features could have been partially or completely replaced with less satisfying functionality.

(4) The results of current state and expectations analysis showed that the end users were somewhat more satisfied with the current system than was anticipated. During the problem follow-up period, fewer problems were reported than was expected. Technical evaluation verified that there were serious faults in the maintenance of the current system. The business value analysis showed that the customer register did not comply with the organizations current needs as it did a decade ago. These results were evaluated with respect to the measurement reliability and the organizational position of the persons who participated in data collection. The results of the current state and expectation analysis supported the decision to modernize.

5. Summary and conclusions

On the basis of the literature survey, it can be concluded, that the overall benefits of software evolution have not been studied comprehensively so far. Potential challenges related to evolution investment assessment are selecting an evaluation method, collecting required data, and valuation of the results. Inspired by these challenges ISEBA framework was created.

The experiences of case studies showed that ISEBA has the following advantages compared to an ad hoc decision process. Firstly, it makes a decision maker take note of relevant issues in evolution investment decision making. The structure of ISEBA incorporates different viewpoints towards evolution options. By following the framework the relevant issues are easily remembered. Secondly, the application of ISEBA leads to the selection of suitable appraisal method, and promotes discussion of the value of the results. In an early phase of system evolution decision making, the data requirements of potential methods are discussed. When doing so, it can be seen which input data is available or collectable. Through conversation this becomes clear to all stakeholders. Also, when selecting the data collection methods, the organization's maturity on their use should be considered. Familiar methods are more easily accepted than new ones. The time aspect is relevant to

development projects where the first benefits may emerge only several months after the completion of the project. Therefore, timing of the benefit evaluation should be carefully planned.

Among the results of the industrial cases, it was found that resources are an important factor influencing the selection of an investment assessment method. Therefore, the labour intensity of potential methods should be known as early as possible. Also, the user organization should decide how much resources they can allocate on evolution options evaluation before they start the evaluation process. Additionally, it was found that, the benefits of modernization tend to appear in both tangible and intangible format and are scattered with respect to time and organizational structure. Because of this reason the viewpoints of different organizational levels (i.e. users, maintainers, managers) should be taken into consideration. For instance, the top management often sees the benefits from strategic perspective while middle-level management or end users may consider operational benefits more relevant. An interesting finding in case 1 was that, a dichotomy exits between upper management decisions and lower level organizational goals. The benefit appraisal was focused on an operative level while real project objectives were set on a strategic level. These different views should be compared to the goals of the intended evolution activities in order to find out the core benefits.

Based on the experiences from real life cases, it can be alleged that ISEBA suits its purpose. However, the results presented in this paper are derived from only two cases and therefore cannot be generalized as such. In the future, ISEBA as a framework requires more empirical validation. The method information database should be also be complemented.

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