A Framework for Assessing the Cost of IT Investments

Per Närman[1], Teodor Sommestad[1], Sofia Sandgren[2], Mathias Ekstedt[1]
[1]Industrial Information and Control Systems, KTH, Stockholm, Sweden
[2] IBM Svenska AB, Stockholm, Sweden

Abstract--**Assessing life cycle costs of IT is a difficult endeavor. There are several factors that contribute to the life cycle costs of IT. Many of these factors are of a technical nature, such as development costs or integration costs. A substantial part of the costs are, however, caused by organizational factors such as the changes the introduction of an IT-system impose on business processes and the temporary loss of productivity this causes, or the cost of training system users before taking the system into operation.**

This paper proposes a framework for IT investment cost assessment. The framework integrates factors as proposed by already existing IT cost estimation frameworks and literature on the subject to be able to take into account both technical and organizational factors and cost drivers related to IT life cycle costs. The framework assists in quantifying these factors together with the costs they influence thereby providing more complete and accurate decision-support to executives faced with having to make investment decisions. The paper also describes how the framework's usefulness has been validated in two case studies at a large Nordic power company.

I. INTRODUCTION

The use of Information Technology (IT) permeates all modern organizations; virtually every existing business process is supported by some sort of IT solution. As a consequence, IT-related operational and capital expenditures consume a substantial part of the overall budgets. This was illustrated in a survey of the IT spending of 2007 by Gartner where it was reported that IT costs consumed 4, 4 % of European firm's revenue. Gartner further concluded that the IT costs were likely to grow, at least in absolute terms. Another study performed by the Bureau of Economic Analysis in the United stated concluded that the share of IT in business equipment investments in USA rose to above 50 percent in year 2000 [28]

The great importance of IT for running a competitive business together with the significant costs associated with IT operations and investments has made it imperative to increase the quality of decisions concerning IT management. Bad decisions not only jeopardize the smooth running of the business, they also cost a fortune.

IT systems often stay with their organizations for a very long time, systems that were developed in the seventies still support core processes in some industries. The longevity of information systems means that a cost assessment framework needs to incorporate all life-cycle costs into the estimations. This is highlighted by numerous studies e.g. the one by Yip et al. [30] which found that 66% of an application's costs were maintenance related.

IT investments today differ from those a few years ago by becoming increasingly centered on Commercial Off-The-Shelf (COTS) products which are pre-packaged IT solutions offering more or less "plug and play" capabilities, i.e. not requiring massive changes to the source code when being installed. Any comprehensive IT cost estimation framework needs to be able to manage IT investments that are COTS as well as in-house developed. Investing in COTS products makes costs more predictable in some ways. For instance, the notoriously fluctuating development costs are substituted by annual or monthly license costs. However, COTS investments pose new challenges as well, and these challenges often translate into new cost drivers [18]. Notable cost drivers are for instance integration costs and costs related to business process re-engineering.

The evolution of IT systems from isolated technical solutions to huge socio-technical systems run by separate organizations and with a pervasive impact on most business processes mean that any cost prediction method or framework need to encompass business and organizational cost factors in addition to the purely technical ones.

Finally, when performing the actual cost estimation, all the sophistication in the world of the taxonomy expressing IT related costs amounts to nothing if it is not coupled with a calculation and data collection method.

One important aspect frequently overlooked in investment analysis is to take the uncertainty of the prediction into account. Every investment assessment will by necessity be uncertain, but the degree of uncertainty varies greatly. Decision makers need to be aware of the uncertainty of their decision support before making decisions in order to determine the risk associated with the decision. The method for calculating costs should preferably make the uncertainty of results explicit in the final analysis.

As with any other investment scenario rational decision-making concerning IT investments require some sort of prediction concerning the benefits of the investment scenario together with a prediction of the likely cost associated with that scenario. In [5] Ballantine and Stray found when conducting two large surveys that evaluation is less widespread for IT investments than other capital investments though the former are no smaller either in absolute size or percentage of budget allocation. When further exploring this in [6], it was found that IT investment appraisals were based on less sophisticated techniques than other capital investments, usually only focusing on the most obvious costs.

This paper proposes a framework factors that influence IT life-cycle costs as well as a method which incorporates both IT cost calculation support and uncertainty assessments. The

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

cost framework and the method were developed in close co-operation with a big Nordic utility and the utility also supplied data for two case studies which provided an opportunity to test the framework and the method

This paper is outlined as follows. The next section introduces the process behind developing the framework. Section three proceeds to detail the framework itself. Section four introduces the method for using the cost framework. Section five demonstrates the use of the framework in a case study at a large Nordic utility and finally section six concludes the paper.

II. THE PROCESS OF DEVELOPING THE FRAMEWORK

The process behind the creation of the framework consists of four steps. Firstly, a literature search yielded a number of sources. Secondly, the sources found were used to devise a framework which was subsequently validated and refined by experts. Finally the framework was used together with the method described in section four to perform a case study. See Figure 1.

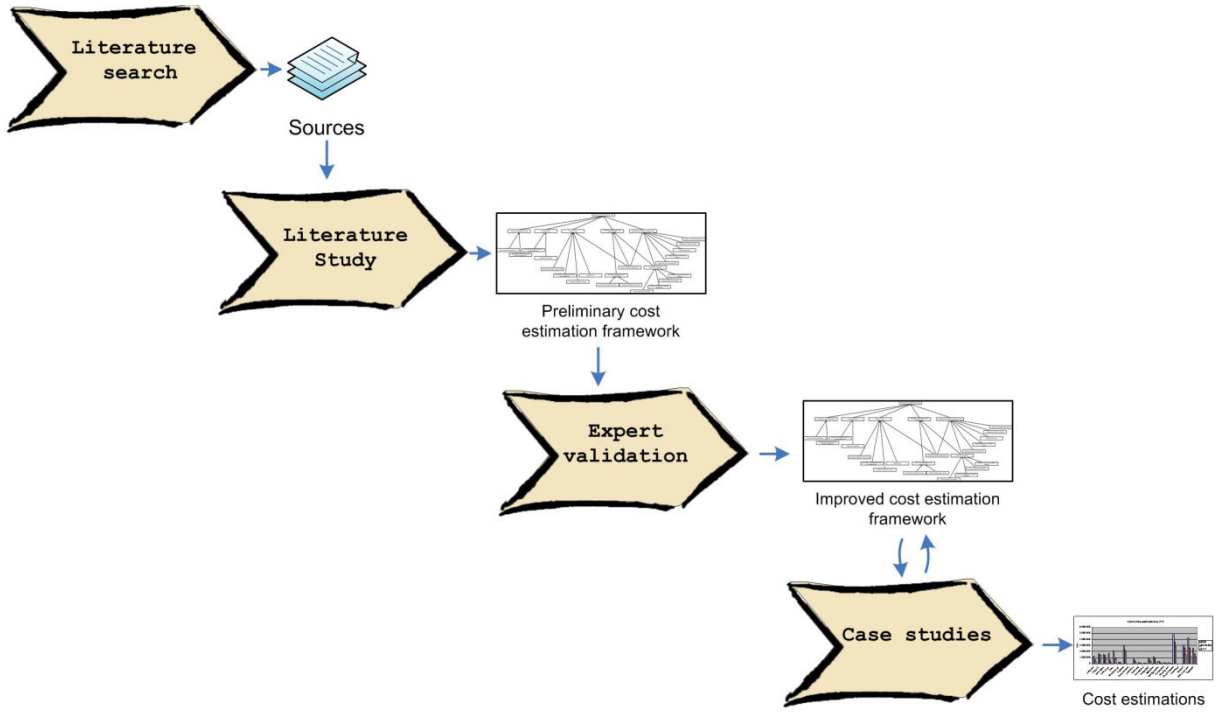

Figure 1: the process behind the developing the framework.

A. Literature search

The first step in developing the framework consisted in a literature study with the objective of finding previously developed IT cost estimation frameworks and methods that might meet the requirements stated in the introduction. Multiple relevant sources were found and were deemed useful yet no-one suited all of the requirements.

A frequently cited method for estimating IT development efforts is Barry Boehm et al.'s COCOMO (COnstructive COst MOdel) method and its successor, aptly named COCOMO II, [16][17]. The method offer a framework and an algorithm to predict the number of man-months needed to complete software development projects. Although based on qualitative experiences and a substantial amount of quantitative data, the method fails to meet the requirements insofar as it is limited to software development projects, which excludes procurement and implementation of COTS products, and in particular does not address the entire life-cycle cost of IT investments. The framework does however describe the impact of several technical factors, and is therefore an important input. The COCOMO community has acknowledged the need to make estimations of COTS-related costs as well which gave rise to the COCOTS [19][20][21]. The COCOTS explores technical factors related to integration of COTS products, but fails to address maintenance related costs or the costs related to the organizational change etc.

A more holistic approach taking "softer" cost drivers into account is presented in a number of IT cost taxonomies proposed by Irani et al in [13][14][15]. These taxonomies emphasize the importance intangible costs derived from for instance the introduction of new work practices that are associated with introducing new IT technology. Although complementing the more technical view expressed in COCOMO and COCOTS, the taxonomy says little on how to use cost factors to calculate IT investment costs in practice.

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

The past decade has witnessed plenty of enterprise-wide Enterprise Resource Planning system implementations. The relatively low degree of success for these implementations has resulted in there being a substantial amount of literature on the subject. Some of this literature offers many insights into the effect large COTS products have on business processes, the organization that uses them and the costs that are thus incurred. See for instance [11][12].

There is an abundance of cost calculation methods in general investment assessment theory. Much investment assessment literature (e.g. [27]) focuses on the correct way to calculate comparable figures of future cost. To facilitate data collection strategies there is also separate literature on estimation methodology [23] [24] and data collection [1]. These sources are not explicit on what costs should actually be assessed in an IT investment situation, but are nevertheless important for designing IT investment assessment methods as they provide guidance for data collection strategies and analysis methods.

The fact that assessments of complex IT investments are uncertain is something which is elaborated upon by Gammelgård et al. in [25], where a framework for uncertainty assessments based on witness psychology is presented and put to use in an architecture analysis.

B. Devising a framework based on literature

The literature found in the previous step was put to use in devising a comprehensive cost estimation framework presented in the subsequent section as well as a suitable method for calculating costs, see section four. The construction of the framework used a simplified text-interpretation method as presented in [2] Using the method as support increased the traceability of the results and therefore the validity of the framework.

C. Validating the framework

A number of workshops and interviews were made with people experienced in implementing IT investments at the previously mentioned Nordic utility. These interviews and workshops served to further corroborate the validity of the framework and yielded a number of additional cost factors that were not discovered in literature to the estimation framework.

D. Case studies

Two case studies were performed in which the cost framework and the calculation method were put to the test, see section four below. During the case study, a number of suggestions for improvements of the framework surfaced, some of which were incorporated in the framework. The test of the calculation method demonstrated the practical usefulness of the calculation method.

III. THE FRAMEWORK FOR IT COST ASSESSMENT

The cost estimation framework comprised two parts: a taxonomy of IT life cycle costs featuring 21 cost nodes and 79 background factors which influence these costs in various ways. In this section the cost taxonomy is first presented followed by a description of the background factors related to each part.

A. Cost taxonomy

The following sub sections give an overview of the framework used in the method (c.f. Figure 2) and its 21 cost nodes. Life cycle cost of a system is here divided into project costs and operation and maintenance costs, where project costs are those costs associated with the change project and operation and maintenance costs are incurred after the system is installed.

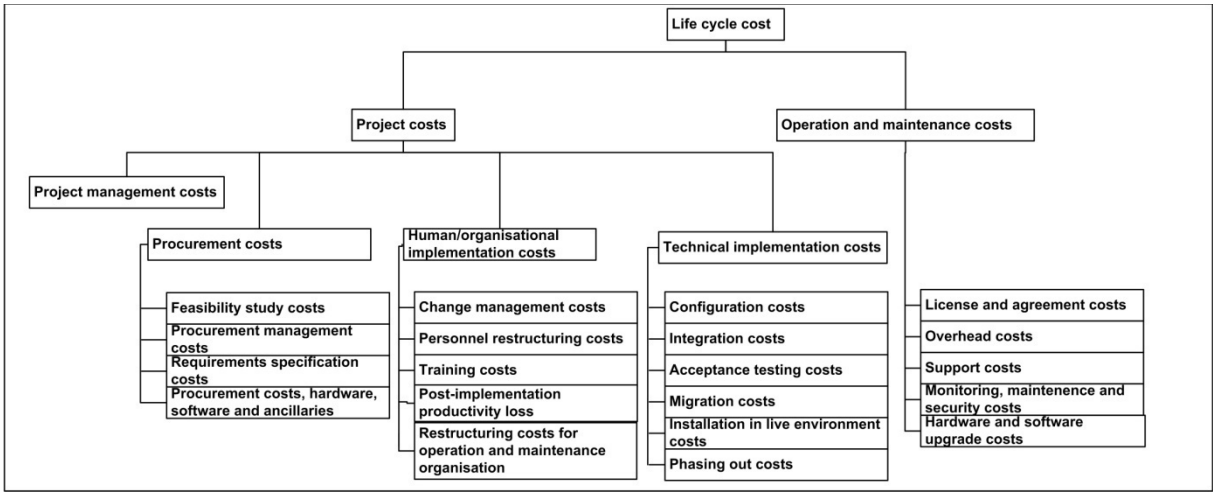

Figure 2 - The cost taxonomy

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

A more detailed description of the taxonomy is given below.

Project management costs

Project management costs involve all administrative work performed to specify, plan and coordinate the IT project itself according to some project model. The project is defined as all activities from feasibility study and requirements specification to implementing the new IT system or systems and phasing out old ones [15][17].

Procurement costs

Procurement costs consists of: Feasibility study costs and Requirement specification costs – the costs to conduct the feasibility study and requirements specification, respectively; Procurement management costs – work to evaluate offers and drafting agreements; and Procurement costs for hardware, software and ancillaries – the direct, initial costs for acquiring the things that comprise the IT investment [17][19].

Human/organizational implementation costs

Human/organizational costs consist mostly of indirect costs attributed to system users having to change their daily routines. This generates costs consisting of: Change management costs – costs to introduce the change to the organizations; Training costs – direct and indirect costs to train system users; Post-implementation productivity loss – the productivity loss due to the time it takes for system users to adapt to the change; Personnel restructuring costs – costs for changes in personnel structure due to the system change; and Construction costs for system operation and maintenance organization – costs to create or restructure the operation and maintenance organization for the system or systems [10][11][15].

Technical implementation costs

Every IT investment involve Technical implementation costs including: Configuration costs – standard configuration activities, parameter initiation etc.; Integration costs – integrating the systems within a system scenario as well as the system scenario with its system environment; Migration costs – pre-processing and migrating data; Installation in live environment costs – costs for the installation process; and Phasing out costs – costs for filing away historical data, completing documentation and software/hardware disposal as well as costs for running old and new systems in parallel. Acceptance testing costs can occur to different extents. Sometimes elaborate testing and re-testing is necessary and sometimes testing included in integration/configuration/migration activities is enough [17][19] [21].

Operation and maintenance costs

The costs of operation and maintenance are substantial for any large IT system and have a high impact on life cycle costs since they are reoccurring. The cost nodes include: License and agreement costs include the yearly costs for licenses and agreements. Overhead costs are arising from things such as floor space, telecommunication costs, etc. Support costs cover support regarding applications and hardware as well as end user support.

Monitoring, maintenance and security cost include both preventive work (user access administration, backing up data etc.) and restoration work (repairs, recreate data etc.). Upgrade costs involves replacing systems or system components/modules with a newer version, including any necessary changes to integration, documentation, data base structure etc. and resulting in a fully functional system satisfying all tests and requirements. Many aspects of Overhead, Support, Upgrade and Monitoring, maintenance and security costs are can sometimes be included in licenses and agreements; therefore care must be taken to only count extra costs under these headings to avoid including it twice [13][15][18].

B. Background factors

The background factors are the cost drivers that impact the cost nodes of the framework one way or another. These are taken from literature or were found during the validation phase of the framework development process.

Project management costs

Project management costs are associated with managing the project, this includes all activities from feasibility study and requirements specification until the new scenario is fully functioning and old systems have been phased out. This is influenced by the cost limit applied to the project and how appropriate the project model is for change projects [22][8]. Furthermore, the geographical spread [13] [12] [10] of the project team as well as the number of organizational units [13] [12] involved is influencing cost. In addition is the number of systems that are involved in the change project is a factor that is worth considering [19][20][18][21].

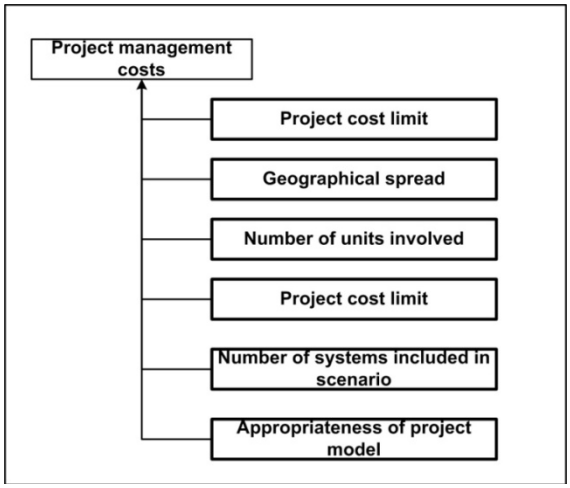

Figure 3 Project management costs, with background factors.

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

Procurement costs

Procurement costs are decomposed into a number of sub-costs in the cost taxonomy, namely: feasibility study costs, requirements specification costs, procurement management costs and procurement costs for hardware, software and ancillaries (cf. Figure 4).

The feasibility study cost is influenced by the extent to which there will be integration issues due to the scenario change; the maturity of the vendors and the market [22][19][17] if there is an established relationship with the vendor(s) [22][19][17]. The costs of producing a requirements specification is dependent on the number of units involved [12] and the geographical spread of the organization. The number of systems that the requirement specification shall cover as well as the number of function changes [16] [10] and the depth of these changes [16] [10] are also important factors to consider. The costs for managing the procurement, procurement management costs, are influenced by if it is possible to reuse documents (e.g. templates) from earlier procurements [17][8] and the number of potential vendors that are involved in the procurement [17] [8].

The costs for hardware, software and ancillaries (e.g. cabling) to these are from the perspective of procurement costs depending on whether plausible future requirements are included in the procurement, as well as how encompassing the license agreement shall be [13][15].

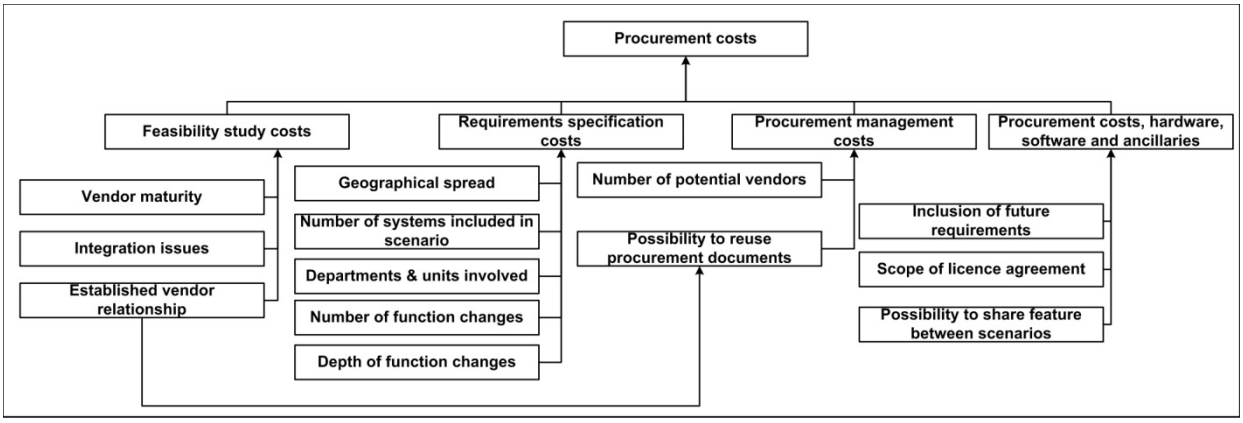

Figure 4 – Procurement costs, with background factors.

Human and organizational implementation costs

A substantial cost in many change projects are that is a result of changing the organization and the humans within it. This includes costs associated with: change management [11][15][12][10], training [15][10], post implementation productivity loss[14][13], restructuring personnel [14][13][15] and the costs of constructing maintenance and operation organization.

Change management is defined as facilitating the insertion of newly implemented systems, structures, and processes into the working practice and dealing with resistance within the organization. This means planning, overseeing and communicating information to the end users about IT induced change. Geographical spread of the organization and the number of units involved [12] in the change project are factors that influence cost, but also the complexity of the business process redesign [10] [15] [26]. The complexity of the business process redesign is in turn is influenced by: how much work content and work processes change [11][12], the type of change (reinvention or streamlining) [11][12], and the number of departments and people involved.

Training costs includes both the direct costs due to the training and as the loss in productivity employees absence from their regular work assignments will result in [15][10]. Two obvious cost drivers to this is the amount training that is needed and extent of this training, which both are influenced by the complexity of business process redesign. If some amount of training is included in the license agreement this will be a relief for this cost node [13][15]. Classroom training is often the more expensive option while online training is considered less expensive as direct costs as well as time away from work are lower. The extent to which relevant skills and competence are available within the organization is also a factor that is of importance, together with the extent to which end users are familiar with the new technology [12].

Personnel restructuring costs are those costs resulting from to changes in the personnel composition, for example [14][13][15]: new competencies might be needed, old personnel might become redundant, and salaries might have to be raised if people's competencies have been raised by training or by working in the project team. The factors that influence this are the complexity of business process redesign, and if the organization already have relevant skills and/or are familiar to new technology. Restructuring cost of the maintenance and operations organization depend on the possibility to reuse the existing organization, if there exist relevant skills and competencies within the organization, and the number of systems that are involved in the change project.

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

Post implementation losses arise since employees are inefficient during a period after deployment due to new work contents, new practices and difficulties with working the new systems [14][13]. The time period that it takes to absorb the new work content is a factor to consider here and indirectly should also the efficiency of change management [11][15][12][10], the efficiency of training and users resistance to change [14][13] be considered. The resistance to change is influenced by the source of change initiation (e.g. top management or end users), the amount of personnel restructuring required [14][13][15] and the complexity of business process redesign. Becoming proficient with the new system (the on the job learning curve) is also a matter of concern [15]. The time this takes is also influenced by the resistance to change and the complexity of business process redesign. In addition to this the technology familiarity among end users and the efficiency of training are factors to consider.

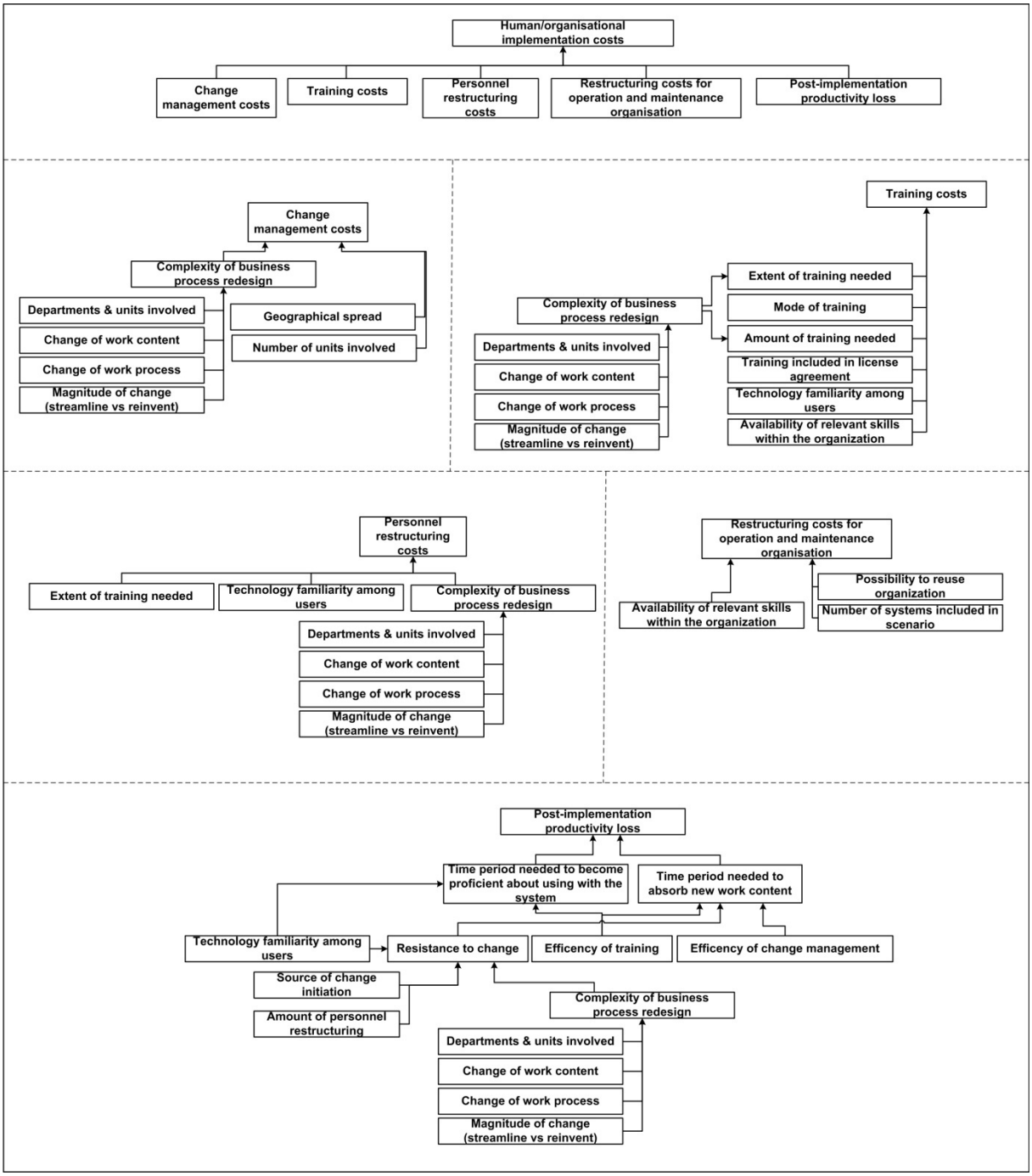

Figure 5: Human/organizational implementation costs, with background factors.

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

Technical Implementation costs

The costs in this category are those that come from: performing acceptance tests, integrating the system, configuring the system, the installation of the live environment, migrating to it, and the cost of phasing out the any old systems.

The first two of these, acceptance testing costs and integration costs, share the same set of background factors. Both are influenced by technical complications that may arise due to the system, and indirectly: the amount of special adjustments made [17][19][21], the uniqueness of the implementation, and the maturity of the product [17][19][21]. The capability of the team managing the technical implementation is also of relevance, and consequently: their experience [17][19][21], involvement in earlier phases of the project and whether there are resources included in the license agreement for doing the implementation. Also relevant is the complexity of the scenario and factors such as the number of systems included, how well it complies to standards, as well as how connected it is internally and externally [17][19][21]. The architectural scenario as such may also give rise to complicating factors that in turn would be influenced by technical constraints [17][19][21], the quality of the design specification [17][19][21][15], the validation quality of the system's architecture [17][19][21], and reliability constraints [17][19][21]. The size of the test procedure is also a factor that influence costs at this stage of a project [17][19][21].

The cost of migrating to the new architecture is also dependent on the capability of the team doing it and the size of the test procedure; in addition to this the data characteristics is of importance, i.e. [15]: the number of conversions that needs to be made, the compatibility of data types and if any improvement effort is made in the project with regard to data quality.

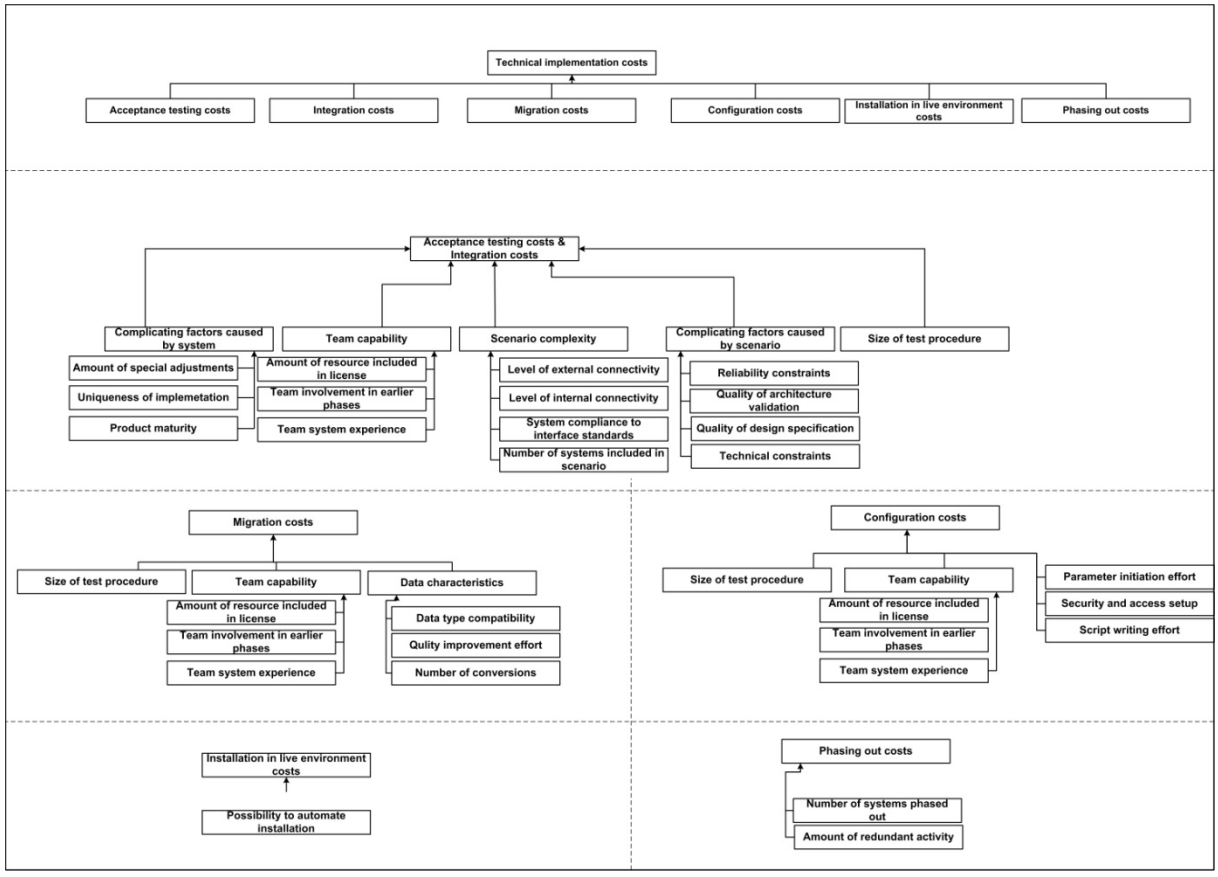

Figure 6: Background factors related to technical implementation costs.

Configuration costs are influenced by the team's capability and the size of test procedures. In addition to this the need for script writing efforts , configuring security related matters and initiating parameters are of importance [17][19][21][15]. The cost for installing the live environment are influenced by possibility to automate the installation; and the cost of phasing out old systems is depending on the number of systems being phased out and the amount of redundant activities that are performed [13].

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

Operation and maintenance costs

The costs of maintaining and operating a system include costs for licenses and agreements; overhead; support, monitoring; maintenance and security costs; and costs for upgrades.

The possibility to manage licenses on a large scale, i.e. enterprise wide, reduces license costs [18]. Another way to reduce costs is to limit the scope of the license agreement. Overhead costs, e.g. costs for space and electricity, are influenced by the amount of overhead that is included in the license agreement [15] [13] and the extent that changes in hardware are required. Costs for support is influenced by how familiar users are with the technology, how many adjustments that has been made to fit the system to the organization, and if relevant competencies are available within the organization. It is also worth considering if support is included in the license agreement [15] and what the content of the Service Level Agreement (SLA) is.

The cost for monitoring, maintenance and security is like license costs influenced by the scope of the SLA and the number of special adjustments that has been made from the standard product. In addition should the complexity of the architectural scenario and the track record with regard to availability also be considered [18]. The costs upgrading for hardware and software depends on whether future requirements where considered in the new architecture; if the business needs change frequently [10]; if the system is upgraded frequently [18]; the scope of the license [10]; and the need to optimize performance of the system [15][10].

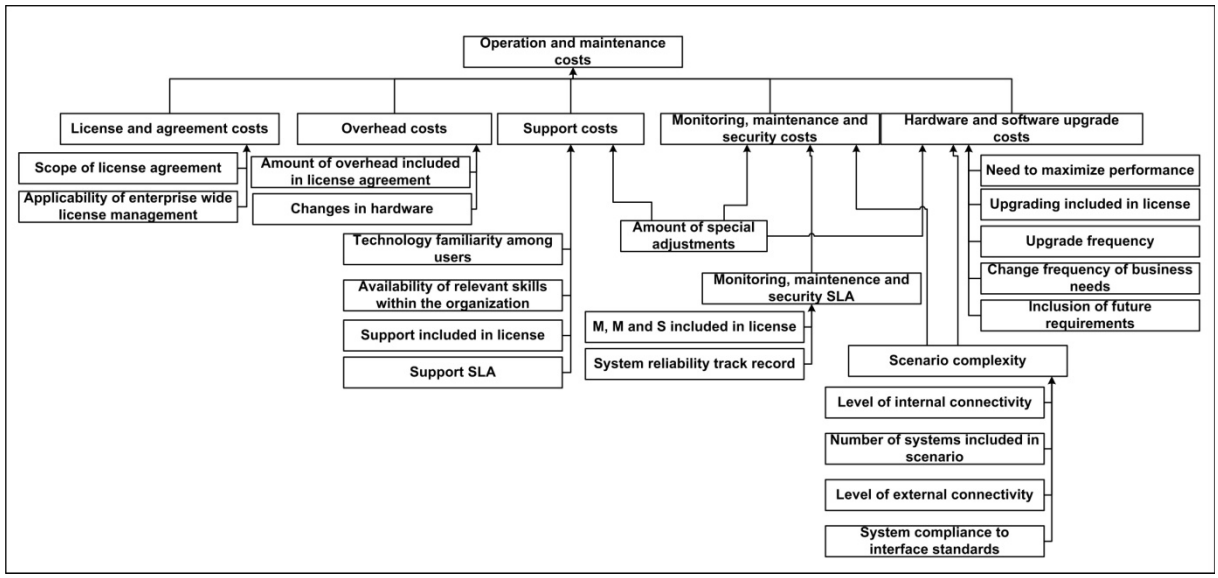

Figure 7: The background factors affecting the operation and maintenance costs.

IV. A METHOD FOR ESTIMATING IT INVESTMENT COSTS

This section describes how the cost estimation framework of the previous section can be applied to produce IT investment cost estimations. The calculation method is based on a discounted cash flow technique [27]. These methods have proven to yield better estimates according to Bacon et al. [7]. All data collection is accompanied by uncertainty estimates as devised by [25] and the uncertainty estimates are used to weight statements from different respondents when performing the calculation.

A. System scenario definition

In order to get consistent responses regarding the costs the system scenario must be well defined. In terms of which systems are included, how will they be connected, what new functionality can be expected, who will be affected by the change, etc.

To be able to calculate net present value, the system scenario definition also entails the system's cost distribution over time.

B. Respondent identification

This step involves identifying approximately three respondents to estimate each cost node described in section 3. Having several independent assessments from respondents with different backgrounds improves the quality of the estimations [1][23].

Suitable respondents are: persons with experience of business side of IT and similar IT projects in general. Persons with insight into the systems and processes affected by the project also provide valuable input. Suitable respondents are also project team members.

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

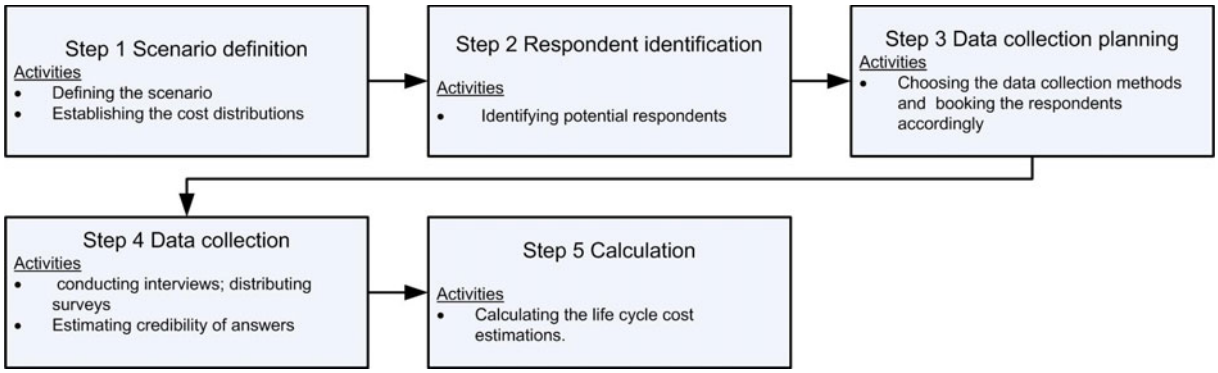

Figure 8 Overview of the phases in the cost estimation method

C. Data collection planning

This step includes deciding on the data collection methods to be used and booking respondents for cost estimations, either by interviews or through web surveys. As stated in section 3, using a mix of data collection methods produce better estimations [3][23].

V. DATA COLLECTION

In this step surveys and introductory material are prepared and sent out, interviews are held and cost estimates are collected. Respondents estimate all the cost nodes of the cost framework from section 4 by answering either interview questions, or web survey questions.

The background factors are used in the data collection both to help the respondents understand what affects the cost nodes but also to assess the knowledge of the respondent. If the respondent is able to assess the values of the background factors associated with a cost node, this means that the credibility, or certainty, of that particular cost node estimation is probably quite high. The use of background factors in the assessment is very beneficial since they promotes *history-based thinking*, i.e. encourage respondents to use their experience of previous similar projects when estimating cost nodes [3][23].

In addition to this, so called credibility heuristics [25] are used to assess the certainty of the cost estimations per se. On this account, questions regarding the respondent's background and certainty about the background factors are asked. The respondent is also asked to do a self-assessment of the credibility of his estimates. In addition, the interviewer also does a subjective estimation of the credibility of the respondent's estimates. These four credibility heuristics are ranked on a scale from "Very certain" to "Very uncertain" and can in the calculation be combined to determine the credibility for each of the respondent's estimates.

Figure 10 below show how the life cycle cost estimations are calculated. The total costs are a weighted aggregation of all the assessments of the cost nodes. In order to get an indication of the variance, or risk coupled with the IT investment, the respondents are asked to do a three point estimate for each cost node.

Notice that only the 21 cost nodes were used for the actual calculation, the background factors were merely used to increase the quality of the responses and estimate the credibility of the respondents' estimates.

The highest estimate of the cost node is a worst case scenario estimation assuming that everything in the project and the subsequent operation of the IT system turns out as bad as possible. The lowest estimation represents the other end of the scale, and the probable estimate should represent the likeliest outcome. The three-point estimates are aggregated separately thus giving three separate cost estimations for the entire IT investment.

When combining the assessments of respondents a weighted average is used. Each respondent's weight is calculated based on the calculated credibility according to the credibility heuristics. Each heuristic is assigned a numerical value, e.g. respondents might state that they are Very certain = 4p or Very uncertain = 1p of their estimates.

The credibility heuristics are divided into four groups: Background factor certainty (B_{fc}) – how certain the respondent is about their answers on background factor questions in the cost node estimations. Respondent background (R_{bg}) – questions regarding the respondent's background. Interviewer's assessment (I_{as}) – how certain the interviewer is that the respondent's estimates for a cost node are correct. Respondent's certainty of the actual cost estimation (R_{ce}) –how certain respondents are about the correctness of their cost estimation. The points for these four groups are first summarized and normalized separately. The groups are then combined to give the weight of the respondent's estimates.

The groups can be prioritised by assigning them factors to reflect the thought importance of each group. For example by weighting the groups in a formula like:

$$\omega_{respondent} = 2R_{ce} + B_{fc} + 0.75R_{bg} + 0.5I_{as}$$

Any weights are of course possible to use when combining the heuristics into one credibility measure. This was the equation used in the case studies and is assumes that the proximity between the estimate and the heuristic group is

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

a good indication of the heuristic group's importance: R_{ce} concerns the estimation directly, B_{fc} is specific for each cost node, R_{bg} is general information about the respondent and I_{as} is the most arbitrary of the weight groups, and has the lowest weight.

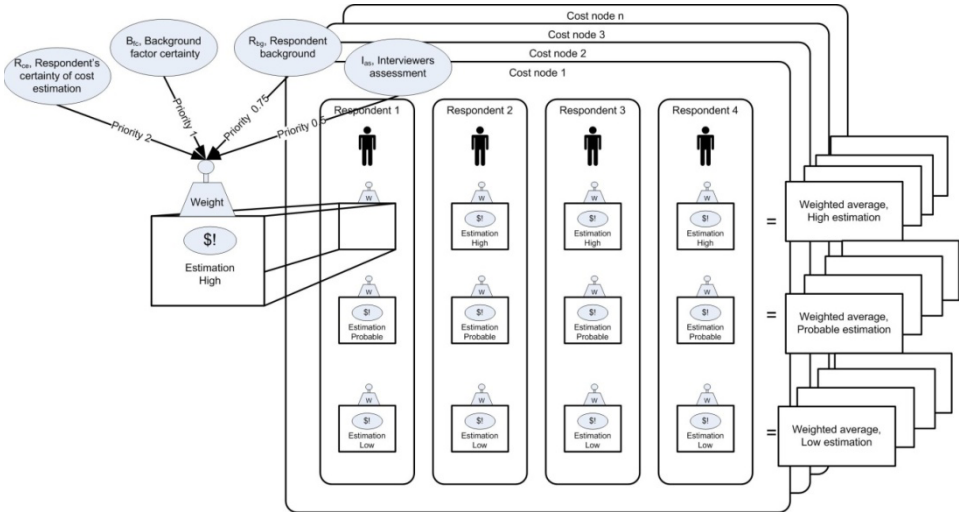

Figure 9: For each cost node, several respondents did three estimations; low, probable and high. These estimations were then combined into a weighted average. The weights of the estimations were calculated with the help of credibility heuristics described in section 3.

A weighted average is then calculated for each of the high, low and probable estimations per cost node using weights calculated as above for each respondent. By combining the high/probable/low cost estimations for all cost nodes with the estimated cost distribution over time obtained in the system scenario definition phase described above it is possible to calculate the sum of costs for each year during the scenario's lifetime. These costs are then discounted to the current year using the discount rate yielding a net present value estimation of the IT investment. C.f. Figure 10.

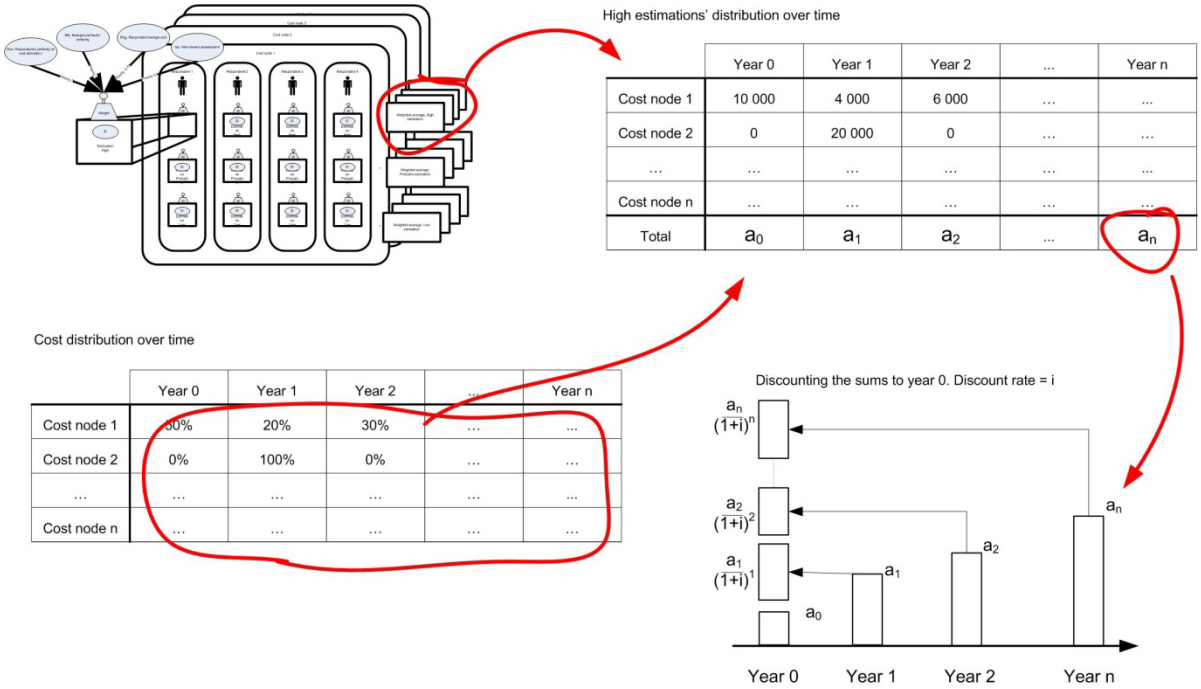

Figure 10: Calculation of the total life cycle cost requires both the weighted average for each cost node, and the approximate cost distribution over time. With this data a standard cash discount calcuation could be performed

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

VI. CASE STUDY VALIDATION

To validate that the cost estimation method was useful in practice, two case studies were performed. The case studies focused on two separate IT change projects a Nordic utility. The utility is one of the largest power companies in Europe and does business in all parts of the energy value chain including electricity generation, transmission and distribution. The case studies were carried out at one of the utility's distribution business units. Both projects were in their finishing stages which made it possible to compare the results of the cost estimation method with some figures about the actual cost of the projects. The overall cost estimations of the two investments are presented in Figure 11, with Figure 12, and Figure 13 showing the breakdown of costs into the cost nodes.

A. Case study 1

Case study 1 concerned system A, a business critical information and decision-making system and a project that involved both development of new functionality and an upgrade to a new version. Estimated lifetime of system A is 8 years. Case study 1 required about 17 hours of data collection, mainly in interviews with 4 different respondents; this included both cost estimations and system scenario definition.

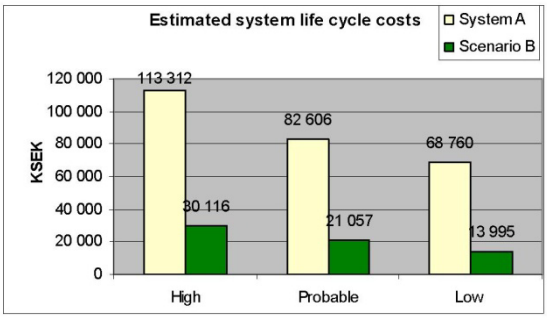

Figure 11 The estimated life cycle costs for Systems A and B in KSEK.

The by far largest cost are the License and agreement costs making up 50-60% of the scenario costs, followed by Support costs and Upgrade costs that also are operation costs and therefore reoccur every year of the scenario's life cycle. Project costs were insignificant in comparison with the operation and maintenance costs.

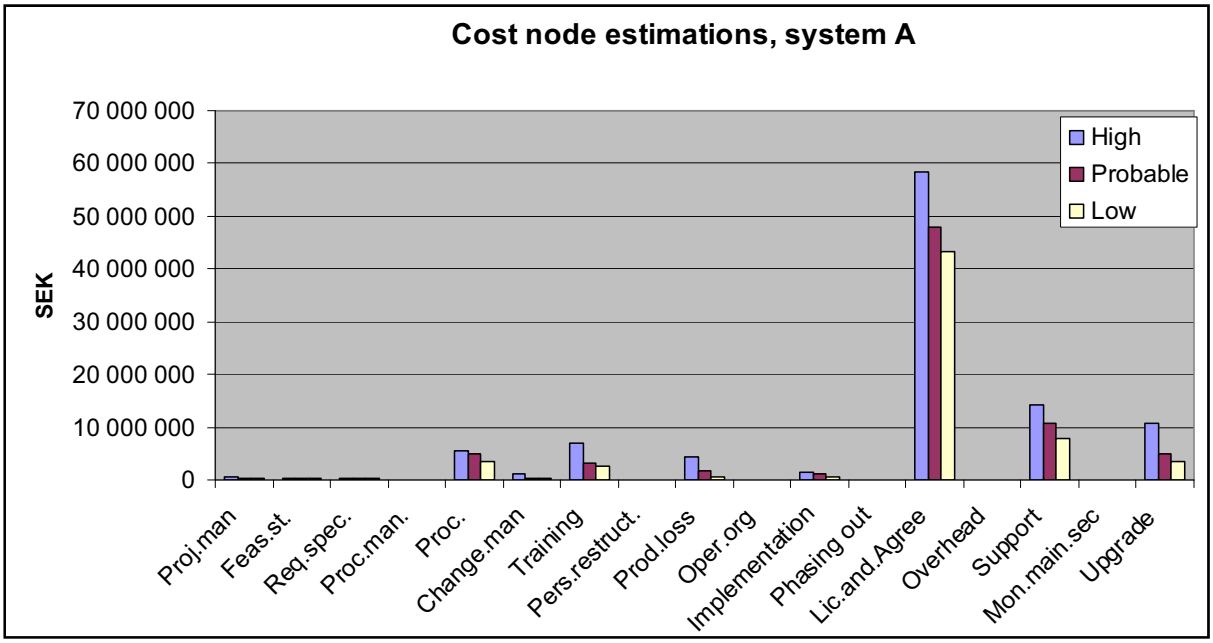

Figure 12 The discounted estimations of all cost nodes for system A. The cost nodes are not quite the same as presented in section 4, since the cost estimation framework was changed after case study 1 based on comments from respondents during case study 1

B. Case study 2

In case study 2, system B, a component-based enterprise system already in use in some parts of the company was implemented in the entire enterprise. System B's lifetime is estimated to 10 years. Case study 2 demanded 11 hours of data collection with 6 respondents; this included both cost estimations and system scenario definition.

The largest impact on the life cycle costs for system B is mostly from operation costs that reoccur every year of the scenario's life cycle, topped by License and agreement costs. However, some project costs have very large impacts considering they are not reoccurring: Training costs make out approximately 10% of the total Scenario costs and Feasibility study costs and Requirement specification costs make out approximately 5-8% each of the total Scenario costs.

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

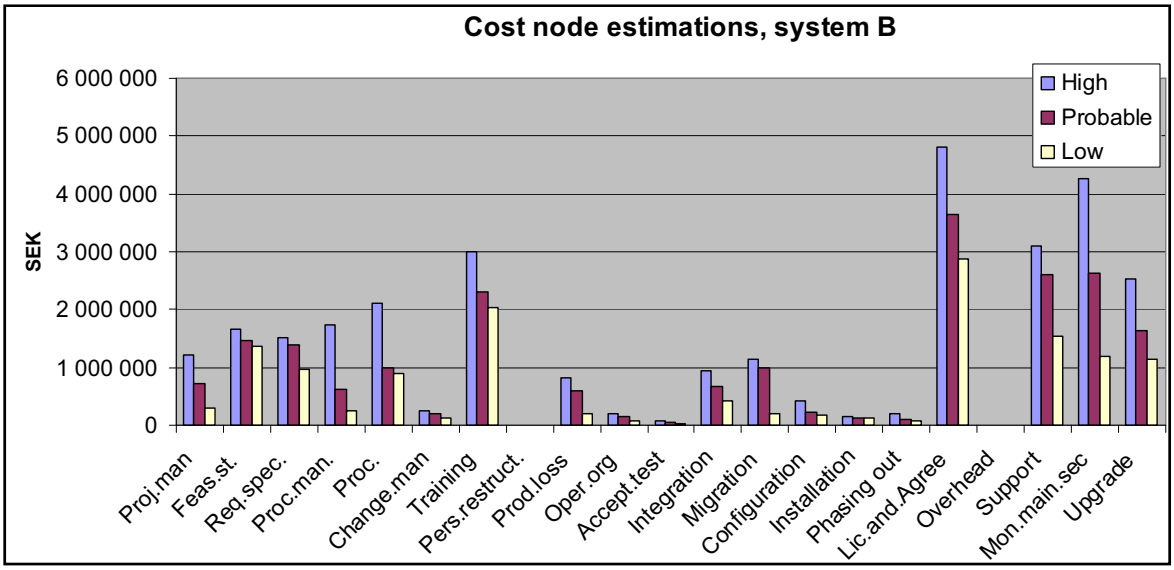

Figure 13 The discounted estimations of all cost nodes, system B

C. Industry feedback

A comparison was made between the cost estimation results from the study for both projects with the cost estimations found in the project plans of the projects each project. It was found that the case study results fell within the same range, although slightly higher, as the estimations in these documents. This would indicate that the method includes the costs from the current estimation process while being more formalized and resulting in slightly higher (perhaps less optimistic) estimations on these cost nodes.

The proposed method worked well in the case studies. Comments received on the framework from respondents in the case studies were mostly positive and consisted of additional background factors that affected the cost nodes.

VII. CONCLUSIONS

This paper has presented a framework for IT investment cost evaluations. Based on literature and incorporating knowledge from practitioners with experience of IT investment analysis, the framework provides a solid foundation for making sound decisions concerning IT investments. In addition the framework has been used in a case study together with a method for appreciating the net present value of IT investments.

REFERENCES

[1] Yin, R.K. Case study research: design and methods third edition. Sage publications, 2003.

[2] Lagerström, R., *A Method for Generating Extended Influence Diagrams from Natural Language Texts*. Department of Industrial Information and Control Systems. KTH

[3] Jørgensen, M. A Review of Studies on Expert Estimation of Software Development Effort. Simula Research Laboratory, Lysaker, Norway. 2002

[4] Remenyi Dan, Money Arthur, Sherwood-Smith Michael, Irani Zahir *The effective measurement and management of IT costs and benefits*. Oxford ; Butterworth-Heinemann, 1995

[5] Ballantine, J., Stray, S., *Information systems and other capital investments: evaluation practices compared* in Logistics Information Management Volume 12 Numbers ½ 1999 pp. 78–93

[6] Ballantine, J., Stray, S., *Financial appraisal and the IS/IT investment decision making process* in Journal of Information Technology (1998) 13, 3- 14

[7] Bacon, J., C., The Use of Decision Criteria in Selecting Information Systems/Technology Investments. MIS Quarterly 1992, pp 335-353

[8] Lederer, A.,L., et.al, *Information System Cost Estimating: A Management Perspective.* MIS Quarterly, Vol 14, No2 (Jun., 1990), pp. 159-176

[9] Renkema, T. J. W., Berghoutb E. W., Methodologies for information systems investment evaluation at the proposal stage: a comparative review. Information and Software Technology 39 (1997) l- 13

[10] Bancroft, N., et al. *Implementing SAP R/3.* 2 ed. Greenwich, Conn. Manning, cop. 1998

[11] Al-Mashari, M. and Zairi, M., *The effective application of SAP R/3: a proposed model of best practice.* Logistics Information Management Volume 13 . Number 3 . 2000 . pp. 156±166

[12] Mandal, Purnendu, Gunasekaran , A Issues in implementing ERP: A case study in European Journal of Operational Research 146 (2003) 274–283 (

[13] Irani Z., Ezingeard, J-N., Grieve R.J. *Costing the true costs of IT/IS investments in manufacturing: a focus during management decision making.* Logistics Information Management Feb 1998 Volume: 11 Issue: 1 Page: 38 – 43

[14] Love, Peter E.D. Irani, Zahir, Ghoneimb, Ahmad, Themistocleous, Marinos *An exploratory study of indirect ICT costs using the structured case method* i International Journal of Information Management 26 (2006) 167–177 (NIO)

[15] Irani, Z., Ghoneim, A., Love P. E. D., *Evaluating cost taxonomies for information systems management*. European Journal of Operational Research 173 (2006) 1103-1122

[16] Boehm, B.W., *Software engineering economics*, Englewood Cliffs, N.J. : Prentice-Hall, cop. 1981

[17] Boehm, B., *Software cost estimation with Cocomo II.* London, Prentice Hall International, 2000

[18] Basili, V., Boehm, B. *COTS-Based Systems Top 10 List.* Software Management May 2001

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.

[19] Abts, C., Boehm, B., Bailey Clark, E. COCOTS: A COTS Software Integration Lifecycle Cost Model - Model Overview and Preliminary Data Collection Findings. 2000, USC Center for Software Engineering
[20] Boehm, B., Abts, C., *COTS Integration – Plug and Pray?* Computer Management January 1999
[21] USC center for software engineering. Information on COCOMO and COCOTS. Accesed 20061211. URL: http://sunset.usc.edu/research/COCOTS/index.html Visited 061211
[22] Meyers, P., Sivakumar, K. Nakata, C. Implementation of Industrial Process Innovations:Factors, Effects, and Marketing Implications J PROD INNOV MANAG 1999;16:295–311
[23] Fabrycky Wolter J., Blanchard, Benjamin S. *Life-cycle cost and economic analysis*, Englewood Cliffs, N.J. Prentice Hall, cop. 1991
[24] Armstrong, J.S., Combining forecasts, in Armstrong, J.S. (ed.), Principles of forecasting: a handbook for researchers and practitioners, Kluwer Academic Publishers, 2001
[25] Gammelgård, M., Ekstedt, M., Närman, P., *Architecture Scenario Analysis – Estimating the Credibility of the Results*. Department of Industrial Information and Control Systems. KTH 200Bass, L., Clements, P., Kazman, R. *Software Architecture in Practice*. Addison-Wesley, 1998.
[26] Davenport, T. H. Putting the enterprise into the enterprise system Harvard Business Review 1998
[27] Brealey, R., Myers, S.,Principles of corporate finance, Boston : McGraw-Hill, cop. 2003
[28] Bureau of Economic Analysis, National Economic Accounts, Table: 5.5.6.Real Private Fixed Investment in Equipment and Software by Type, Chained Dollars, www.bea.gov, accessed: February 2007
[29] Smith M., et al, IT Spending and Staffing Report, Gartner Research, 2008
[30] Yip, S., A Software Maintenance Survey, Proceedings of the Software Engineering Conference, 1994

Authorized licensed use limited to: KTH THE ROYAL INSTITUTE OF TECHNOLOGY. Downloaded on February 28,2010 at 03:29:27 EST from IEEE Xplore. Restrictions apply.