COTS integration and estimation for ERP

Wilson Rosa [a,*], Travis Packard [a], Abishek Krupanand [a], James W. Bilbro [b], Max M. Hodal [c]

[a] Air Force Cost Analysis Agency, 1500 West Perimeter Rd, Suite 3500, Joint Base Andrews NAF, Washington, MD 20762-9998, United States
[b] Cirrus Technology Inc., United States
[c] Wyle, Inc., United States

ABSTRACT

This paper presents a comprehensive set of effort and schedule estimating models for predicting Enterprise Resource Planning (ERP) implementations, available in the open literature. The first set of models uses product size to predict ERP software engineering effort as well as total integration effort. Product size is measured in terms of the number of report, interface, conversion, and extension (RICE) objects configured and customized within the commercial ERP tool. Total integration effort captures software engineering plus systems engineering, program management, change management, development test & evaluation, and training development. The second set of models predicts the duration of ERP implementation stages in terms of RICE objects, staffing, and the number of test cases. The statistical models are based on data collected from 20 programs implemented within the federal government over the course of nine years beginning in 2000. The data was collected during the time period from 2006 to 2010. The models focus on the vendor's implementation team, and therefore should be applicable to commercial ERP implementations. Finally, ERP adopters/customers can use these models to validate Vendor's Implementation Team cost proposals or estimates.

© 2012 Elsevier Inc. All rights reserved.

1. Introduction

1.1. Problem statement

Implementation of ERP systems continues to grow throughout the world. According to the Gartner group, ERP software is the largest segment within the Enterprise Application software market and they have forecasted that ERP software revenue will grow to $23.3B in 2011 (CBR, 2011). One of the most interesting aspects of the growth in ERP systems is that it continues in spite of significant cost and schedule overruns that have been occurring since their inception. A recent survey of 187 companies that had implemented ERP systems found that 61% of the implementations exceeded schedule and 74% exceeded cost (Panorama, 2011). Within the Federal Government, a recent U.S. Government Accountability Office (GAO) report indicated that cost and schedule overruns were of major concerns with only one of the 10 major U.S. Department of Defense (DoD) ERP programs having been successfully implemented at the time of the report after a total investment of $5.8B (GAO, 2010). In fact, according to the research of one of the authors

(Rosa), all major DoD ERP programs have exceeded cost and schedule estimates by more than 30%.

The problem with estimating the cost of implementing ERP systems is due to their complex nature. While ERP systems are based on current-off-the-shelf (COTS) software products, implementing an ERP system cannot be treated in the same manner as implementing an IT system. ERP systems involve not only software and hardware, but business processes, and organizational structure and culture as well. The interaction between these elements results in a complexity that has been recognized for over a decade (Stensrud and Myrtveit, 1998a,b). In recent years vendors have made numerous changes in an attempt to reduce the complexity by creating more agile (i.e. tailorable) systems (Hesterman et al., 2010). Nevertheless, estimating the cost of implementing ERP systems continues to be a major problem – as is evidenced by the aforementioned cost and schedule overruns.

1.2. Deficiencies in past studies

There have been – and continue to be many efforts aimed at characterizing the cost/effort associated with implementing ERP systems. Much of what is readily available today is either in the form of prescriptive processes or academic studies. The prescriptive processes involve descriptions (in varying degrees of detail) of what to do in the course of preparing for implementing an ERP system (Ganly, 2009; Seaver, 2006; Cal Business, 2011). While these

* Corresponding author. Tel.: +1 240 612 5593.
E-mail addresses: wilson.rosa@pentagon.af.mil (W. Rosa), travis.packard@pentagon.af.mil (T. Packard), abishek.krupanand@pentagon.af.mil (A. Krupanand), jbci@knology.net (J.W. Bilbro), Max.Hodal@wyle.com (M.M. Hodal).

process descriptions are informative, they still leave large areas to be defined by the user, and since most users do not have the data upon which to base detailed estimates, the ability to obtain accurate cost estimates remains somewhat problematic. Some of the academic studies, while establishing feasibility (or difficulty) of various cost estimation methods, have primarily been associated with a single vendor (SAP) and have not provided usable cost models nor accessible data bases (Stensrud, 2001; Francalanci, 2001). More recent academic studies have focused on size and complexity of ERP implementations (Daneva, 2008, 2010). These studies focus on sizing using Functional Point Analysis (FPA) along with methods for sizing Non Functional Requirements (NFRs). These processes have yet to develop into practical methods for estimating a broad range of ERP implementations. A more in-depth discussion of these academic studies occurs in the literature review section. Organization

This research paper is organized into 8 sections:

- Section 1 introduces the problem and deficiencies in past studies.
- Section 2 summarizes the scholarly literature of the variables and research questions addressed in the study. It highlights the cost drivers, standard work breakdown structure, and rationale for selecting an ERP configuration size measure.
- Section 3 briefly explains the study's proposed solution.
- Section 4 goes over the research method step by step. It briefly explains the survey method, participants, sample, instrumentation, variables used in the study, procedures for selecting and validating the estimating models, and the experimental design matrix.
- Section 5 describes the data demographics, including ERP type and vendors, contributors to cost and schedule overruns, implementation cost allocation, and productivity comparison by business area.
- Section 6 discusses the resulting effort and schedule estimating models, including regression equations, applications and limitations, model selection rationale, multicollinearity tests, and model accuracy and validity results.
- Section 7 presents the research conclusions on the basis of the hypotheses. It also highlights the contributions and limitations, and outlines areas for further research.
- References section cites the sources used in the paper.

2. Literature review

2.1. What are ERP systems?

Enterprise Resource Planning (ERP) systems are COTS software systems that are designed to integrate all core functions of an enterprise around a unified data base regardless of business type or charter. The term "ERP" originated with the Gartner Group over two decades ago as an outgrowth of Manufacturing Resource Planning (MRP) (Managing Automation, 2011).

2.2. ERP implementation cost drivers

Early attempts at estimating the cost of ERP implementations utilized the tools for estimating custom software development, Source Lines of Code (SLOC), function points (FPs), etc., but this resulted in less than satisfactory results since, as was pointed out earlier, ERP implementations are not exclusively custom software development activities.

Stensrud introduced the concept of using what he termed Enhanced Object Points (EOP) to size ERP systems (Stensrud, 1998). In his paper he contrasts the use of EOPs to the use of the de facto standard in the research community – function point

Table 1
Stensrud enhanced object point metrics.

Users
Business units
Sites/Countries per business unit
Plants
SAP modules
of interfaces
# of conversions
# of SAP enhancements
# of reports
# of third part tools integration

(FP) counting. He discusses the difficulty of using FP counting and describes why EOPs are preferred by many practitioners as a means of more accurately sizing ERP implementation activities. He describes EOPs as a suite of multi-dimensional metrics that can be used to address the multi-dimensional aspects of ERP systems and provides a representative list of EOPs used to estimate SAP products. It is clear from examining the identified metrics (Table 1) that, for the most part, they should be applicable to estimating a broader range of ERP products than just those provided by SAP. In fact, the RICE objects used as metrics employed in this paper are a subset of Stensrud's list.

Stensrud and Myrtviet used these factors to evaluate the ability of analogy and regression tools to augment human performance in the cost estimation of ERP systems (Stensrud and Myrtveit, 1998a,b). In the course of their evaluation they produced what we believe to be the first multiple regression model using such metrics in the open literature. The model was based on data drawn from 48 completed ERP projects in the Anderson Consulting (now Accenture) internal data base. Descriptive statistics were provided on all 10 of the variables listed in Table 1. However, unfortunately, the effort associated with the implementations was considered sensitive and as such was not provided, thereby making the model of limited practical use. A subsequent expansion to the paper (Myrtviet and Stensrud, 1999) discussed the reduction of the ten initial factors to a subset of three factors by elimination of those that were not clearly and sufficiently defined, as well as those that were highly correlated with the final factors used in the model. The final model was then based on; the # of Users, the # of Electronic Data Interfaces and the # of Conversions.

Although the focus of Stensrud and Myrtviet's papers was on assessing the impact on human performance in cost estimating, the papers did produce the following regression model and establish the validity of using regression analysis in conjunction with EOPs as a means of enhancing human performance in cost estimation for ERP systems.

$$DA\_days = 328 + 2.18\, users + 554\, EDI + 101\, conversions \tag{1}$$

Stensrud continued his investigations into ERP cost estimation by developing a short list of estimation tool candidates including analogy, neural networks and regression, and then examining their efficacy in some detail. Stensrud concludes that regression analysis seems to be the best choice for ERP cost estimation (Stensrud, 2001).

Francalanci investigated the impact of the technical size and organizational complexity of SAP/R3 projects on implementation effort (Francalanci, 2001). Project size was measured in terms of the number of SAP modules and sub-modules that are implemented, and complexity was defined as the organizational scope of the project in terms of users involved and overall company size. The data used in Francalanci's study was provided by eight consulting companies on 43 SAP installation projects. Francalanci put forth hypotheses that positive correlations existed between the overall implementation effort and: