THREE DIMENSIONS OF ERP MAINTENANCE: THE CASE STUDY AT AN ENERGY COMPANY

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Abstract. Enterprise Resource Planning (ERP) systems have reached a high level of maturity, and maintenance and improvement of implemented systems is becoming increasingly important. This paper proposes to analyze the ERP maintenance problem along three interrelated dimensions: software maintenance (SM), business process management (BPM) and process improvement (PI). It is argued that BPM and PI practices facilitate maintenance of ERP systems. The proposed analysis framework is applied to study maintenance of the ERP system at a large energy company. The analysis suggests that relatively high level of maturity has been achieved in corrective and adaptive maintenance. However, the level of maturity is lower in perfective and preventive maintenance, and links between maintenance of the ERP system and BPM should be improved.

Keywords: ERP systems, software maintenance, process improvement, case study.

1 Introduction

Enterprise Resource Planning (ERP) systems are large complex software packages used to implement business processes at enterprises. They have reached a high level of maturity, and majority of large enterprises has implemented some kind of ERP systems. The operations and maintenance instead of new implementation have become the main focus for ERP practitioners. Traditional software maintenance (SM) practices can be used in maintenance of ERP systems as well as information technology resources governance methodologies such as ITIL (Information Technology Infrastructure Library). On the other hand, operation of ERP systems is tightly interrelated with business process improvement (PI) activities, and enterprises continuously strive to increase business value of their investment in ERP systems. Therefore, operation and maintenance should consider both technical and business aspects of ERP systems.

Longworth [9] identified over 300 Information System Development Methodologies. However, there are few methodologies aimed specifically at SM [7], [14], [16], [17] and only a handful of the systems development methodologies pay much attention to SM [4], [13]. Taylor [14] summarizes all methodologies and gives direction of information systems methodologies usage for SM activities. Nah [10] investigate technical aspects of maintenance of ERP systems. Light [8] investigates maintenance of custom modifications of ERP systems. Nah et al. [10] define characteristics of ERP SM and identify main tasks of ERP maintenance by means of cases studies. Although the authors acknowledge differences between traditional software and ERP, the operation and maintenance is analyzed purely from the SM perspective alone. Ng et al. [11] establish ERP maintenance taxonomy. This taxonomy classifies causes of maintenance activities and emphasizes that maintenance activities should contribute to business benefits of ERP systems. Business benefits considered include competitive advantage, globalization, system integration, best practices and cost efficiency. However, these benefits could be achieved more efficiently if contribution of maintenance is considered jointly with other related factors.

The objective of the paper is to establish a framework for analyzing maintenance of ERP systems along different dimensions and to apply this framework for evaluation of ERP maintenance at an energy company. The two main dimensions of analysis are the software maintenance dimension and the business process management (BPM) dimension. The former is assumed to address mainly technical aspects while the latter is assumed to address mainly business-related aspects of ERP systems operation and maintenance. Additionally, the third dimension of process improvement is introduced. This dimension is aimed to represent knowledge accumulation and process evolution within enterprises involved in maintenance of ERP systems. Particularly, process improvement at an ERP implementation consulting company is analyzed. The process improvement dimension is deemed important because structured and optimized maintenance processes are expected to contribute to efficiency of software maintenance and vice versus. It is expected that: 1) there is a synergetic effect among the dimensions, i.e., ERP maintenance benefits from advances in BPM and PI; 2) only all three dimensions together allow addressing all problems arising during the maintenance process. The contributions of the paper are threefold: 1) the comprehensive analysis framework for ERP maintenance is proposed; 2) interactions between the defined dimensions are identified; and 3) an ERP maintenance case is investigated according to the proposed framework.

The rest of the paper is organized as follows. In Section 2 we discuss about three dimensions of ERP system maintenance: identify key categories of SM dimension, represent PI main phases of BPM dimension, look at the representations of CMMI (Capability Maturity Model Integration) dimension, and identify interactions between those dimensions. To demonstrate practical side of interaction between dimensions in Section 3 is presented case study based on ERP system maintenance at an energy company. Observations based on this research could be found in Section 4.

2 Dimensions of ERP Maintenance

Three dimensions of ERP maintenance considered are software maintenance dimension, business process management dimension and software process improvement dimension.

2.1 Software Maintenance Dimension

During ERP SM provides services to improve, adopt and integrate ERP system. SWEBOK (Software Engineering Body of Knowledge) [1] defines that SM is the modification of a software product after delivery to correct faults, improve performance, or other product attributes, or to adapt the product to a new or changing environment. ITIL provides guidelines for incident management, problem management, configuration management, change management and release management. All these disciplines together produce software service support. Adaptation and software services are especially important in the case of ERP systems because their operation requires continuous attention.

SM is usually analyzed by defining several SM categories [2]. The most frequently considered SM categories are corrective, adaptive, perfective and preventive maintenance [10]. The user support is frequently added as the fifth maintenance category [10]. Each category has its specific purpose and tasks to be performed including tasks specific to ERP systems. Activities of corrective maintenance frequently refer to defects, which are raised by system users. These defects should be eliminated to conform to the agreed software specification. Adaptive maintenance activities are aimed at adapting the system to changes in the operating environment. Perfective maintenance activities are influenced by enterprise business processes and system vendor support terms for the current product version. Workflow automation, implementation of new applications and ERP modules, and decision making support activities, where decision making support often is realized by business intelligence tools, are a part to this category. Work done on a software system to address problems of deterioration structure is known as preventive maintenance. The preventive maintenance applies monitoring of system problem areas and performs preventive activities. Final, user support refers to the service provided to satisfy end-user's requests and help them work with the system. The strategic planning and coordination category is introduced in this paper to supplant the external parties category by Nah et al. [10]. It reflects supporting activities in ERP maintenance that are necessary across the traditional categories and business side involvement in the system evaluation process. Supporting activities of traditional categories could be communication and collaboration with ERP vendor, third-party vendors, and consultants. It is important for both the maintenance performer and the business side to comprehend potential bonuses of such activities. This category performs activities like work efficiency and business strategy plan review and brain storming about potential directions of system evolution.

Analysis according to the SM dimensions allows identifying what ERP maintenance activities are being performed and what are practical challenges of ERP maintenance.

2.2 Business Process Management Dimension

BPM is a systematic approach to improving a company's business processes. It attempts to improve processes continuously. Information technology including ERP systems is used as a key enabler of BPM and there are certain interactions between these two [10]. From the ERP implementation perspective, ERP system is deployed to execute and automate current enterprise business processes. From the BPM perspective, PI is an ongoing activity, which requires continuous updating of supporting information technology systems. Given that ERP systems are rarely outright replaced, business PI drives changes in ERP systems during their operation and maintenance. Trkman [15] notes that the design of an organization must 'fit' with the environment and effective organizations do not only have a proper 'fit' with the environment but also between its subsystems. That applies also to ERP systems. However, the ERP system's configuration could implicitly restrict implementation of additional business processes. Thus, there are mutual interactions between maintenance of ERP systems and BPM.

The most typical representation of BPM is its PI life-cycle consisting of four main phases [5]: design and formalization, execution, monitoring and supervision, and analysis and optimization. Design and formalization encompasses identification of existing processes and the design of "to-be" processes. During the execution phase, the formalized business processes are used as a basis for implementation of business processes. Business processes can be executed using custom developed or off-the-shelf software. Monitoring and

supervision encompasses tracking of individual processes, so that information on their state can be easily seen, and statistics on the performance of one or more processes can be provided. The analysis and optimization phase includes retrieving process performance information from the monitoring phase; identifying potential areas of improvement and current problems, and using both heuristic and exact methods to optimize business processes.

The aim of analysis along this dimension is to identify relationships between ERP maintenance and BPM at each stage of the BPM process and how BPM practices could contribute to improved operation and maintenance of ERP systems. It is expected that strengthening relationships between BPM and ERP maintenance helps to address business related issues of ERP maintenance.

2.3 Process Improvement Dimension

Capability maturity model (CMM) is one of the most widely recognized software development PI and quality management approaches [12]. Using this model, the maturity of software development processes, including maintenance processes, can be assessed. It is assumed that a higher level of process maturity allows improving maintenance efficiency. The capability maturity model integration (CMMI) is seen by many as a natural evolution of CMM, which was originally designed for software focus. CMMI expands the CMM to address systems engineering and integrated product development as well. A special version of CMM for maintenance purposes also has been proposed [3]. However, this version has not become as widely accepted as the general version.

CMMI offers two approaches called “staged representation” and “continuous representation“. Five levels are defined for staged representation of CMM [6]: 1) initial; 2) repeatable 3) defined; 4) managed; and 5) optimizing. All levels play an important role in implementing CMMI. They define and support the framework each process area needs to operate consistently, predictably, and manageably. In other words, the CMMI levels provide the commitment, ability, directed implementation, and verification needed for each process area. Thus, it could be applied for software support dimension.

Four process areas are defined for continuous representation of CMMI: project management, engineering, support, and process management [12]. The Project management area of CMMI helps to plan, manage, and report on project progress. The Engineering process area is focused on establishing workable requirements, developing appropriate solutions, assembling components into an integrated whole, verifying product features, and validating product performance. Support process areas are designed to provide the kind of infrastructure that management and engineering need to execute project activities in a well-oriented and controlled environment. The Process management area deals with how the organization manages, maintains, and institutionalizes its process program and the assets it contains. The focus is on strategic management, improvement, and development.

It is assumed that higher level of maturity and capability contributes to ERP maintenance. The aim of analysis along this dimension is to identify process areas, which provide the most significant contribution.

2.4 Interactions

As it is known, an ERP system is a part of business and business growth is directly depended on potential capabilities of the ERP system. Thus, a trusted approach is needed to discover way to optimal usage of ERP system potential according to external influences. Three dimensions discussed before is equally important to maintenance and improvement of ERP systems.

Interactions between BPM and SM are mutual. Any change of BPM or request for a new business process initiates activities belonging to different SM categories. For example, if a new business process model is requested then according to reason that causes this request it will refer to adaptive, perfective or preventive maintenance categories. If the change of existing business process is requested then it will refer to corrective maintenance. Thus, BPM is an area of support from the SM perspective. From the other side, ERP systems have limitations established by vendors or system architecture. These limitations are often taken in account in BP design. During SM, there is also a need for managing maintenance activities and software quality control. Thus, the best practice of each CMMI process area also could be useful for SM.

BPM and CMMI approaches combination with traditional SM and best practice establish successful environment and give benefits for maintenance of ERP systems. The following interactions between ERP maintenance and BPM are proposed:

B1. Formalized business process representation facilitates localizing impact of hot packs during the corrective maintenance.

B2. Formalized business process representation facilitates testing during the adaptive maintenance.

B3. Business process execution depends upon transfers, modifications and tuning of interfaces during the adaptive maintenance.

B4. Business process monitoring initiates activities of corrective and adaptive maintenance.

B5. Business process analysis and design initiates activities of perfective maintenance.

B6. Version upgrades during the perfective maintenance initiates business process design activities.

B7. Business process monitoring overlaps with routine administration and workflow monitoring in ERP systems during the preventive maintenance.

B8. Formalized business process representations facilitate user support.

B9. Formalized business process representation is essential for strategic planning and coordination.

The following interactions between ERP maintenance and CMM are proposed:

C1. Higher level of capability in configuration management and PI improves corrective and adaptive maintenance, particularly application of hot packs and transfers.

C2. Higher level of capability in all project management process areas improves transfers and version upgrading.

C3. Higher level of capability in process and product quality assurance, verification and validation improves testing during the adaptive maintenance and facilitates preventive maintenance.

C4. Higher level of capability in requirements management and requirements development improves introduction of modifications and enhancements during the adaptive and perfective maintenance.

C5. Higher level of capability in technical solutions facilitates introduction of modifications and enhancements and tuning of interfaces during the adaptive maintenance and workflow automation during the perfective maintenance.

C6. Higher level of capability in measurement and analysis facilities monitoring activities during the preventive maintenance.

Other interactions between SM, BPM and PI also can be identified, but the propositions listed above focus on the most profound interactions.

3 Case Study

In order to understand challenges faced by companies during the maintenance and operations phase of ERP systems, maintenance of the ERP system at large energy company is analyzed from the joint perspective of SM, BPM and PI. Initially, SM activities at the company are analyzed for each category of SM. That is followed by analysis of interactions between SM and BPM and PI. The case is analyzed from the point of view of the third party service provider.

3.1 Case Description

The company investigated in this case study is a large energy company (EC). It is using Oracle e-Business Suit (EBS) ERP system. This ERP system was implemented at the company starting from 2001 and two initial phases of implementation lasted two years. The maintenance of the ERP system is performed by a third-party (IC), which also was responsible for initial implementation, and EC internal support staff. Implementation initially was characterized by many customizations. During, the maintenance phase several significant issues of adaptive maintenance were performed: integration of new modules and implementation of system modifications. Currently, there are about five thousands active users, and the ERP system covers large part of business (totally, 7 modules are being used) and user support is important part of EC system maintenance. This investigation focuses on the last two years of the maintenance phase. Relatively stable operations of the ERP system have been achieved at the beginning of this period and the last major functionality expansion (launching of a major new module) was completed in 2006.

The main overall concerns during the maintenance and operation phase are: 1) qualification of maintenance staff; 2) finding best solutions for change requests; and 3) overall understanding of the system and seeing the big picture.

The maintenance staff of the ERP system should know not only how to technically prevent problems, but also to understand functionality of the ERP system and business needs. It is hard to find qualified technical people who can understand systems functionality from the business side and additional training usually is needed for new consultants. Identification of necessary changes and finding the best solution for these is also challenging. EC usually has the best understanding of business needs at the module level while IC usually has the best understanding of technical capabilities and limitations, and better understands the overall relationships within the system. Balancing the business needs and efficient technical solutions often has been difficult.

The information necessary for this case study is gathered using the personal experience as the maintenance team leader by one of the authors, interviews with members of implementation and support staff at IC and using records in an issue management system, which is used as a main communication vehicle during the maintenance process.

3.2 Analysis of Software Maintenance Activities

SM activities are analyzed according to the framework discussed in Section 2.1. For the given case study, SM activities performed are identified and their characteristics are discussed.

Corrective maintenance: *Hot packs* from the product vendor are installed only if there are bugs that may not be corrected in another way. Hot pack implementation requires extensive testing, because functionality of dependent modules might be affected. *Troubleshooting* is performed in response to problem issues registered in an issue tracking system. Figure 1 shows the number of issues opened and issues solved for every month. The analysis shows that there have been some irregular rises of new issues. The largest spike in September 2008 appeared because of database version upgrade what might suggest insufficient testing. By analyzing issues for the end of the month, we can see that number of issues have a tendency to decrease. The purpose is improvement of maintenance process by doing such things as implementing agile development process, defining goals, working on feedback from customers and team members, working on quality and capturing of high level business processes.

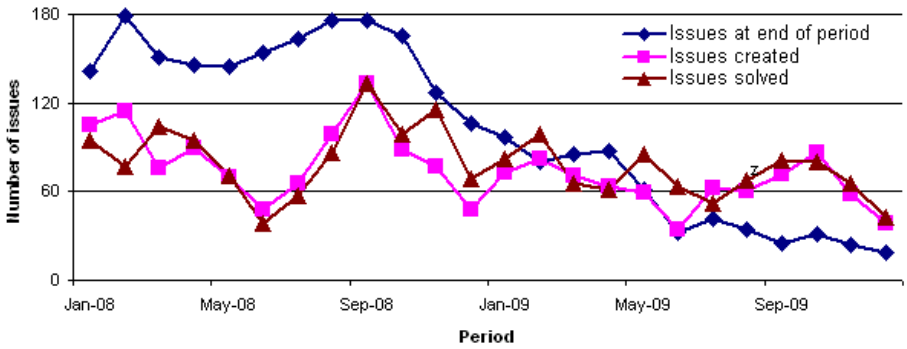

Figure 1. Number of newly created, solved and end-of-period open issues

Adaptive maintenance: *Testing* is performed before implementing any changes in the system. Initially, the system is *tested* manually in the IC's test system, followed by acceptance testing performed by EC Regress testing of the critical functionality is tested before every delivery. Testing process is performed starting with testing of critical functions and those most directly affected by changes. Time needed for testing affect intervals between subsequent transfers. Regular *transfers* are made once in every two weeks. However, there are many non-regular deliveries, which are made because of some critical problems in system functionality, urgent changes are needed (e.g. non-predictable changes in business process or changes in legislation) or influence of external systems (e.g. bank systems). There are two types of *modifications*: configuration or system modification. *Authorization* activities such as user and permissions management are performed by the help desk operated by EC. It is important to close unnecessary responsibilities and users, because amount of users and responsibilities determine cost of licenses. The ERP system has several *interfaces* with external systems such as client portal, banks, geographical information system. These interfaces are relatively stable but most frequently modifications are in interfaces responsible for interactions with other systems owned by EC (for instance, utilities management system and geographical information system).

Perfective maintenance: Implementation of additional modules continues during the maintenance process. In order to optimize workforce at EC, project costing processes have been automated by implementing appropriate *module*. A new *version upgrade* is being planned. However, there are still concerns about the best way to perform it because of costs and time required for the upgrade. The main problem is migration of system modifications introduced in early implementation stages, especially, because they are made internally rather than externally.

Preventive maintenance: System administrators at EC are *monitoring* system load, performance and errors. If there are any anomalies preventive activities are performed or a problem issue is submitted to IC. This monitoring concerns only technical aspects of systems operations and does not concern measuring efficiency of business process execution. *Code reviews* are performed by competent technical specialist after each new development. However, *documentation* is updated irregularly or not updated at all since the implementation and it is poorly structured. New maintenance team member require longer ramp-up time.

User support: During implementing major new releases, *training* for key users is held by IC Subsequently, the key users run trainings for end users at EC. *Help desk* maintained by IC is where all organization IT (Information Technology) related issues are processed. If it concerns ERP, an issue goes to EC's IT department, and they are solving the issue. If the issue is complicated, it is forwarded to IC as a problem issue or change request.

Strategic planning: A monthly meeting is being organized for module owners of ERP system. Change requests and problems are discussed with goal for every member to know what is going on in the system and find out if there are any changes which may affect his area.

Table 1 summarizes the main tasks performed at EC during the maintenance process and main achievements (marked with (+)) and difficulties (marked with (-)) associated with these tasks.

Table 1. Summary of software maintenance activities at the company.

Maintenance categories	Tasks performed	Appraisal
Corrective maintenance	Application of hot packs	Time consuming analysis of low level interdependencies (-) A lot of testing (-)
	Troubleshooting	Relatively small number of problem issues (+) Uneven distribution of problem issues (-)
Adaptive maintenance	Transfers	Throughoutly tested, reliable regular deliveries (+) Many irregular deliveries (-)
	Testing	Regress testing (+) Detailed test cases (+) Lack of time for regress testing (-)
	Modifications and enhancements	Understanding and capturing of high level processes (+) Analysis of dependencies (+)
	Authorizations	Payment of licensing fees for unnecessary functionality (-)
	Tuning of system interfaces	Use of standards (+)
Perfective maintenance	Version upgrade	Many system level customizations (-)
	Workflow automation	Proof of efficiency of automation (+) Add hoc approach (-)
	New application implementation	Implementation of client portal (+)
	New ERP modules implementation	One new module successfully implemented (+) Lack of defined requirements (-)
	Decision making support	On-the-fly requests (-)
Preventive maintenance	Routine administration	Workflow monitoring (+)
	Code review	Code reviewing established (+) Code review checklist made (+)
	Documentation update	New documentation as user stories in process (+) Lack of documentation for maintenance team (-)
	Data archiving	In process (+/-)
User support	Help desk	Operated using ITIL guidelines (+)
Strategic planning		Steering committee meetings (+) Lack of formalized approach (-)

3.3 Analysis of Interactions

BPM is performed by EC and IC observes only outcomes of their BPM activities. Business processes at EC have evolved over time and are considered unique to a company (therefore, many modifications in the ERP system were implemented) and level of their formalization is low. Knowledge of business processes is also largely restricted to individual departments. IC has elaborated formalized representations of high level processes for their own purposes. EC shares with IC an annual departmental roadmap of planned changes in business processes and systems. The ERP plays the major role in execution of business processes, although there are many other related systems. Measuring, analysis and optimization of business processes is performed in ad hoc manner. However, IC knows which functions has the highest business value and also change requests are accompanied with appraisal of their business value and importance.

Software development PI is a part of company wide drive for quality improvements at IC. IC is an ISO (International Organization for Standardization) certified company and has its own internal quality assurance and process development departments. The self-appraisal of process maturity and capability is given in Table 2. The table shows that capability level is at least 3 for every process area and even the fifth level has been reached in some of the process areas. It means that quantitative management and optimization is being used in these areas. An agile project management methodology is used as a backbone of project management processes. New releases are developed and deployed during two weeks long development iterations. Issues and change requests are allocated to the iterations according to their priority. Prior to each iteration, development effort is estimated and tasks are **planned**. For every period quantitative measurements are used to control development process. These measurements include planned/worked hours on issues, percent of planned goals reached and number of issues that have been returned from client testing. Optimization opportunities are discussed at the end of every period with whole project team in retrospective meeting. *Project Monitoring and control* is related to *Risk management* and *Measurement and analysis*. Possible risks are measured by giving every risk a value in scale from 1 to 3 (no risk or low level of risk, average level of risk or high level of risk). The maintenance project is measured in many ways and at different organizational levels. There are measures for organization management, which include costs, revenue, terms and client satisfaction. Project manager defines goals and measures project by number of issues, created and solved issues in period, planned/worked man-hours and percent of

revenue/costs. Client-related measurements are defined in service level agreement. Measurements and risks are optimized if needed. *Configuration management* and *Product integration* is measured by number of releases, number of extraordinary releases. Automation is used to optimize these processes.

Table 2. Appraisal of process maturity and capability at IC. (ML - maturity level, CL - capability level and "Y" - achieving the specified level of capability)

	Name	CL1	CL2	CL3	CL4	CL5
ML2	Project Planning	Y	Y	Y	Y	Y
	Project Monitoring and Control	Y	Y	Y	Y	Y
	Supplier Agreement Management	Y	Y	Y		
	Requirements Management	Y	Y	Y		
	Process and Product Quality Assurance	Y	Y	Y		
	Configuration Management	Y	Y	Y	Y	Y
	Measurement and Analysis	Y	Y	Y	Y	Y
ML3	Integrated Project Management	Y	Y	Y		
	Risk Management	Y	Y	Y	Y	Y
	Requirements Development	Y	Y	Y		
	Verification	Y	Y	Y		
	Validation	Y	Y	Y		
	Technical Solution	Y	Y	Y		
	Product Integration	Y	Y	Y	Y	Y
	Decision Analysis and Resolution	Y	Y	Y		
	Organizational Process Focus	Y	Y	Y		
	Organizational Process Definition	Y	Y	Y		
	Organizational Training	Y	Y	Y		
ML4	Quantitative Project Management	Y	Y	Y		
	Organizational Process Performance	Y	Y	Y		
ML5	Causal Analysis and Resolution	Y	Y	Y		
	Organizational Innovation and Deployment	Y	Y	Y		

Interactions between ERP maintenance, BPM and CMM are analyzed according to propositions made in Section 2.4. Formalization of business processes has minor impact on application of hot packs (B1) because analysis is conducted at more technical level using software design documentation though it is very helpful in testing (B2) and user support (B8). In order to enforce this link and due to the lack of formalized business process representations at EC, IC has developed high level business process representations for using in testing, training and planning. Implemented modifications have direct impact on business processes at EC (B2), for instance, customer service functionality is now available though the enterprise portal rather than using the ERP system directly. The link between business process monitoring, corrective and adaptive maintenance (B4) is weakly developed. Monitoring focuses on technical performance measures and maintenance activities are initiated only when problem occurs. Different departments at EC have different understanding of business process and they often do not communicate between each other sufficiently. That results in incomplete change requests, which need to be clarified and rework several times. Monitoring is performed by EC and this information is shared with IC only upon request produced during processing of problem issues. Similarly, there have been few activities of perfective maintenance related to business process automation (B5) because EC does not systematically seek for improvement opportunities. Additionally, changes in business processes are not being synchronized with maintenance activities. That results in a situation when a new service at EC is announced without regards to possibilities to implement this service in the ERP system within the provided timeframe. Changes in other systems owned by EC also are not being synchronized with ERP maintenance activities. Even those EC does not want to restrict its operations due to the ERP system, in the long-term that prevents from finding the most efficient solutions. The planned upgrade to the latest version of the ERP systems is expected to cause important changes in business processes at EC (B6) because fewer customizations will be introduced.

Configuration management and product integration are highly automated at IC thus facilitating applications of hot packs and releases (C1). An open source version control systems is used, and a custom built ERP configuration tool is used for automate applying of changes in the production environment. However, some modifications in the system are made also by EC themselves. These changes are resembled in the configuration manually. High maturity of project planning has enabled to deliver changes on schedule (C2). Late deliveries result in penalty fees, which almost regularly paid till the beginning of 2009 but no late deliveries penalties have been levied since that. Attitude and sense of responsibility among the maintenance team members also have been improved resulting in more predictable and stable workflows. Lack of quantitative measurements in verification and validation causes problems in quality of the product (C3). About 15% of issues in each release come back from the client testing. Ways to improve testing procedures currently are being explored, and automated testing

seems one of the most plausible solutions. Requirements management is performed using the issue tracking system. The main problem in requirements management is that requirements are often insufficiently specified and require multiple iterations of refinement (C4). Requirements have clear prioritizations associated with their business value though their identification is not systematical. Both requirements management and requirements development processes require further improvement. Technical solution capabilities currently are also at the third level and there are some difficulties with finding the best solution for implementing changes and version upgrading (C5). Currently, the main technical objectives are transition from internal modifications in the core system to external add-ons and usage of best practices. In the area of business process automation, new technologies such as mobile computing are pursued, for instance, currently a modification for using mobile devices in metering is in the planning stage.

4 Conclusion

The framework of analyzing ERP maintenance according to SM, BPM and PI dimensions has been elaborated and applied in this paper. Incorporation of BPM and PI related aspects in analysis of ERP maintenance allows for deeper understanding causes of ERP maintenance success or failure. Using the case of ERP maintenance has been concluded that mature configuration management and project planning practices enable timely and error free introduction of hot packs, modifications and new modules or applications. Agile project management techniques have been particularly helpful in improving maintenance efficiency and the number of open issues at the end-of period is steadily decreasing. Formalization of at least high level business processes allows improving adaptive maintenance and incorporation of new members into the maintenance team. However, interactions between ERP maintenance and BPM remain the most problematic issue. That is because there is lack of business process formalization and inter-departmental communication within EC and system's adaptation and perfection opportunities are identified in an ad hoc manner. Currently, IC has limited options for intervening in BPM activities, and it has mostly focused on technical aspects or ERP maintenance. However, as suggested by Gillot [5], IT (e.g., IC) should have a role in identification of business process integration opportunities and definition of best practices. On the other hand, that contradicts to EC's implicit policy of increasing its ownership of ERP maintenance processes.

References

[1] **Abran, A., Moore, J.W., Bourque, P., Dupuis, R.** Guide to the Software Engineering Body of Knowledge (SWEBOK), Ironman Version. IEEE Computer Society Press, Los Alamitos CA, 2004.

[2] **April, A., Abran, A**. Software Maintenance Management: Evaluation and Continuous Improvement. Wiley-IEEE Computer Society Press, 2008, p. 324.

[3] **April, A., Abran, A., Huffman J., Dumke, R.** Software Maintenance Maturity Model (SMmm): the software maintenance process model. Journal of software maintenance and evolution: research and practice, vol. 17, 2005, pp. 197 – 223.

[4] **Boehm, B.** A spiral model of software development and enhancement, IEEE Computer, vol. 21, issue 5, 1988, pp. 61-72.

[5] **Gillot J.N.** Complete Guide to Business Process Management: Business Process Transformation or a Way of Align, Booksurge Llc, 2008, p. 381.

[6] **Grubb, P., Takang, A.** A. Software maintenance: concept and practice. World Scientific, 2003, p. 349..

[7] **IEEE.** Draft standard for software maintenance. IEEE, New York, U.S.A, 1992.

[8] **Light B.** The maintenance implications of customization of ERP software. Journal of software maintenance and evolution: research and practice, vol. 13, issue 6, 2001, pp. 415 - 429.

[9] **Longworth, G.** Designing Systems for Change, NCC, Manchester, U.K, 1985.

[10] **Nah, F. F. H., Faja, S., Cata, T.** Characteristics of ERP software maintenance: a multiple case study. Journal of software maintenance and evolution: research and practice, vol. 13, issue 6, 2001, pp. 399 – 414.

[11] **Ng, C. S. P, Gable, G.G., Chan, T.** An ERP-client benefit-oriented maintenance taxonomy. The Journal of Systems and Software 64, 2002, pp. 87–109.

[12] **Persse J. R.** Process Improvement Essentials. O'Reilly Media, Inc. 2006, p. 352.

[13] **SSADM.** SSADM Developers Handbook, version 4, NCC Blackwell, Oxford, U.K, 1990.

[14] **Taylor, M. J., Wood-Harper, A.T.** Methodologies and Software Maintenance. Software Maintenance: research and practice, vol. 8, 1996, pp. 295-308.

[15] **Trkman, P.** The critical success factors of business process management. International Journal of Information Management, vol. 30, issue 2, 2010, pp. 125-134..

[16] **Vinje, P.** Aktiv Systemforvaltning, Teknisk Forlag, Copenhagen, Denmark, 1991.

[17] **Watchel, R.** The Software Modification Manual, North Bay Software Analysis, Occidental, California, U.S.A, 1991.

[18] **Wetzstein, B., Ma, Z., Filipowska, A., Kaczmarek, M., Bhiri, S., Losada, S., Lopez-Cobo, J.M., Cicurel, L.** Semantic Business Process Management: A Lifecycle Based Requirements Analysis. Proceedings of the Workshop SBPM 2007, Innsbruck, April 7, 2007, pp. 1-11.