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ERP systems: aspects of selection, implementation and sustainable operations

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Abstract:
This paper gives recommendations for selecting, implementing and sustainably operating ERP systems. We indicate special aspects which are important from our point of view. The paper addresses practitioners who are responsible for ERP systems, especially IT and project managers. The structure of the paper matches the three main phases of an ERP system's lifecycle within an enterprise: selection, implementation and operations. General process models are given for selection and implementation of ERP systems. Our suggestions stretch from project management, business process reengineering, system selection criteria, reporting and customizing to choosing key users, data migration, and user training. Operations of ERP systems are commented according to the views defined by the ARIS concept. We are focusing on organizational issues, but give also remarks on business process maintenance, exploitation of ERP functions, and data management. While other publications give rather general advice, recommendations in this paper are selected to be use-oriented and easy to apply. The recommendations do not depend on any particular ERP system.

Keywords:
ERP system selection; ERP implementation; ERP system operations; ERP system maintenance.

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1. Introduction

Enterprise Resource Planning (ERP) comprises management, planning, documentation, and control of all business processes and resources of an enterprise (see [1]). Though ERP is based on an integrated information system, it is much more than just information technology since it affects all parts of an enterprise and is usually subject of Business Process Reengineering (see [2] and [3]). Today, most European companies of a certain size use ERP systems. However, they may wish to update their ERP system or migrate to another system in order to take advantage of new software functionality (e.g. Business Intelligence or Customer Relationship Management) or simply because their old ERP system runs out of maintenance. Others might just wish to operate their ERP system properly or more efficiently.

Despite decades of experience in selecting, implementing, and operating ERP systems, a considerable percentage of corresponding projects fails or exceeds time and budget, and existing ERP systems do not meet management expectations and are plagued with low user satisfaction (see [4] and [5]). This holds true not only for large enterprises but also for medium-sized companies with fewer users and less complex IT infrastructure.

Several lists of "Dos and Don'ts" as well as useful hints regarding ERP selection, implementation, and operations have been published, mainly on the internet and – in some cases – in scientific papers (see [6], [7], and [8]). However, some of these recommendations are generic to the level of common sense. Others are very specific, e.g. Reed [7] relates specifically to upgrading to SAP ERP 6.0. This paper summarizes our recommendations on ERP system selection, introduction, and operations. At first, selection of ERP systems is discussed. Later on, implementation projects are examined. Finally, several aspects of operating and maintaining ERP systems are discussed.

Our personal experience results mostly from selecting, implementing, maintaining, and operating a number of ERP and other enterprise-level information systems. We both led or took part in several corresponding projects in large or medium-sized companies of the automotive industry and the machine and plant engineering and construction industry, mostly in Germany but also in other European countries. Furthermore, we carefully summarize case reports and technical literature on ERP and other business information systems.

This contribution is a revised and extended version of [9]. It does not focus on any particular ERP system. Most recommendations are applicable not only to implementing an ERP system from scratch, but also to the migration from one ERP system to another as well as to major upgrades and to keeping an ERP system up-to-date.

2. Selection of an ERP system

2.1 Phases of ERP system selection

Deciding which ERP system should be implemented and choosing an appropriate implementation partner, is the foundation of a successful first-time implementation of ERP or of an evolution of ERP within an enterprise. Selecting a system and a vendor is a complex decision problem that requires a structured approach and represents a project of its own. Several process models for software selection have been proposed, e.g. [10], [11], and [12]. All these models cover the five phases shown in Fig. 1 which we will use to structure our remarks. The picture shows a simplified model. Some phases may be performed concurrently, and some may require feedback.

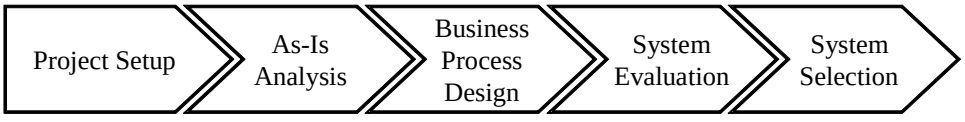

Fig. 1. Phases of ERP system selection

2.2 Project setup

The most important task of project setup is project planning. A first scenario for a follow-up system implementation project should be developed, in order to prognosticate, when a new system may become available. The latter is necessary for keeping management expectations at bay. Additionally, a first budget for ERP implementation should be estimated right from the start. It is important to verify the intention and the ability to invest into a large infrastructure project. Otherwise, there is a risk that the software selection project will be prolonged due to a lack of budget for signing a contract with a software vendor.

High visibility of the ERP project helps to staff the right project team. It is important to include at least one representative of every business department into the team. Managers of business departments show a tendency to delegate the less qualified – and therefore rather expendable – employees to the ERP project. Contrary to this habit, the best trained and most experienced business experts with the ability of strategic thinking should contribute to the ERP project. Only they are able to identify the best way to exploit the potentials of the new ERP system. Their limited availability for daily business during the project will pay off later by increased efficiency of optimized business processes.

2.3 As-is analysis

ERP implementation projects lead to long-term consequences for business execution and are typically combined with business process reengineering. The as-is processes are usually historically evolved and only partially documented. Consequently, the functional requirements for a new ERP system are vague in the beginning. Therefore, a thorough as-is analysis is necessary.

In addition to merely describing the as-is processes, they have to be assessed according to their appropriateness, and weaknesses have to be identified. The analysis indicates which business processes have to be redesigned and allows the qualification and – partially – quantification of improvements that can be achieved by the new ERP system. Quality of business processes should be quantified if possible. Assessing business processes is not a simple task. Good business processes have an explicit goal, are effective, efficient, process capable, flexible and compliant. These criteria are not measurable directly and therefore the degrees of fulfillment have to be assessed by experts using methods like model inspection, simulation and prototyping (see [13]). However, there are at least a few general metrics for measuring business process quality: Good business processes require a short cycle time that varies only slightly. They have few interfaces to other business processes, do not alternate repeatedly between two departments and distinguish between a few cases only. Failures that require a complete or partial repetition of the business process occur seldom. In addition to these general metrics, specialized metrics for certain business domains may be used, of course. For instance, the SCOR model (see [14] and [15]) provides metrics for measuring the performance of business processes in supply chains.

2.4 Business process design

There is a strong interdependence between ERP system implementation and Business Process (Re-)Engineering (see [16]). ERP system implementation provides a chance to improve business process efficiency. In our opinion, the major part of business process (re-)design should not be deferred to the actual ERP implementation project. It should be done in the system selection project already. Business processes that do not fit on the conceptual level will not become efficient when transferred to an ERP system. Furthermore, the to-be processes determine the criteria for system selection.

The main task of business process design is the development of a to-be concept for all business processes. Weaknesses and issues identified in the course of the as-is analysis indicate that processes need to be redesigned. These processes should represent a desired state. Possibly limited functionality of specific ERP systems should not limit the design of to-be processes. Functional requirements, their priorities and quantitative parameters like the number of concurrent users and the amount of data to handle have to be derived from the designed to-be processes. If the requirements would have

been solely derived from the as-is business processes, the opportunity would be missed to optimize business processes and capitalize on the capabilities of modern ERP systems. It is usually not ambitious enough to just automate the as-is processes since it would increase efficiency only slightly.

The business experts should contribute most to the definition of new business processes. Different opinions should be discussed until an agreement is reached. The business experts will advocate the new system more convinced and more convincingly if they have participated in its selection and configuration.

2.5 System evaluation

Identification, analysis and assessment of viable software systems are done in the system selection phase. This phase is structured into four steps:

1. As many viable systems as possible have to be identified. Only systems that appear on this list may be selected later on. Therefore, a thorough screening of the vendor market is required. The list of viable systems may contain more than 100 items. Internet research and trade magazines are the first and easiest source of information. Up-to-date market overviews are published regularly (e.g. [17]). Additional information may be collected at industry fairs, from industrial federations, and from specialized consultants. If an ERP system is distributed by value added resellers (e.g. Sage ERP X3), not only the system but also the reseller has to be identified.
2. Since it is not possible to analyze every system in detail, a pre-selection has to be performed. The pre-selection is based on formal, easy-to-check criteria and uses publicly available documents as well as self-reports from software vendors. Selection of a system and a vendor is usually based on three aspects: suitability, sustainability, and cost.
    - Suitability is checked on the level of business modules (e.g. material management, production planning, and financial accounting). The focus should be on differentiating criteria, i.e. requirements that are specific for the enterprise, that are not shared by most other companies of the same branch of industry, and that are not met by almost every ERP system.
    - Sustainability is checked based on the system architecture and on the vendor's financial stability. Over the past two decades, there has been a clear tendency towards fewer and larger software companies. Smaller vendors have been acquired by larger ones (e.g. JD Edwards by PeopleSoft, PeopleSoft and Siebel Systems by Oracle, and Damgaard and Navision by Microsoft). This trend is still going on. Therefore, the chosen software vendor may be acquired in a few years. In the worst case, the acquiring vendor may cease further development and try moving its new customer base to its own ERP system.
    - Cost estimation should be based on the Total Cost of Ownership (TCO) (see [18]). Investment cost covers license price, hardware cost, customization, consulting, initial training and deployment. Ongoing cost contains maintenance fee, system administration and regular user trainings.

    Considering suitability, sustainability and cost of each viable system, pre-selection should reduce the original list to approximately five to ten systems.
3. The remaining systems have to be assessed based on the detailed requirements list. Information about the fulfillment of requirements originates from presentations, visits to reference sites, and workshops during which the main to-be business processes are tested. Software demonstrations should follow a script compiled by the project team, not the software vendor. The script should contain the most important business processes with an emphasis of company specifics. Such demonstrations and workshops have to be prepared very carefully, both by the project team and the vendor. We recommend to use company specific data instead of generic demo data and to include a "Hands-on" session. The evaluation of the alternative ERP systems should reduce their number down to two – perhaps with a definite preference. A main result of the evaluation is the degree to which the previously defined to-be processes can be realized, which amount of customization is necessary, and which business processes have to be adapted in order to match the system's functionality.

4. Finally, the contract is negotiated with the software vendor or value added reseller. The first aspect is the price, i.e. license price and maintenance fee. External maintenance and support cause annual costs ranging between 15% and 25% of the license price. In software business, price models are often complicated and list prices are usually negotiable. The more licenses a customer buys, the higher the rebate he can achieve. Special attention has to be paid to the exact terms: Deliverables (just installation, or complete implementation), service level agreements (guaranteed system availability and response times to inquiries), as well as license type (named user, node locked or floating) and license scope (site specific or worldwide) have to be clearly defined. We recommend involving a consultant experienced in negotiating software contracts.

The first two out of these four steps may partially be performed in concurrence with the business process design phase.

2.6 System selection

ERP system installations are surprisingly persistent. A company that has chosen and implemented an ERP system will usually use it until there is no alternative to a change. Therefore, system selection may easily effect the next ten or twenty years. Hence, this decision should be made with care. When choosing an ERP system, the recommendation of consultants and certified public accountants should be heard but it should not overrule other important aspects of the choice – especially applicable business logic and functionality.

System selection actually covers two main choices: selection of a software system and selection of an implementation partner. As mentioned above, the main decision criteria for system selection are suitability, sustainability and cost. Suitability is the most important of these criteria. Since there will be no perfectly fitting solution available, system selection should be based on the fulfillment of key requirements as well as an open technology and a positive outlook on future developments. Due to the long-lasting effect of ERP system selection, a TCO calculation is mandatory. Maintenance fees and operating costs are important factors.

For a successful implementation, choosing the right implementation and service partner is almost as important as choosing the right system. If the implementation partner lacks experience, competence, and/or capacity, the implementation project will be bound to run into problems.

3. Implementation or upgrade of an ERP system

3.1 Phases of ERP system implementation

There is a wide variety of process models for ERP implementation, and some of these models are augmented with tools and utilities like checklists and calculation sheets. Several process models are specific for certain ERP systems, e.g. On-Target for Microsoft Dynamics NAV (see [19]). Other process models are maintained by consultancies and IT service providers, e.g. the Accenture Delivery Methods (see [20]), and some are derived from generic software development models, e.g. from the Unified Process (see [21]), Model Driven Architecture (see [22]), and even Extreme Programming (see [23]). The various process models differ in their approach to manage interdependencies between project phases, the handling of changes, the availability of supporting tools, and the consideration of software specifics. It is necessary to carefully select an appropriate process model and to adopt it to the specific needs of the implementation project in question.

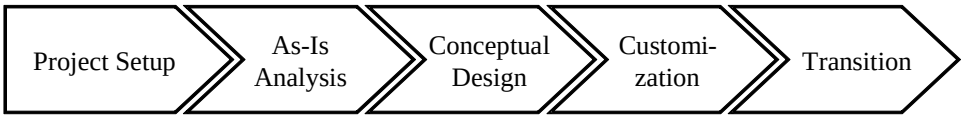

Fig. 2. Generic process model of an ERP implementation project

All process models cover the major phases shown in Fig. 2. This general model resembles the traditional waterfall model of software development. Despite its simplicity, the model structures our remarks on ERP implementation well.

3.2 Project setup

Considering an ERP implementation as just another IT project is the first step to failure. Top management support is a key factor for success. A first-time implementation project is usually initiated by top management. Thus, management awareness can be assumed. However, this is not true for major upgrades. In some cases, the project is initiated and driven by only one of several business units that dominate the configuration of the ERP system consecutively. Experience shows that all relevant organizational units should be represented equally. The members of the project team responsible for system selection should also take part in system implementation.

A crucial aspect during ERP implementation is change management: ERP implementation is a socio-technical change process that requires management. Change management deals with all aspects of organizational changes. This includes advertising the project, managing employee education, and managing the transition to ERP based business processes company-wide (see [24]). A change management agent should be announced. Neither the IT department nor the project manager should take on this role. Instead, a manager of a business department or an external consultant should be assigned to this task.

3.3 As-is analysis

The implementation project requires a detailed as-is analysis. In the case of a major upgrade of an ERP system, the as-is analysis is important as well: It has to be checked whether the as-is business processes match the previously defined to-be processes. Experience shows that usually not all implemented business processes are executed as they were designed (see [25]). Especially if the handling of the ERP system is not user-friendly and if the objective of a business process can be achieved without the ERP system, some users will tend to escape the ERP based business process. This behavior leads to issues like island solutions, media discontinuities, redundancies, incomplete or wrong information, delays in business process execution, etc. Therefore, deviations between to-be and as-is processes have to be identified as well as functional gaps and weaknesses of the ERP installation and the IT landscape in general. Furthermore, environmental changes that require a change of business processes have to be identified and analyzed.

3.4 Conceptual design

To a certain extent, all ERP systems can be configured to cover a variety of business processes. However, this flexibility is limited. Thus, the question of customer specific development arises. We agree with [26] on avoiding the development of specific applications as much as possible. In most cases, it should be preferred to adopt the previously defined "ideal" to-be business process to the ERP system over extending the ERP system.

Conceptual design also initially determines the users' access rights: They should never be granted on the level of single users, but on group level only. User groups may be derived from the company's organizational structure. No "anonymous" users (e.g. "sales" or "trainee") should be created, since it would not be possible to trace the distinct person who has edited data. In multi-tenant environments, it has to be carefully considered which user is granted which access right in which tenant (e.g. for avoiding the editing of data in a tenant erroneously chosen).

ERP systems never stand alone. Thus, conceptual design also deals with integration of external systems, e.g. Advanced Planning Systems, Data Warehouses, B2B platforms, B2C web frontends, Computer Aided Quality Assurance systems, (offline) Customer Relationship Management systems, and smartphone applications. They will not all be coupled in the beginning, but communication with any of them has to be considered during conceptual design.

Conceptual design deals not only with software, but also with the hardware of the IT infrastructure. This includes an emergency and backup concept. We suggest mirroring the ERP servers. The backup hardware should be identical to the live system, and the backup system should always be kept up-to-date: Firstly, the software installed should be the same

and equally parameterized as the software installed on the live system, and secondly, the data from the live system should be replicated at least every ten to twenty minutes to keep the data loss at a minimum in case the live system fails. The switch from the live system to the backup system should be tested at least once a year to make sure the backup system is available in case of emergency.

3.5 Customization

Once the utilization concept for the new ERP system is defined, it has to be configured and integrated into the IT landscape of the enterprise. From a technical perspective, there are typically three different types of customization in an ERP system's implementation:

1. Codeless configuration: This type of configuration requires a thorough understanding of the ERP system and the future business processes, but it does not require writing source code. Instead, codeless configuration is done in an integrated and often graphical environment provided by many modern ERP systems. Even model based customizing (see [27]) is applied sometimes. Alternatively, global control parameters are set. Codeless configuration should be done by in-house IT specialists supported by external consultants.
2. Application development: It might be necessary to fill functional gaps with specific applications. These applications should be developed by external partners. It usually does not pay off to establish the necessary expertise in-house. As mentioned in the previous section, customized applications should be avoided if possible. Interfaces to other software systems occupy an exceptional position in application development: An effective integration of the ERP system into the IT landscape of the company is a key success factor. In most cases, interfaces to Product Data Management systems, Manufacturing Execution Systems and Warehouse Management Systems are needed.
3. Key performance indicators and reports: ERP implementation projects always have to deal with reporting: Standard reports provided by the ERP system must be reconciled with company specific reports already in use. This reconciliation has to be done with care. Otherwise, inconsistencies and misinterpretation will arise which lead to dissatisfaction, repeated "incidence reports", long explanations, and thus additional effort. Reports should not overlap with regard to their content. If this occurs nonetheless, they will have to follow the identical definition and to be executed over exactly the same set of data. The expertise for report development should be gathered in-house – in contrast to application development. Key users should be provided with training and appropriate tools to create reports. Most ERP systems provide these tools or support the application of external business intelligence software.

Testing the customized system is an important task. The test should not be limited to the parts of the software directly affected by customization: Even an out-of-the-box ERP system should not be expected to work error free. At least one successful trial run of each business process is highly recommended. However, testing the main processes could be enough because they cover the majority of the business transactions. Test scenarios and test processes should be defined prior to the test. Tests should be documented with text, screenshots and diagrams. The documentation may then be applied as (a basis for) a user's guide. We recommend testing in small teams of two up to four key users. If the teams are larger, there will be too much idle time, a waste of resources, and no efficient testing. If the teams are smaller, there will be no synergy and tests will possibly be biased.

3.6 Transition

ERP system transition may be done either with a "Big Bang" or in a phased approach (where phases are based either on modules or business units). The phased approach seems to be more secure at a first glance, but is significantly more complicated to realize due to the complex interdependencies between modules and business units (see [28]). Therefore, we recommend a Big Bang transition at least for key modules. Transition comprises data migration, system activation and user training. The change of fiscal or calendar year is the best occasion to activate the new ERP system: The year-end closing will be performed in the legacy system, and all transactions of the new year will be executed in the new ERP system.

Data migration from the legacy to the new system is an important part of the transition. While the migration of master data is rather easy, it is hard to transfer transaction data, since transaction data structures are more complicated and intertwined. Beyond that, the structure of transaction data differs from one ERP system to another. Therefore, the mapping and conversion of record fields do not suffice, but structural transformation is needed. The effort to migrate transaction data should not be underestimated.

When starting the final data transfer, data must not be changed in the legacy system anymore. Hence, business activities have to be suspended until the new system is activated. The time needed for performing the data migration is determined by trial runs. Two days up to one week for data migration may be considered normal.

The activation of the ERP system and its performance should be successfully tested in trial runs several times. Shortly after activating the new ERP system, there is no way back to the legacy system because the data in the new ERP system evolve whereas the data in the legacy system do not. Often, the data in the new ERP system are more detailed than in the legacy system. Thus, data migration back into the legacy system is impossible or at least causes data loss. After the activation of the new ERP system, the legacy system may stay available for some users in read-only mode for plausibility checks.

User training and providing a company specific user guide is another important aspect of the transition phase: The first training involves key users and IT personnel only, takes place immediately after the ERP system is chosen, and is conducted by the vendor of the ERP system. The training of the key users should take place away from the office in order to avoid distractions. It is important to teach the interrelations between all relevant modules (sales, material management, production, accounting etc.).

After all business processes are defined and the system is customized, the key users train the remaining users. The training should not start earlier, because it could be confusing if preliminary versions of the processes were taught. If too much time elapses between training and operating the ERP system, many already trained procedures will be forgotten.

ERP systems are not widely applied in Asia yet. Therefore, most Asian employees are not yet experienced in operating ERP systems (see [29]). Thus, training them is even more important. Since Asian employees often do not give direct negative feedback, it is imperative for them to perform prepared exercises and answer compiled control questions. Thus, their understanding can be assessed and deepened if necessary.

4. Operations and maintenance of ERP systems

4.1 ERP systems as integrated information systems

Once the transition phase is completed, the ERP system is used on a daily basis and is essential for keeping up business activity. Each ERP system is an integrated information system and can be seen as a socio-technical subsystem of an enterprise. Therefore, the ARIS model (see [30]) can be applied to ERP systems. This model is based on the following idea: Each enterprise is structured into organizational units which are performing business processes while the company is operating. The business processes control the execution of functions which evaluate, manipulate, and create data (see Fig. 3). While operating, companies produce products and provide services to their customers according to the purpose of the company. These aspects have to be considered when developing or optimizing an ERP system, as well as operating and maintaining it sustainably. We will discuss some aspects of organization, business processes, functions, and data in the following sections.

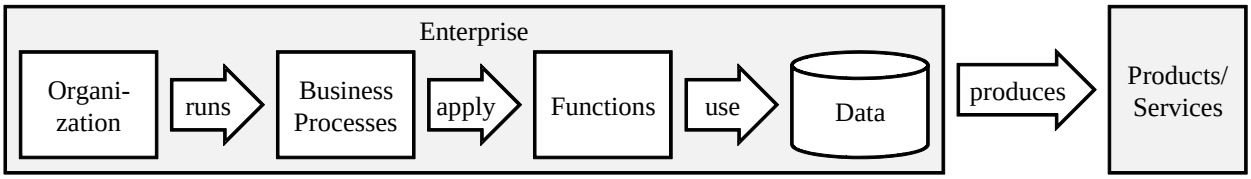

Fig. 3. Aspects of integrated information systems

4.2 Organizational view

The organization describes the static structure of a company. It consists of organizational units, e.g. divisions, departments, and employees, which are related to each other. Despite their static nature, organizational units and their relations are subject to change: Organizational units and their relations arise, evolve, shrink, split up, merge, or cease to exist. Every organizational change has to be reflected in the ERP system. The simplest cases are the introduction of a new employee who needs to be established as a user of the ERP system and granted the appropriate access privileges, and the resignation of an employee who must be disabled as user of the ERP system. Changes on the level of departments and business units are more complicated, since these changes typically require adaptations of business processes and workflows (see section 4.3). Another issue is that year-on-year comparisons of key performance indicators of the effected organizational units become complicated or even impossible.

Over time, the organization accumulates much knowledge about operating and maintaining the ERP system. This knowledge should always be shared by at least two people and be recorded as text, diagrams, screenshots, or videos. A document management system (see [31]) could be a good place for storing knowledge about operating and maintaining an ERP system sustainably. In case a specialist retires, s/he should pass on her/his knowledge duly.

Regular training should not be neglected even if ERP is running smoothly already. It prevents mistakes in operating the ERP system and deviations from business processes. Regular training should take place on the level of departments, carried out by the key user of the respective department and be customized to exactly the business processes and functions relevant for the department. Although this approach requires a thorough preparation by the key user, it is usually more efficient than giving every user the same unspecific five-days overall standard training.

The support team of the ERP system is part of the company's organization. As a rule of thumb, the number of IT specialists needed for internal maintenance and support should equal the number of users divided by 100 and rounded up. A lack of manpower for maintenance and support reduces efficiency of ERP, strategic issues are neglected, and significant costs are induced. We recommend employing two teams of equal size: one for operative tasks, the other for long-term tasks. Members of one team should be able to act as substitutes for members of the other – especially if there are two "teams" consisting of only one person respectively. We recommend two levels of in-house support: key users as first level internal support and ERP system advisors as second level internal support. Initial support requests should never address second level internal support directly but always address first level internal support first. Only second level internal support should request external support from the system vendor.

Even skilled internal personnel will not know every technical detail of the ERP system. Hence, external maintenance and support are needed. If the system operates more than twelve hours per day, extended external maintenance and support is recommended, even if costs increase progressively. The procedure of incident management has to be settled with the vendor during the design phase already. The most important criterion for good maintenance and support is a guaranteed response time relative to inquiries. Incident classification and initial support as well as investigation and diagnosis should be provided within 24 hours. Resolutions should be achieved within two work days for 85% of the issues.

Costs for external maintenance and support seem to be high but a good service guarantees the ERP system running smoothly. In case the ERP system crashed, business activities could not be maintained. That would cause financial

damage much higher than the costs for external maintenance and support. Costs for external maintenance and support should be weighed up against losses caused by a potential outage of the ERP system.

Hardware is an essential part of an ERP system instance. A few years ago, most hardware for ERP systems was kept in-house, and ERP system software was running directly on the hardware. Nowadays, most ERP system software and even its databases may be running on scalable virtual machines. This simplifies backups, and it is easy to migrate from one piece of hardware to another. Hence, we recommend virtualization. Keeping the hardware in-house, renting dedicated servers out-house, or putting the software and especially the data into the cloud is a matter of trust and costs, and we dare not yet to give a recommendation in this field.

4.3 Business process view

Organizational units run business processes. A business process is a set of activities which are related to each other and are performed by organizational units in order to achieve certain goals (see [31]). ERP systems are the stone the business processes are carved in. In some cases, this is a positive, since IT based workflows stabilize business processes and prevent undesired changes of these processes which may be caused e.g. by the carelessness of personnel or by the replacement of employees. On the other hand, it is essential to change business processes over time. Necessary changes are triggered by organizational changes, new products, new services, new production technology, upgrades of the ERP system, business process reengineering and so on. These changes have to be implemented in the ERP system in a well-defined manner.

Changing a business process is a special business process itself (see [33]) and should be executed event-controlled. Many activities in this special process address changing the process model in the ERP system which defines the workflows. If these special processes are not yet established, there will a risk arise that changes of business processes will not be correctly reproduced in the ERP system. To minimize this risk, the physical business processes of the company and the logical business processes executed in the ERP system have to be aligned time-controlled at least quarterly. In order to ensure that the business processes are appropriate, their efficiency should be measured at least once a year using suitable key performance indicators (KPIs) (see section 2.3).

4.4 Functional view

Many activities of business processes apply business functions of the ERP system or are supported by them. Some activities could apply business functions of the ERP system but either the ERP system does not provide these functions yet, or these functions have not been prepared to be applied by these activities yet. Typical examples are functions related to return material authorization (RMA), service order or service contract functions, finite capacity planning functions, functions of electronic document management, to-bin and from-bin strategies for chaotic material management, or functions of continuous inventory taking. The ERP system advisor should be aware of all functions relevant for the company but not yet applied. If this is not the case, these functions will have to be identified during the regular business process review (see section 4.3). Potentially useful functions should be assessed regarding their importance, their expected benefit and their costs of implementation. The best fitting functions should be implemented as soon as capacity, budget or a new version of the ERP system become available.

The implementation of each function is a project that consists of at least the following steps: requirements analysis, business process design, customizing (if necessary), test, training, and activation. The functions to be implemented should always be viewed in the context of the business processes applying them. As previously mentioned, extending the functionality of the ERP system via application development should be avoided if possible.

Experience shows that ERP systems tend to grow and the number of implemented functions and supported business processes increases. However, sometimes single functions or even whole business processes become obsolete. These functions should be identified, put out of service or even dismantled actively. Discarding these functions saves costs for (external) support, maintenance, testing and updates. Furthermore, unintended use of these functions and subsequent errors are prevented, and operating the ERP system becomes easier for the end-user.

Some important functions are not intended to be provided by the ERP system itself. These functions are not in the focus of ERP but are subject to other business information systems like Data Warehouses, Advanced Planning Systems and Product Lifecycle Management systems. Introduction, implementation and upgrades of these systems are managed separately. However, these systems are typically tightly linked to the ERP system via business processes and interfaces. In order to ensure the successful execution of business processes across system boundaries, the collaboration of these systems with the ERP system has to be carefully monitored and special emphasis should be put in maintaining the interfaces.

4.5 Data view

Functions of ERP systems store and manage large amounts of data that can be classified into master data and transaction data (see [34]). Master data describe persistent business objects the company has to cope with, e.g. customers, suppliers, products, bills of materials, and task lists. Transaction data reflect the ongoing business and its related documents, e.g. sales orders, purchase orders, delivery notes, invoices, material movements, and production orders. Data of ERP systems are created, read, updated, and sometimes deleted – typically in an underlying relational database. Although the basic structure of this database is predefined by the system's vendor, there are some degrees of freedom how to model business data: Often different types of one kind of master data have to be managed by one ERP system. For instance, piece goods and bulk goods are both materials with common attributes like material number and name, but there are also type specific properties like length, width, and height for piece goods and angle of repose for bulk goods. In order to provide type specific edit forms, properties, default values, ranges of values, and mandatory fields, so called "class lists of characteristics" should be applied. However, maintaining these lists (by adding, editing or removing properties or changing inheritance relations) requires much effort, since existing data have to be migrated. Therefore, reasonable care has to be exercised when defining class lists of characteristics.

Ensuring data quality is essential for achieving the objectives of ERP. This holds true for both master and transaction data. In order to avoid duplicate entries, as few users as possible should be allowed to create master data. To a certain extent, wrong or contradictory values can be prevented by defining explicit constraints and plausibility checks. Correctness and up-to-dateness of master data should be checked regularly. If the data are flawed, the extract, transform, and load (ETL) procedure, borrowed from data warehousing, will be applicable. First, the data are extracted from the database. Second, the data are analyzed and transformed into a consistent state. Third, the data are reloaded into the database.

The amount of active master data should be kept constant. For this purpose, obsolete master data should be purged from the ERP database together with the related transaction data. However, these data should be archived in a Data Warehouse for long-term analyses.

High quality of transaction data is as important as quality of master data. Especially dates (time points), durations, amounts of money, quantities of goods/services, and relations to master data have to be entered correctly. Another aspect of data quality is timeliness, i.e. transaction data should be entered at the point in time when the according business event happens. Sales orders should be entered when placed, material movements should be booked when the material is moved physically, progress towards production order completion should be confirmed when it happens, etc. As a consequence, back flushing (automatic goods receipt) should be avoided. If data were not entered correctly at the right time, the ERP system and its users would come to false conclusions while planning, and subsequent purchase or production actions would be faulty as well.

It is not possible to completely prevent entry errors – despite automatic checks and automated data capture via barcode scanners or similar tools. Periodic user training helps to keep the amount of wrongly entered data at bay. In order to identify wrongly entered data, all data should be analyzed periodically – best daily and at least weekly. The analysis should work automatically and identify suspicious data based on plausibility rules. Identified mistakes have to be corrected manually and immediately because some mistakes are irreversible after a certain amount of time. Furthermore, most mistakes result in subsequent faults which will become increasingly difficult to eliminate. Data Warehousing and Data Mining methods may support data management: When transforming data, filtering and

analyzing them, or loading them into a Data Warehouse, many inconsistencies could be found and subsequently eliminated in the source (ERP) system.

5. Conclusion and future work

Nowadays many companies use ERP systems. Although there is comprehensive know-how about selecting, implementing and operating ERP systems, many implementation projects face serious issues, exceed schedule and budget, and the goals of ERP implementation are only partially achieved when operating the ERP system afterwards. This contribution presented a collection of "Dos and Don'ts" for successful selection, implementation, operations, and maintenance of ERP systems.

In order to gain maximal benefit from ERP, the appropriate ERP system has to be selected. Therefore, the ERP system selection project has to be planned and conducted carefully. The selective list of viable systems should be long in the beginning and not be shortened too quickly. Instead, all viable systems have to be assessed according to suitability, sustainability and cost in a thorough pre-selection process in order to create a shortlist. The ERP systems on the shortlist have to be evaluated meticulously. The same care should be taken when choosing an implementation partner and negotiating the contract.

ERP system selection creates the basis for system implementation. From our point of view, key success factors for a successful implementation are top management support, involvement of all business departments and a well-considered project plan which takes the company's specifics into account and is carried out thoroughly.

Once the ERP system is implemented and in use, it must not be neglected. Instead, it has to be maintained and should undergo a continuous improvement process that covers both business processes and ERP system installation. Special emphasis has to be placed on evolving business processes and keeping a high data quality.

As already mentioned, there are many process models covering selection, implementation, operations, and maintenance of ERP systems, e.g. [35]. When developing these models further, our recommendations should be considered. Current trends let us expect that ERP projects will become even more complex in the future. The extension of ERP clients from classical PC based terminals to mobile devices and cyber-physical systems will bring new challenges in developing and maintaining ERP infrastructures. In order to achieve the real-time enterprise (RTE) [36], the need of change in organization and business processes should be detected automatically by means of enterprise service busses (ESB) [37] in connection with complex event processing (CEP) [38]. ESB and CEP might even offer a chance of adapting and testing business processes semi-automatically. But the latter options are topics of future work and research.

Although our suggestions address every phase of selecting, implementing and operating ERP systems, they are far from complete. Nevertheless, they may help practitioners to avoid pitfalls and common mistakes when selecting, implementing and operating the next generation of ERP systems in their companies.

References

[1] B. Wagner and E. Monk, *Concepts in Enterprise Resource Planning*, 3rd ed. Boston, MA: Course Technology Cengage Learning, 2008.

[2] V. K. Garg and N. K. Venkitakrishnan, *Enterprise Resource Planning: Concepts and Practice*, 2nd ed. New Delhi: Prentice-Hall, 2006.

[3] J. Sarkis and R. P. Sundarraj, "ERP-Enabled Business Process Reengineering," in *Business Process Transformation. Advances in Management Information Systems*, V. Grover and M. L. Markus, Eds. M. E. Sharpe, pp. *141-152*, 2008.

[4] J. Balyeat. (2013, April 2). *DOs & DON'Ts of ERP software implementations* [Online]. Available: http://www.bkdtechnologies.com/Articles/Dos_and_donts_of_ERP.htm

[5] C. Kanaracus, "The scariest software project horror stories of 2012," *Computer World*, December 2012.

[6] A. Gupta. (2011, March 12). *Do's And Don'ts – ERP Implementations* [Online]. Available: http://technofunc.com/members-speak/member-articles/do-s-and-don-ts-erp-implementations

[7] J. Reed. (2013, April 2). *49 Do's, Don'ts, and Customer Lessons for SAP Upgrades* [Online]. Available: http://go.panayainc.com/49DosDontsandCustomerLessons.html

[8] G. Glenn, *Enterprise Resource Planning 100 Success Secrets - 100 Most Asked Questions: The Missing ERP Software, Systems, Solutions, Applications and Implementations Guide*, Newstead, Australia: Emereo Publishing, 2008.

[9] T. Munkelt and S. Völker, "Some Remarks on ERP System Implementation in Medium-Size Enterprises," in *CENTERIS - ENTERprise Information Systems. International Conference*, Vilamoura, Portugal, pp. *280-289*, 2011.

[10] F. Ritschel and U.-M. Schmieder, *Methodische Softwareauswahl in Handels- und Industriebetrieben*, Halle, Germany: Conomic Marketing & Strategy Consultants, 2010.

[11] SoftResources LLC. (2013, April 2). The 6 Phases of Software Selection [Online]. Available: http://www.softresources.com/software-selection-tips

[12] H. Lin, A. Lai, R. Ullrich, M. Kuca, J. Shaffer-Gant, S. Pacheco, K. Dalton, K. McClelland, W. Watkins and S. Khajenoori, *COTS Software Selection Process*, Albuquerque, USA: Sandia National Laboratories, 2006.

[13] P. Kueng and P. Kawalek, "Goal-based business process models: creation and evaluation," *Business Process Management Journal*, vol. *3*, no. *1*, pp. *17-38*, 1997.

[14] P. Bolstorff and R. Rosenbaum, *Supply Chain Excellence. A Handbook for Dramatic Improvement Using the SCOR Model*, New York, USA: Mcgraw-Hill, 2003.

[15] Supply Chain Council. (2013, April 2). *Supply Chain Operations Reference (SCOR®) model* [Online]. Available: http://supply-chain.org/f/Web-Scor-Overview.pdf

[16] D. Paper, K. B. Tingey and W. Mok, "The relation between BPR and ERP systems: a failed project," in *Annals of cases on information technology, vol. 5*, M. Khosrow-Pour, Ed. Hershey, USA: Idea Group Publishing, pp. *45-62*, 2003.

[17] *ERP Software 360* (2013, April 2). *ERP Software 360* [Online]. Available: http://www.erpsoftware360.com

[18] Aberdeen Group, *The Total Cost of ERP Ownership in Mid-Size Companies*, Aberdeen TCO Series, 2007.

[19] M. Hesseler and M. Görtz, *Basiswissen ERP-Systeme: Auswahl, Einführung & Einsatz betriebswirtschaftlicher Standardsoftware*, Herdecke, Germany: W3L, 2008.

[20] *Accenture* (2013, April 2). *Accenture Delivery Methods for SAP* [Online]. Available: https://methodology.accenture.com/sap

[21] P. Kruchten, *The Rational Unified Process: An Introduction*, 3rd ed. Upper Saddle River, USA: Addison-Wesley, 2004.

[22] P. Dugerdil and G. Gaillard, "Model-driven ERP implementation," in *8th International Conference on Enterprise Information Systems*, Paphos, Cyprus, pp 77-87, 2006.

[23] B. Zuther, "Agile Entwicklung zur Einführung eines ERP-Systems am Beispiel einer Internetagentur," Diploma Thesis, University of Magdeburg, Germany, 2010.

[24] *Management Study Guide* (2013, April 2). *Management Study Guide: Change and Risk Management in ERP Implementation* [Online]. Available: http://www.managementstudyguide.com/change-risk-management-in-erp.htm

[25] J. Rehage, "ERP-Projekte scheitern am Menschen," *IT Management*, no. *6*, pp. *2-6*, 2006.

[26] *ERP Software Best Practices* (2013, April 2). *ERP Software Best Practices* [Online]. Available: http://www.erp.asia/erp-best-practices.asp

[27] J. Becker, M. Kugeler, and M. Rosemann, *Process Management: A Guide for the Design of Business Processes*, Berlin, Germany: Springer, 2003.

[28] P. Robinson. (2013, April 12). *Should you implement ERP with the BIG BANG or phased approach?* [Online]. Available: http://www.bpic.co.uk/faq/bigbang.html

[29] E. Scherer and M. Urban, "ERP-Projekte in China erfolgreich managen," *IT-Business*, no. *1*, pp. *28-29*, 2008.

[30] A.-W. Scheer, *ARIS – Business Process Modeling*, 3rd ed. Berlin, Germany: Springer, 2000.

[31] A. Adam, *Implementing Electronic Document and Record Management Systems*, New York, USA: Auerbach Publications, 2007.

[32] D. Draheim, *Business Process Technology. A Unified View on Business Processes, Workflows and Enterprise Applications*, Berlin, Germany: Springer, 2010.

[33] IT Governance Institute, *Governance of the Extended Enterprise: Bridging Business and IT Strategies*, Hoboken, USA: John Wiley & Sons, 2005.

[34] R. K. Rainer and C. G. Cegielski, *Introduction to Information Systems: Enabling and Transforming Business*, 3rd ed. Hoboken, USA: John Wiley & Sons, 2010.

[35] ISO, IEC-IEEE, *Systems and software engineering – Software life cycle processes*, International standard. Reference number ISO/IEC 12207:2008(E), IEEE Std 12207-2008.

[36] P. Fingar and J. Bellini, *The Real-Time Enterprise: Competing on Time with the Revolutionary Business S-Ex Machine*, Tampa, USA: Meghan-Kiffer Press, 2008.

[37] D. Chappell, *Enterprise Service Bus: Theory in Practice*, Sebastopol, USA: O'Reilly, 2004.

[38] K. Chandy and W. Schulte, *Event Processing: Designing IT Systems for Agile Companies*, McGraw-Hill, 2009.

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