Integrating Reuse Measurement Practices into the ERP Requirements Engineering Process

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Abstract. The management and deployment of reuse-driven and architecture-centric requirements engineering processes have become common in many organizations adopting Enterprise Resource Planning solutions. Yet, little is known about the variety of reusability aspects in ERP projects at the level of requirements. Neither, we know enough how exactly ERP adopters benefit from reuse as part of the requirements engineering process. This paper sheds some light into these questions and suggests a practical approach to applied ERP requirements reuse measurement by incorporating reuse metrics planning as part of the implementation of metrics on an ERP project. Relevant process integration challenges are resolved in the context of SAP R/3 implementation projects in which the author participated while being employed at the second largest telecommunication company in Canada.

1 Introduction

The business requirements for an Enterprise Resource Planning (ERP) solution in intra- or inter-organizational settings are the documents about the ERP adopter's organizational unit set-up, their business processes, data needs, and communication channels that are covered in the scope of the ERP implementation project. Requirements Engineering (RE) for ERP is the process concerned with all aspects of the reuse, the analysis, the adaptation, and the management of a large number of these descriptions. Its ultimate objective is to enhance the fit between the ERP adopting organization and its ERP system. The process begins ones a business case for the ERP implementation project is finalized and business drivers are identified and it continues throughout the entire implementation cycle in the form of tracking of the life history of any particular requirement and business issue. The better the resulting business requirements are conceptualized, the faster the progress in subsequent phases, because the necessary decisions concerning the future ERP solution have been made and agreed upon [4,5,24].

To streamline the RE process and to assure high quality results, the ERP vendors and their consulting partners have invented and marketed systematic requirements reuse approaches, infrastructures of processes, people and tools for ERP adopters to reuse, and, since 2000, industry-specific solution maps that are descriptions of the most important business processes within an industry sector, the technologies (ERP elements and add-ons), and services needed to support the processes. These can be

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seen as domain-specific frameworks [17] with three major features: an *architecture* defining the structure of integrated information systems within the business problem domain, a set of *business application components* engineered to fit the architecture, and a set of *tools* that assist the consultant in building component-based solutions using the domain knowledge within the architecture.

Nine years after the official launch of the first standardized ERP RE process by SAP, despite the increased attention to ERP requirements reuse, very few approaches have emerged to quantitatively measure the results from requirement reuse the customers have achieved [3]. As leading software metrics practitioners recognized earlier, we 'can not do effective reuse without proper measurement and planning' [19].

To obviate this issue, the present paper takes a measurement planning perspective [10]. We propose a practical solution that rests on a Goal-Question-Metrics-compliant process [1] of defining a requirements reuse measurement plan that links the reuse measurement needs to the ERP reuse goals and action items to be taken in the RE process. Our key objective is to provide a sound and consistent basis for incorporating reuse metrics planning as part of the implementation of metrics on an ERP project. We applied a case-study-driven research method [25] that was focused on the requirements reuse measurement activities in the context of implementing the SAP R/3 System, a leading product in the ERP software market [2,15,24]. However, our approach is generic enough and could easily be applied to any other ERP project implementation.

The layout of the paper is as follows: in the next section we motivate our approach. Section 3 is designed to answer some fundamental questions about the building blocks of our reuse measurement plan. Section 4 discusses how measurements are useful. Section 5 generalizes our experience. Section 6 concludes the paper.

2 Motivation

An ERP requirements reuse measurement process is a systematic method of (i) adopting or adapting standard reuse counting practices in ERP RE, (ii) measuring the ERP reuse goals, and (iii) indicating reuse levels targeted at the beginning and achieved at the end of each stage of the ERP implementation cycle. The main purpose of this process for ERP-adopters is to learn about their own business, technological and environment opportunities by learning how much reuse their ERP-supported business processes could practice. The motivation behind the integration of the reuse measurement process in the RE process is to achieve the following five goals:

- To enable the reuse process to be planned and reuse planning to be done as part of the RE process.
- To reduce the probability of errors and accidental omissions in the business process requirements.
- To spot requirements problems and conflict by identifying anomalous reuse measurements.
- To collect reuse data to serve as an input to an effort estimation model.

- To provide a foundation for (i) re-prioritizing the business requirements, (ii) communicating the value of ERP-reuse, (iii) increasing ERP users' understanding of the ERP functionality, and (iv) building and reinforcing partnerships,

3 The ERP Requirements Reuse Measurement Plan

Like any software development organization, an ERP adopter should document its requirements reuse measurement process in the form of a reuse measurement plan [6,10]. Its purpose is to establish a reuse measurement practice as part of a larger organizational process, namely, the ERP RE process. Moreover, it represents a communication vehicle to ensure that all the team members agree on the approach as well as serves as the on-going reference model to manage the implementation of reuse metrics. The plan defines the measurement process with exact information on stakeholders involved, measurement frequency, sources of metrics data, counting rules, metrics data interpretation rules, tools support, reports to be produces, and action items that can be taken based on the metrics data (Fig.1.).

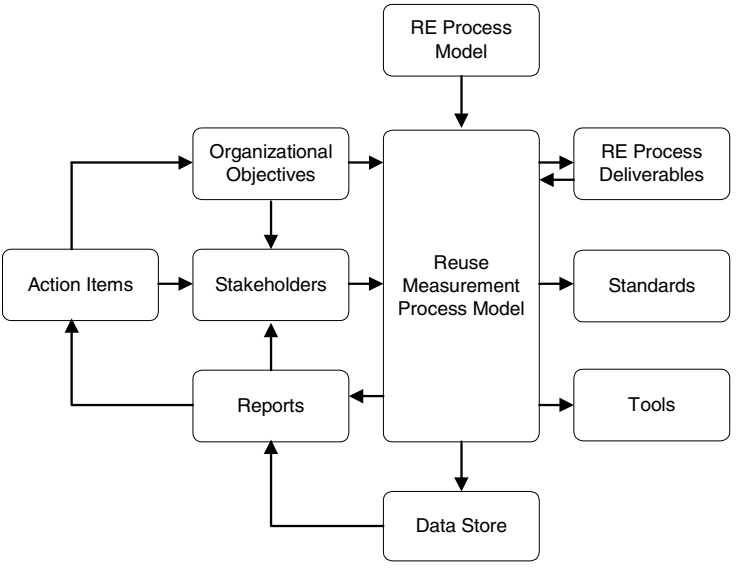

Fig. 1. The components of the SAP reuse plan

Stakeholders and their objectives define what is to be achieved by running a reuse measurement process. Next, as per the recommendations provided by software metrics researchers and practitioners [19,20], a model of the RE process is needed to capture the ERP reuse activities and to understand where measurements fit in. It should provide sufficient knowledge of (i) how to map reuse measures to RE

activities, (ii) where and when in the RE process measurements could be taken, and (iii) how measurement activities could be integrated into the larger process. Given this context, a reuse measurement process model is required to specify what to count as requirements reuse, what units of measure to use, and how to count it. Furthermore, tools, data stores and standards for data collection, processing and packaging are to be selected to ensure the quality of the reuse metrics data. Finally, the plan concludes with strategies for using the reuse data. These are presented in terms of metrics data reports to be created and action items that can be formulated based on the reported data. The components of our ERP reuse measurement plan are discussed in detail in the next sections.

3.1 Understanding Stakeholders and Their Roles

Adequate and timely consultation of the ERP project stakeholders arties is a must to the planning of reuse metrics. It helped us (i) make sure that the definitions of our metrics are based on our SAP team members' goals, (ii) eliminate misunderstandings about how metrics data is expected to be used, and (iii) define relevant procedures for packaging, cataloguing, publishing and reporting reuse metrics data.

To identify the stakeholders, we applied the approach developed by Sharp et all in [23]. Based on early SAP project documentation, we developed stakeholder interaction diagrams that captured three important aspects of our team working environment: relationships between stakeholders, the relationships of each stakeholder to the system, and the priority to be given to each stakeholder's view. The organizational knowledge represented in the diagrams is needed to manage, interpret, balance and process stakeholders' input into the SAP requirements reuse measurement process. It was used to structure the SAP project team members in four groups: (i) *business decision makers*, who are corporate executives from the steering committee responsible for the optimization, standardization and harmonization of the business processes across multiple locations, and define the concept of ownership over the SAP R/3 system and are most interested in learning about the business benefits from SAP reuse, (ii) *business process owners*, who are department managers responsible for the project in specific business areas, and contribute the necessary line know-how, design new processes and procedures to be supported by the R/3 business application components and provide the project with the appropriate authority and resources, (iii) *technical decision makers*, who are SAP project managers responsible for planning, organizing, coordinating and controlling the implementation project, and (iv) *configurators*, who are both internal IT team members and external consultants involved in various work packages, e.g. process and data analysts, configuration specialists, ABAP programmers, system testers, documentation specialists. Each stakeholder had its own questions that should be answered by using the metrics data. Business decision makers wanted to know:

- What level of standardization could be achieved by reusing ERP software assets?
- What competitive advantages does the team get from ERP reuse?

- What are the implications of reusing ERP processes in a constantly changing business environment?
- How to align business processes across locations so that ERP reuse can yield significant cost reductions and enterprise-wide benefits?

Business process owners asked:

- How ERP reuse works with volatile process requirements?
- How much customization effort is required to implement minor/major changes in the business application components?
- What processes have the greatest potential for practicing reuse?
- What activities in our processes prevent us from reusing more?

Technical decision-makers needed to know:

- How much effort is required to produce the user and training documentation associated to the customized components?
- How much reuse the team did?

Configurators asked:

- Are there any rejected requirements that should be re-analyzed because of reuse concerns?
- What implementation alternative fits best?
- Which segments of the requirements are likely to cause difficulties later in the implementation process?

The questions relevant to each group have been documented and attached to the stakeholder interaction diagrams.

3.2 The RE Process in Point

The standard methodology for rapid R/3 implementation, called AcceleratedSAP (ASAP), provides a disciplined reuse-driven, architecture-centric process for coordination, controlling, configuring and managing changes of the R/3 business application components [2,15]. To investigate the ASAP RE process, we modelled it as a spiral (Fig. 2.). Its the radial arms represent the increasing collection of information by three types of activities: (i) *requirements elicitation* activities which deliver the foundation for the business blueprint and are concerned with finding, communication and validation of facts and rules about the business, (ii) *enterprise modelling* activities which are concerned with the business processes and data analysis and representation, and (iii) *requirements negotiation* activities which are concerned with the resolution of business process and data issues, the validation of process and data architectures and the prioritization of the requirements. The ASAP methodology suggests four iterations of the spiral. Level 0 iteration aims at developing a clear picture of the company's organizational structure based on the pre-defined organization units in the R/3 System. Next, the main objective of level 1 iteration is to define aims and scope for business process standardization based on the R/3 application components. Level 2 iteration aims at deriving company-specific business process architecture based on scenarios from the standard SAP process and data architecture components. Finally, level 3 iteration refers to the specification of data conversion, reporting and interfaces requirements. The major actors in these

activities are business process owners who are actively supported by the SAP consultants and the internal SAP process and data architects. Next, the ASAP RE process is supported by the following tools: (i) the *ASAP Implementation Assistant* [15] which provides reusable questionnaires, project plans, cost estimates, blueprint presentations, blueprint templates, project reports and checklists, as well as manages the documentation base; (ii) the *SAP Business Engineer*, a platform including a wide range of business engineering tools fully integrated into the R/3 System [1]; (iii) *enterprise modelling tools* (ARIS-Toolset, LiveModel and Visio) which have rich model management capabilities and assist in analyzing, building and validating customer-specific process and data architectures based on the reusable reference process and data models.

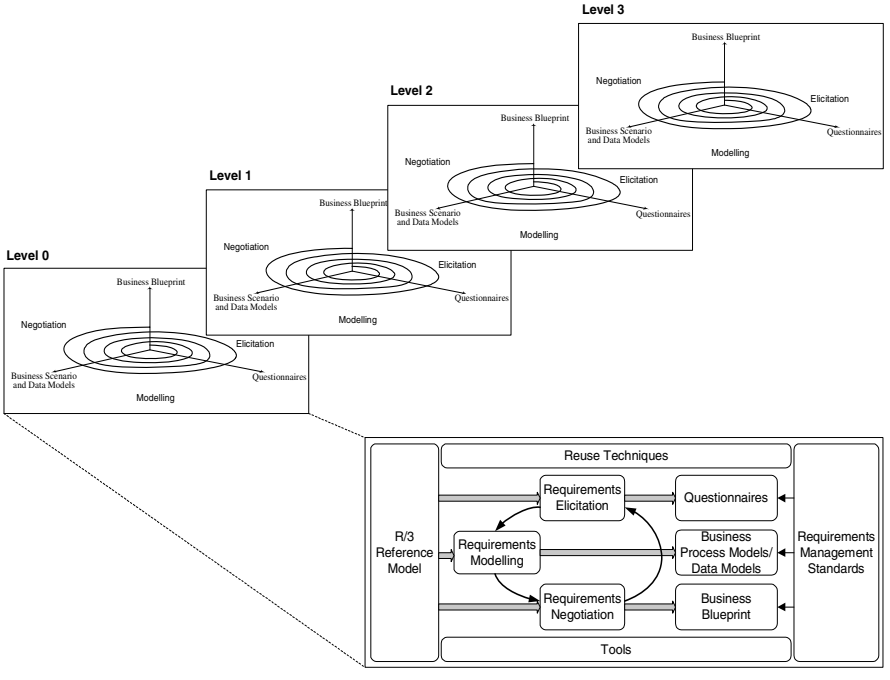

Fig. 2. The SAP requirements engineering process

The ASAP RE begins with reuse, ends with reuse and includes reuse in all the tasks in-between. It is based on proven reuse practices and techniques and it ensures that the requirements are correct, consistent, complete, realistic, well prioritized, verifiable, traceable and testable. This is achieved by using the R/3 Reference Model, a comprehensive architectural description of the R/3 System including four views: *business process* view, *function* view, *data* view and *organizational* view. Specifically, the R/3 Reference Process Models represent integrated and function-spanning collections of business processes that occur often in practice and can be handled to the greatest extend possible automatically if a corporation implements the complete R/3 System [15]. Instead of building an integrated information system from

scratch, with the R/3 Reference Model we build a solution from reusable process and data architectures based on SAP's business experience collected on a large scale. Our analysis indicates that the R/3 Reference Model [2] supports the RE process in multiple ways: (i) in *requirements elicitation*, it provides a way for process owners and consultants to agree on what the SAP business application components are to do, (ii) in *requirements modelling*, it applies common requirements models [16] and serves two separate but related purposes: to quickly develop a requirement definition that shows to the business owners the process flow the solution is expected to support, and, then, to view it as a design specification document that restates the business specification in terms of R/3 transactions to be implemented, and (iii) in *requirements negotiation*, the R/3 Reference Model serves as a validation tool. It makes sure that the solution will meet the owners' needs, it is technically implementable and it is maintainable in future releases.

Reusing architectural components in the RE process is saving both time and money. As the business process requirement analysis is the most expensive consulting service in a business engineering exercise, the reuse of the R/3 Reference Model definitely provides the greatest savings.

3.3 Process Integration Model

This section presents how reuse measurement was integrated with the RE activities and where in the RE process reuse measurement data was taken (Fig. 3).

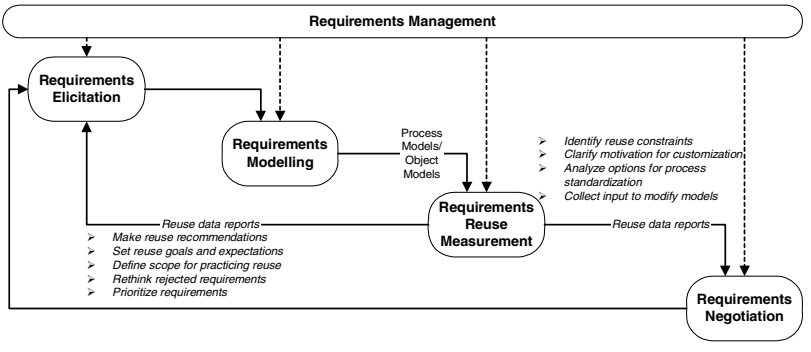

Fig. 3. Integration of requirements reuse measurement in RE

We adopted the following assumptions:

- reuse data are extracted by an SAP process analyst on the basis of two major RE deliverables: business scenario models and business object models [2];
- reuse metrics data analysis is based on quantitative indicators;
- reuse metrics data is used to support stakeholders' decision during the requirements negotiation and elicitation;
- reuse metrics data is reused at a later stage to support decision making in planning for future releases, upgrades and major enhancements.

We suggest reuse measurement be applied once the modelling activities of level 2 iteration are completed and the customer-specific process and data architectures are built (Fig.3). Given the reuse metrics data, the SAP process analyst may decide what negotiation / elicitation activities to take place next. The use of the metrics data is discussed in more detail in Section 4.

Our integration model implies that reuse measurement activities support the RE process in five areas: (i) definition of measurable reuse goals and expectations, (ii) quantitative analysis of process and data architecture reuse prior to solution design; (iii) assessment of the requirements specification, (iv) better understanding of the technical risks early in the ERP implementation cycle, (v) definition of the scope of ERP reuse and how it fits into the business environment.

3.4 The Measurement Process

As Pfleeger [14] recommends, we have to choose reuse metrics based on what is visible for the SAP project team in the requirements modelling process of level 2 iteration. Our approach uses the results of our previous research on the derivation of reuse indicators from SAP scenario process models and business object models [3]. It is based on the notion of "reuse percents" [20] and suggests a reuse indicator that includes reused requirements as a percentage of total requirements delivered [2]:

$$SAP\_Reuse = (RR / TR) * 100\%$$

where *RR* represents reused requirements, and *TR* represents total requirements delivered. In this paper, requirement borrowed from the R/3 Reference Model are classified as *reusable* if it does not require modification. If a borrowed requirement does require minor or major enhancement before use, we term it '*customized requirement'*.

To build well-defined and valid metrics [10], we selected a consistent and reliable means for structuring and collecting data to make up metrics. A standard functional size measurement methodology, namely Function Point Analysis (FPA) [11] was applied to size the total and the reused requirements in the project. It was chosen because of its appropriateness to the software artifact being measured [11,22] and its proven usage and applicability in software reuse studies [14,20]. However, we needed to adapt FPA the SAP requirements. This has been achieved in [3] by defining rules for mapping SAP business process models and data object models to the FPA counting components: we mapped SAP data entities to FPA data types, and SAP process components to FPA transaction types. As a result, the size of a scenario process model is assumed to be a function of the process components included in the model and the data objects defining the data that support the process. The step-by-step procedure for counting Function Points (FP) from scenario process models and business object models is described in [3] in terms of inputs, outputs and deliverables. Generally, it involves three stages: analysis of the process and data components, assignment of complexity values to the components and calculation of the final FP value.

Based on the analysis of the changes [15] that could be applied to the R/3 Reference Model throughout the reuse-based process modelling exercise, the measurement data collected throughout the FP sizing procedure [3], and the modes of component reuse investigated by Karllson [14], we have defined three levels of requirements reuse:

- *Level 3*: It refers to process and data components that were reused without any changes. This category of reuse would bring the greatest benefits to the SAP customer's organization. Scenarios with higher reuse rate at this level have greater potential of practicing reuse.
- *Level 2*: It refers to *minor enhancements* applied to reference processes and data components. A minor enhancement is defined as a change of certain parameter of a business process or a data component that does not result in a change of the process logic. This category of reuse refers to those processes and data components of the R/3 Reference Model that logically match the business requirements but their parameters need to be changed at code level to achieve their business purpose. Level 2 reuse is as desirable as level 3 reuse.
- *Level 1*: It refers to *major enhancements* applied to reference processes and data components. A major enhancement is any considerable modification in the definition of a process or a data component that affects the process logic from business user's point of view. This category of reuse refers to those processes and data components that do not match the business requirements and require changes at conceptual level, as well as at design and code level to achieve their business purpose. Level 1 reuse is at least desirable.

In these definitions, the term *process (component)* refers to the functional units of any SAP scenario process models and the term *data component* means a data entity, a relationship or an attribute from the data model describing the SAP business data requirements. Furthermore, we introduce a level of new requirements, *No_Reuse,* to acknowledge the fact that reuse is not practiced at all. It refers to newly introduced processes and data components. This does not mean a reuse category; it just helps us to partition the overall requirements and to get understanding of how much requirements are not covered by the standard scenario processes and business objects.

Given our definition of what to count as reuse and how to count it, we have derived three reuse indicators [3]:

$$\text{Level}_i\ \text{SAP\_Reuse} = (\ RR_i / TR\ )*100\%$$

where i = {1, 2, 3}, RR_i represents reused requirements at Level_i, and TR represents total requirements delivered. The indicator

$$\text{No\_Reuse} = (\ NR / TR\ )*100\%\ ,$$

where NR represents the new requirements, and TR has the above meaning, reports the percentage of requirements that can not be met by the R/3 application package unless some customer-specific extensions are not developed. Currently, case studies are being carried out to validate empirically our counting model and its application procedure. This exercise is being done on the basis of Jacqet's framework [13] for investigating measure validation issues and is carried out with the collaborators from Concordia University, Canada. It is part of a research project on building size and cost estimation models for inter-company ERP systems [5].

3.5 Assembling a Toolset for Data Collection

To assure the quality of the reuse data, we found that at least three tools were needed: (i) a form for recording all the counting details; (ii) a reuse metrics database, and (iii)

a process knowledge repository. We extended the FP counting form suggested in [8] by including information needed for calculating the reuse indicators. Based on our FP counting model [3], we devised a counting form usage procedure that indicates at exactly what point each piece of data should be collected. information has been stored and processed in Excel spreadsheet software. Summarized and detailed reports have been extracted from Excel tables. For example, Table 2 reports on size numbers for six SAP business scenarios and Table 3 presents the summarized results from measuring reuse. Since reuse metrics provided knowledge about the business processes, reports on metrics data were treated as part of the SAP process documentation. can be We stored, packaged, catalogued and published reuse data by using a corporate intranet repository as well as standard process modelling tools and the ASAP Implementation Assistant. In this way, data was made available for review and analysis to all interested parties. Users of SAP documentation could easily navigate from scenario models to functional size and reuse metrics data.

Table 2. Functional size measurements in FP for six SAP scenarios

Business Scenarios	*Level 3 FP*	*Level 2 FP*	*Level 1 FP*	*New FP*
Recruiting	170	87	88	92
Business Trip Processing	120	41	20	25
Payroll Processing	236	26	16	32
Benefit Administration	195	87	102	91
Employee Relocation	165	21	10	16
Employee Numbers Processing	22	8	0	38

Table 3. Reuse levels for six SAP scenarios

Business Scenarios	*Level 3 Reuse*	*Level 2 Reuse*	*Level 1 Reuse*	*No Reuse*
Recruiting	39%	20%	20%	21%
Business Trip Processing	58%	20%	10%	12%
Payroll Processing	76%	8.5%	5%	10.5%
Benefit Administration	41%	18%	22%	20%
Employee Relocation	78%	10%	5%	7%
Employee Numbers Processing	32%	12%	0%	56%

3.6 How to Link Reuse Data to Action Items

Measurements are considered useful if they help stakeholders (i) understand what is happening during the ERP RE process, and (ii) control what is happening on the ERP project [10]. Typically, two types of reuse profiles could be derived from a requirements reuse measurement table (Table 3): *scenario-specific* profiles which present the levels of reuse pertinent to a given scenario, and *level-specific* profiles which show how the requirements are reused at a specific level within a project. Business decision-makers can use both types of profiles in at least three ways: (i) multiple reuse profiles of two or more different ERP products (SAP, Oracle, PeopleSoft) can be compared to determine which package best serves the needs of the company and offers the greatest opportunity for reuse; (ii) multiple reuse profiles of

different releases (SAP R/3 4.0B, 4.5, 4.6) of one ERP package could be compared to determine which release brings biggest benefits to the company; (iii) multiple reuse profiles of a single ERP package (e.g. SAP R/3) can build an assessment of the overall level of standardization of the ERP solution in the organization. Reuse profiles of a single ERP package (e.g. SAP R/3) can be used by technical decision-makers to plan and control the reuse levels in the later phases of the ASAP implementation process. Business process owners and configurators can track requirements reuse levels over time to control the changes in overall reuse during the iterations of the RE process.

Furthermore, the specific use of each profile was systematically documented by using a Reuse Data Usage Table. We built it to characterize four aspects of a reuse profile: who needs to read the profile data, what the profile can help us understand, what the profile can help us control and what action items are likely to be taken based on the reuse profile. Tables 4 and Table 5 report on the current usage of the scenario-specific and level-specific profiles, respectively. (BDM, PO, TDM and C stand for business decision-makers, process owners, technical decision-makers and configurators, respectively.)

Table 4. Reuse data usage table for scenario-specific profiles

Usage	BDM	PO	TDM	C	Action items
Understand the customization risk for upgrade projects.	x	x	x	x	1. Assess the difficulty in the migration of processes with low reuse rates. 2. Reengineer the business requirements. 3. Budget and plan resources for extra gap analysis for the processes with low reuse rates.
Understand how much reuse the team did.		x	x	x	1. Set reuse expectations for later stages. 2. Define scope for practicing reuse. 3. Make process reuse recommendations.
Understand reuse constraints / Assess the level of standardization.	x	x		x	1. Elaborate alternative process flows to eliminate the need for customization. 2. Re-assess reuse levels. 3. Compare processes to select the best alternative.

Table 5. Reuse data usage table for level-specific profiles

Usage	BDM	PO	TDM	C	Action items
Define focus for negotiation meetings.		x		x	1. Review scenarios on a function-by-function basis to justify why customization is necessary. 2. Structure requirements in three categories: must-to-have, nice-to-have and possible-but-could-be-eliminated.
Select an implementation strategy.	x	x	x		1. Consider a step-by-step approach to a sequenced implementation, if Level 1 reuse dominates. 2. Consider a big-bang approach, if Level 3 reuse dominates.

4 Discussion on the Reuse Data Usage

Table 2 and 3 show example scenarios referring to the SAP Human Resource Management component. The *Level 1 Reuse* and *No_Reuse* ratings of the *Recruiting,* and *Benefits Administration* processes as well as the *No_Reuse* rating of the *Employee Number Processing* scenario are relatively high due to significant customization and numerous external interfaces required by the process owner. Next, the scenarios of *Payroll Processing* and *Employee Relocation* are the ones, which practice most *Level 3* reuse.

The scenario-specific data usage table suggests what benefits the reuse measurements bring to those stakeholders who are responsible for planning for reuse and assigning target reuse levels to each scenario to be achieved throughout the R/3 implementation project. Some examples of how these profiles were helpful include the following:

- The data was used in level 3 requirements elicitation to understand what prevented some teams from reusing more. In the *Recruiting* and *Employee Number Processing* scenarios, the low level of reuse was due to three reasons: (i) the standard R/3 functionality did not offer enough support to the business practices specific to a non-unionized mobile telecommunication services operator, (ii) many external interfaces to legacy systems had to be built, and (iii) hiring processes have not been standardized across locations in three Canadian provinces. We attempted to achieve requirements reuse trough re-engineering [12] of the major legacy systems.
- The data were useful in planning for both new implementations and upgrades. In the first case, unforeseen process modeling risks appeared for processes with high *Level 1 Reuse* or *No_Reuse* rates. They were likely to need additional resources (e.g. business process owners, internal training specialists, and documentation analysts) to get documented. In case of upgrades, reuse profiles helped the team assess the degree of difficulty involved in the migration to the new release. For example, Table 2 suggests that the process of *Employee Number Processing* needs to be migrated with extra caution.

Next, the level-specific usage table was important to requirements negotiation activities. Two illustrative examples of our experiences refer to the activities of (i) requirements prioritization and (ii) selection of an implementation strategy:

- The reuse data were used to decide what to focus the negotiation efforts on. As the process owners got a better understanding of the SAP reuse, and recognized customization options as one of the riskiest matters, they become more conscious to the avoidance of unnecessary adaptation and were willing to re-prioretize the requirements.
- The level-specific profiles helped both business and technical decision-makers determine what SAP implementation strategy fitted best with the organizational objectives. If *Level 1* reuse dominates and much customization efforts are anticipated, the team is likely to adopt a step-by-step approach to a sequenced implementation of the SAP components. If *Level 3* reuse rates are the highest ones, the customization risks are reduced and a big-bang approach to implementing multiple components seems to be reasonable.

5 Evaluating Experiences

SAP requirements sizing and reuse counting has been practiced in 13 SAP projects [4]. Each project was broken down in subprojects based on the number of SAP components to be implemented. For example, if a project implemented three components, it was broken done in three subprojects. The total number of all subprojects was 65. These varied in size and included new implementations, upgrades, and consolidations of system instances due to organizations' mergers and acquisitions. While applying the process, we collected and documented some facts and observations about the context of reuse measurement. Thus, we obtained a set of experience packages that suggested explanations of how and why the measurement process worked as part of the RE cycle [7]. We used these facts and observations to evaluate how the measurement process worked. Each package includes characteristics of the project context, a logical conclusion about specific aspects of the measurement process, and a set of facts and observations that support this conclusion. The conclusions represent either lessons learnt that tell us what and how worked in the process or critical success factors that suggest why it worked.

A summary of our lessons learnt is given in Table 6. It lists observations about what worked and how, and the number of subproject in which the observations occurred.

Table 6. Lessons learnt

Lessons learnt	Number of observations
Requirements reuse measurement helps understand in both qualitative and quantitative terms the role of the pre-defined process models in ERP RE.	60
The measurement process must be focused on defining action items based on the reuse data metrics, not on collecting and reporting data.	65
The process leads to consistent traceability information being maintained for all the business processes.	56
It increases the probability of finding poorly prioritized requirements.	48
Reuse data is a central record of all the process specific reuse information.	65
Reuse data helps to focus the validation process.	59
Reuse measurement should not be practiced as a short-term process that would be dropped at the end of the SAP implementation cycle.	53

Moreover, we identified 10 critical success factors:

- Apply a stakeholder identification method to the SAP project organization. This made sure that all important stakeholders have been captured, and yet that irrelevant actors have not been included.
- Use the ERP vendor's standard processes, deliverables, and tools. This significantly shortened the time needed to model the RE process and to spot where in this process measurements could be taken, analyzed, and used.
- Adopt (if possible) or adapt a standard methodology for sizing the business requirements. FPA proved its usefulness and applicability in ERP RE.
- Integrate the reuse measurement process incrementally. Pilot it by applying it to the business scenarios pertinent to a selected ERP component.
- Consider the metrics data reports as a supplement to the business blueprint. The business process owners should review reuse data as the other RE deliverables.

- Take extra efforts to experiment with the reuse measurement process and to collect and document the series of action items the team members suggest based on the metrics data.
- Understand the role of the reusable components and the reuse techniques in the ERP RE process.
- Maintain a limited number of requirements reuse measurement process documents: it is sufficient to start with a reuse measurement plan, a FP form and a customizable report template for presenting the results.
- Think out a strategy of how to maximize the benefits of the business engineering tools the team uses in the course of the ERP implementation. These can be of great support to the measurement process.
- Use the data for planning action items.

6 Conclusions

ERP requirements size and reuse measurement starts receiving the attention it deserves as a contributing factor in the success of ERP RE. This paper addresses both planning and technical aspects of making reuse indicators work in ERP project settings. We blended stakeholder interaction analysis with a process integration model to ensure the visibility of both reuse measurement and RE activities. This resulted in a practical requirements reuse measurement plan that one can apply incrementally to selected portion of the business requirements as well as to the entire project. The plan documents the components of a consistent measurement process: relevant stakeholders, a RE process model, a process integration model, counting rules, tools and reuse data usage tables. The process is reasonably simple so that RE teams can concentrate on their requirements elicitation and negotiation activities while functional size and reuse counting and data report generation playing a supporting role. Experiences of practicing the reuse measurement process have been packaged in 13 projects to derive lesson learnt and critical success factors for an on-going ERP reuse measurement initiative. We found that reuse requirements measurements were particularly valuable for highlighting anomalous customization requirements that may be unnecessary. ERP scenarios were then analyzed, then, in more detail.

We consider the work reported in this article as only the beginning of an ongoing effort to develop better requirements reuse measurement practices. In our future efforts, we plan to focus on answering the following research questions: How ERP requirements reuse relates to project cost? Does the claim that reuse decreases efforts [18,20,21,] remain valid in ERP settings? Which level of reuse dominates in each of the three project types, new implementation, upgrades, and instance consolidation? How to apply real options thinking [8] to ERP reuse as part of the RE process? What represents a good model for estimating the costs of keeping requirements reusable and estimating the future options [9] that this investment offers?

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