BUSTECH 2013

The Third International Conference on Business Intelligence and Technology

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BUSTECH 2013

Foreword

The Third International Conference on Business Intelligence and Technology (BUSTECH 2013), held between May 27 and June 1, 2013 in Valencia, Spain, continued a series of events covering topics related to business process management and intelligence, integration and interoperability of different approaches, technology-oriented business solutions and specific features to be considered in business/technology development.

We take here the opportunity to warmly thank all the members of the BUSTECH 2013 Technical Program Committee, as well as all the reviewers. We also kindly thank the authors who dedicated much of their time and efforts to contribute to BUSTECH 2013. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations, and sponsors. We are grateful to the members of the BUSTECH 2013 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that BUSTECH 2013 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of business intelligence and technology.

We are convinced that the participants found the event useful and communications very open. We hope that Valencia, Spain provided a pleasant environment during the conference and everyone saved some time to explore this historic city.

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Using Process Simulation to Assess the Effect of Data Format Standardization in Collaborative Processes

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***Abstract*— Data quality plays an important role in the context of collaborative engineering and virtual enterprise. Drawing on business process management perspective, this paper attempts to gain deeper understanding of data format standardization in B2B processes by using process simulation methodology on data drawn from a large industrial project situated in automotive industry. Analysis results of this process from the virtual engineering domain show that implementation of the data format standard does have a positive effect on business process performance in terms of process costs and execution time not only for the main manufacturing enterprise but also for its suppliers. These findings have implications for data quality and standardization initiatives illustrating the use of simulation technique for process performance evaluation.**

Keywords- Data in supply chain collaboration, data management, business process simulation.

I. INTRODUCTION

Process changes that are induced by re-engineering activities of process elements like activity, data or organizational structure are difficult to assess without implementing the process in real life. Simulation tools can support this assessment by providing first insights into the new process. Complex simulation scenarios require high amounts of data on the process details as well as on business process environment. Using business process modeling and simulation software enables process documentation that contains process details as well as subsequent process simulation based on the documented process flow and included information on process logic and tasks. This analysis technique is applied here to assess the effects that are induced by the introduction of a format standard for data interchange and documentation on process performance within a collaborative process in automotive industry.

Being the foundation of business to business (B2B) communication, data needs to be managed towards several aspects. In 1999 a survey performed by NIST (National Institute of Standards and Technology) revealed that the economic cost of bad data exchange processes in the US automotive industry is $1 billion per year [7]. Similar studies with similar results have been conducted in Japan and Germany [16]. This problem can be approached from two angles: considering intrinsic or extrinsic aspects related to data exchange process. Intrinsic aspects cover data content and its structure, whereas extrinsic aspects relate to issues appearing during data translation [2].

Here, intrinsic aspects of data exchange in the context of collaborative engineering are put in focus. Simulation-based design tools in manufacturing context make it possible to analyze the behavior of complex products without constructing their physical prototypes. Manufactured parts can be virtually tested so that design and tolerance problems are detected in an early phase saving costs and time. This virtual prototyping can simulate a crash test with a virtual car and analyze dynamic behavior of mechanical parts.

Two main simulation types can be distinguished [2]: Discrete event simulation and geometric (continuous) simulation. A case study from the second type situated in the context of a major German car manufacturer is analyzed in this paper. Heterogeneous simulation and design software as well as accordant data standards in the context of virtual engineering cause interoperability problems as well as process performance drawbacks within the considered supply chain. A consortium containing a major German car manufacturer as well as involved simulation partners was founded to develop a continuous simulation process to eliminate the mentioned drawbacks.

One of the most important measures to achieve the goal of a continuous simulation process is the development of a data format standard that supports data transaction requirements in automotive industry with the focus on the virtual prototyping process. As the common format an XML-based data format was developed and implemented throughout the process of virtual prototyping. To perform data exchange a central information system has been envisaged. Selecting XML as the data interchange syntax provides for enough freedom in structuring geometric data, at the same time ensuring that different proprietary standards can be made interoperable. XML is an open data format recommended by [17] for all communications between the elements in a mediator-based system that allows platform- and system-independent encoding and integration of semi-structured data. Benefits of this standardization effort are expected on the output and process levels [19] supporting efficient and safe task execution [9]. Data is considered as the lowest level of abstraction resulting from measurement, that is storable in documents, i.e. semantically structured files, and processable using specific syntax.

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There is relatively little research activity in this domain, thus to close this gap, the guiding research question of the paper is focused on how to assess the impact of data format standardization in virtual prototyping on the process level. As the actual roll-out of the process is cost-intensive and requires re-structuring of the processes of the involved actors this question is addressed using the process simulation method. Furthermore, simulation allows creating “before” (as-is) and “after” (to-be) scenarios.

Using the method of process simulation with time and cost related indicators on the as-is and to-be process that includes integration of the common data format, the question of the direction of the effect induced by data format standardization is addressed. The results show positive changes in the process performance measured using process simulation. This effect is referred here to the data format standardization. Although, these results might be expectable, only little scientific evidence on this matter exists. Furthermore, these results can be used by managers of collaborative processes to promote data standardization in the particular environment.

The reminder of the paper is structured as follows. In Section II related work on the effects of data standardization as well as simulation in business process management context is presented. Section III describes the case study in focus as well as the process under analysis. In Section IV the applied research method as well as the simulation set-up is described. Analysis results are presented and discussed in Section V. Conclusion and outlook finish the paper.

II. RELATED WORK

The effect of electronic data interchange (EDI) as paperless transmission of business documents between trading partners has been extensively covered in research. MacKay [6] defines EDI as “paperless transmission of business documents between trading partner application systems, via a computer and communications network, in a standard message format”. Survey-based research by MacKay [6] showed that the component sector in automotive industry did experienced benefits from EDI adoption being among others: improved relations with trading partners, improved data accuracy as well as increased productivity. Keller et al. [12] showed that external collaboration, i.e. collaboration between supply chain actors, does not directly improve logistical effectiveness, measured in costs. Nevertheless, their research shows that collaboration with external supply chain entities influences increased internal collaboration, which in turn improves logistical service. Rajgopal and Abdumalek [1] use a case-based approach to demonstrate how lean manufacturing tools can help process industry to obtain better overall financial and operational control. Therefore, they apply the value steam mapping (a simulation method by Rother and Shook [10]) on snapshot data such as inventory levels before each process, process cycle times, number of workers, and changeover times. They also use “before” and “after” scenarios as well as value stream mapping in order to demonstrate potential benefits of lean manufacturing tools.

In the research area of business process management, business process simulation has been widely used for business process re-engineering [5], [15], [4] as well as organizational design [3] and quality assessment [18] among other domains.

Business process simulation has gained a lot of attention in the context of business process re-engineering in 1990ies as a tool to support managerial decision and illustrate potential effects of a newly designed business process without significant financial effort. Business process simulation aims at assisting the process of modeling and analyzing organizational structures. Use of simulation in the context of business process re-engineering is based on the approach to computer-aided analysis expressed by [11]. Being an operational research technique simulation has a major advantage as it allows experimentation with any element of a business system [3] being used in order to measure, understand, and predict the metrics of process improvement and quality [5] and to explore the effects introduced IT-support on the process performance.

III. PROCESS CONTEXT AND DESCRIPTION

The goal of this paper is to use a case-based approach to demonstrate how data format standardization influences process performance. Here, the virtual prototyping process of a major German car manufacturer is analyzed. Since some of the information is confidential, the company is referred to as Construction throughout this paper.

In the context of automotive manufacturing numerous actors are involved in the cooperative and digitalized development and manufacture planning composing a virtual or extended enterprise. Figure 1 shows the general architecture for the IT-supported processes during the product creation. Multiple actors are involved and different IT-support levels are needed to bring a (manufacturing) product to life. Here, the process of virtual prototyping of car parts consisting of the subprocesses: forming, joining, drying and crashing is considered.

The sub-processes are performed by different actors that use different Computer Aided Engineering (CAE)-systems and data formats. Only after all the sub-processes are successfully performed and functionality of the parts is given, the parts can be built. Therefore, the process considered here is centered at data generation and transmission. The sub-processes are organized in a way that their sequence and thus generated data is crucial for the subsequent step. Without the data following sub-processes cannot be executed. The as-is process is shown in figure 2. Due to the heterogeneous architectures of the cooperation partners the prototyping process is currently time and cost consuming.

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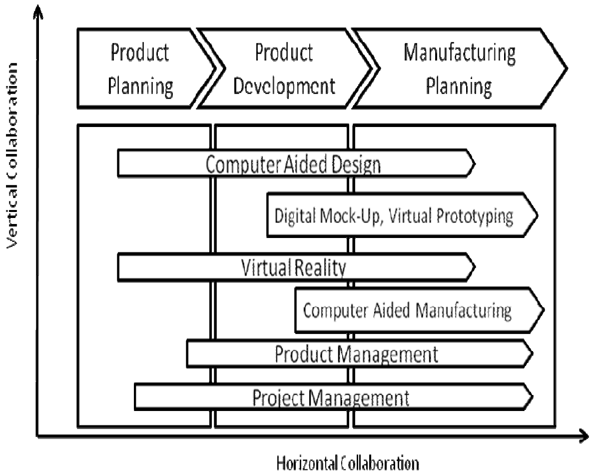

Figure 1. IT-support during the product creation process [13]

To overcome the mentioned shortcomings, process actors built a consortium to develop a continuous simulation process that will be based on a data format standard, i.e. common data definitions, representation, and structures. This initiative is based on the expectation that this standard will allow a more robust process as well as diminish the effort of data transformation, i.e., the time and costs expenses. Thus, the main goal of the consortium is to integrate heterogeneous software and enterprise architecture and enable a continuous simulation chain from the concept to the product. As standard language for data structuring and transmission XML has been chosen and the process flow has been subsequently adapted to the emerged changes. Figure 4 shows the envisaged to-be process that includes the data management system(s) that supports collaboration and data exchange between process actors.

The process is situated in the automotive industry and describes prototype simulation within a construction process. Main actor is the car manufacturer (Construction). Parts (virtually) designed by the Construction need to be (virtually) tested in numerous scenarios to identify their fit and possible quality drawbacks before being sent for actual realization. Thus, the process contains four simulation sub-processes (see figure 2): forming, joining, drying and crashing. These simulations are performed by different simulation partners (abstracted in the collapsed pool: simulation). Only when data from all simulations is derived and approved, the simulation process can end and the parts can be sent for physical construction.

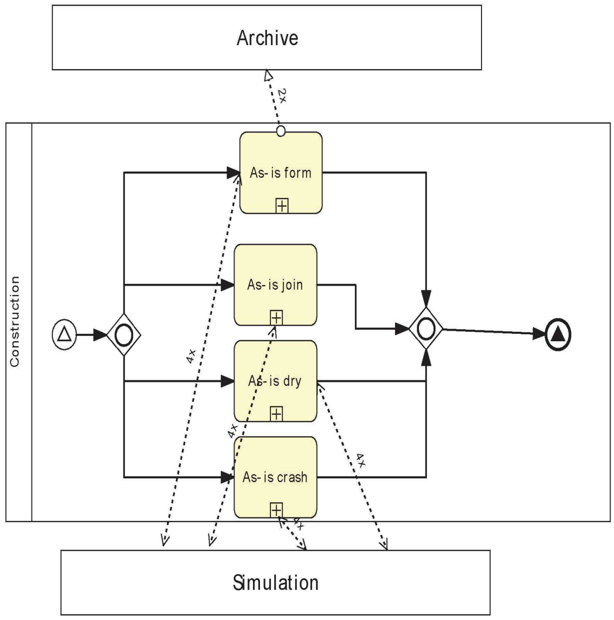

Figure 2. As-is process: generalized cooperation view

Figure 2 shows the cooperation activities between process actors, i.e., as-is simulation process from the abstract view point. Figure 3 shows an example of an as-is sub-process, here: drying, on a detailed process level.

The sub-processes are structured in a similar way. First the part has to be designed by the Construction and a contract with the simulation partner has to be negotiated. Then, Construction collects the data needed for simulation and sends this data to the accordant partner. The partner has to evaluate data for their completeness and correctness. If the data is not sufficiently elaborated, the partner sends the data back to Construction for re-work. Re-worked or complete initial data are then preprocessed, simulated and post-processed by simulation partner and the results are sent to the Construction. Construction receives the results, evaluates them according to the test goals and disseminates them to further partners involved in the subsequential manufacturing activities.

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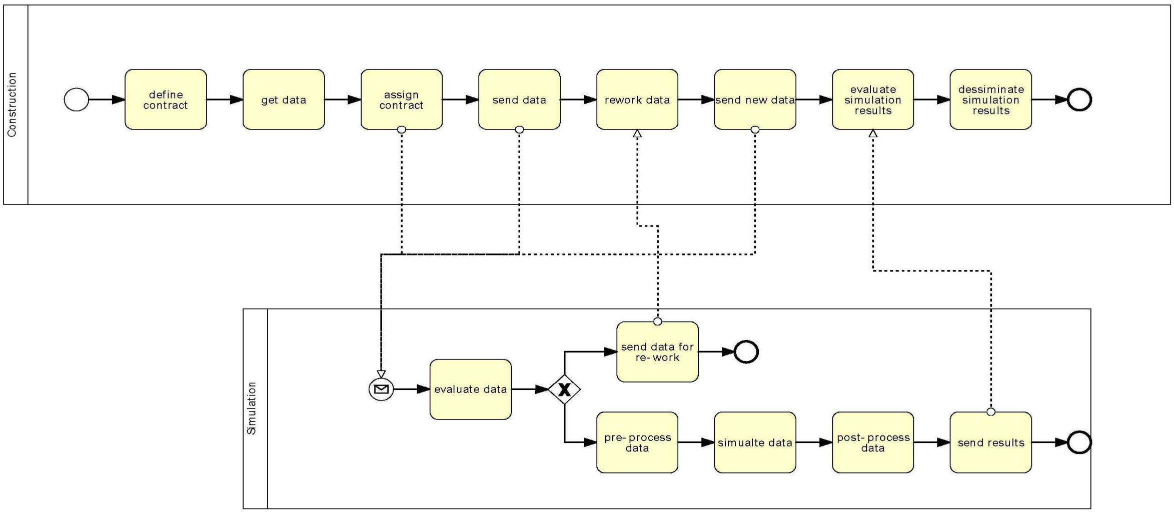

Figure 3. As-is process: sub-process (simplilfied)

As mentioned above, the as-is process provides potentials for performance enhancement that are addressed by the new data format standard. The re-engineered business process includes information systems that manage and convert incoming data into the defined format. Therefore, the process structure is changed to accommodate data management support and conversion efforts. In the process model these changes are visible through the addition of an extra pool called information systems (IS) that includes three application systems supporting cooperation in and execution of the process. Figure 4 shows the abstract view on the re-engineered to-be process.

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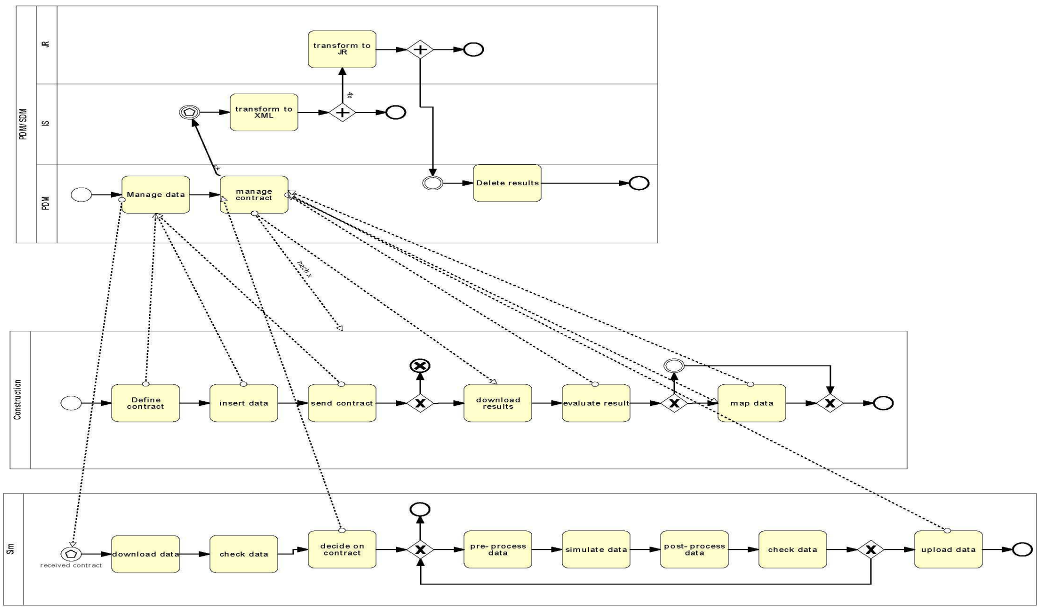

Figure 4. To-be process: abstract view

Using these "before" and "after" scenarios process performance change is now analyzed towards the effect of data format standardization.

IV. SIMULATION SET-UP

The main research method that was used here to assess the research question whether data format standardization has an impact on a collaborative business process performance was business process simulation. The choice of the research method allows assessing the effect of standardization on process performance and structure in different business domains as well as industries. The simulation set-up is briefly described here. Figures 2 and 3

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show the as-is process on the abstract level as well as an example of one of the sub-processes accordingly.

Two processes, as-is as well as the to-be process, have been simulated and their results were compared (see Table I). A case-based research methodology was chosen here with the aim to provide an example of practice and test the proposition that the supporting tools of process mapping and business process simulation can illustrate the effect of data standardization on the process performance. Although a single-site study has obvious limitations with respect to the generalizability of the findings, the case is not aimed at being representative, but rather exemplary. Thus, the researcher does not need to assume that the simulation results that were retrieved are exhaustively representative for all similar situations (same reasoning has been successfully applied in [14]).

To perform business process simulation of the described processes, they have been modeled according to interviews, workshops and documentation using Business Process Modeling Notation (BPMN) as well as enriched with detailed information on their organizational and temporal structure.

Derived information as well as the business processes have been modeled using Adonis® 2.01 community edition software. It is a business process analysis tool supporting business process management, specifically simulation and calculation of business performance indicators, such as human resources, process costs, etc. It allows business process modeling using BPMN, process analysis, simulation, evaluation as well as publishing and process automation with BPMN 2.0 XML.

To gain an insight on the effect of the introduced data format on the business process performance, the process has been modeled and simulated using two different scenarios.

In the first scenario, the as-is process as described in interviews, workshops and documentations has been represented. In the second scenario, data management system and accordant process adjustments due to the new data format have been modeled. The overall duration of the simulation was set to five years in working days with 8 hours per working day and 190 working days per year (excluding holidays and vacation time) for both scenarios. Activity costs were assigned according to the data elevated in interviews.

Hlupic [4] suggests a process for business process simulation that consists of the following phases that were also adopted in the presented research:

- Define modeling objectives;
- Decide on model boundaries;
- Collect and analyze data;
- Develop business process simulation model;
- Test model;
- Model experimentation;
- Analyze output;
- Provide business process change recommendations.

Hlupic [4] suggests this proceeding for evaluation and decision support. Thus, the last phase is omitted here as the goal of the research is not recommendatory but rather exploratory. The modeling objective here is to document a business process to perform scenario-based performance evaluation using business process simulation. The model boundaries are the process boundaries, including process actors and their processes involved in the virtual engineering in the given case study.

Data has been collected to define the process flow as well as performance characteristics such as time, costs and frequency of an activity. The simulation model used here, has been developed to include the process (logic and temporal) flow as well as execution times as defined by process workers in the as-is process. For the to-be scenario expert interviews were led with process workers, process managers and process owners to derive an estimate for realistic task times and costs. The to-be process has been modeled and simulated.

These results were presented to the interviewees to assess their feasibility. Simulation results of both scenarios as well as their comparison are described and discussed in the following section.

V. RESULTS

A. *Simulation Results*

Results of the process simulation are shown in Table I. Process cycle time is elevated in days: hours: minutes: seconds format. Costs are expressed in money units (MU). Activity times are measured for one execution cycle (process cycle). Delta is computed in hours for the time metrics and as the difference in change between “before” and “after” metrics.

Process execution time represents the sum of activity times without consideration of their parallel execution, while process cycle duration represents the time for the actual process flow.

Performance quotient is an additional metric that enables a better assessment of time and costs performance of the process. It is calculated as the quotient of costs and actual process execution time.

Simulation results show that process cycle duration of the to-be process is larger than in the as-is process. This is due to the fact that the goal of process re-engineering was to create a continuous process where the sub-processes are executed sequentially rather than parallel as it is the case in the as-is process. Nevertheless, execution time of the to-be process is by 19.59% shorter and costs by 17.83% lower than in the as-is process. This effect is also reflected in the sub-processes, suggesting that simulation partners also benefit from data format standardization. The performance quotient of the to-be process is more than 88% higher than for the as-is process indicating a more effective process flow.

TABLE I. RESULTS OF PROCESS SIMULATION

KPI	As-is process	To-be process	Delta(in%)
Process cycle duration	4d:00h:09min:20s	6d:01h 52min:47s	+ 55.12
Process execution time	38d:07h:26min:43s	32d:04h: 25min:22s	- 19.59

Process costs (MU)	25772	21176	-17.83
Performance quotient (MU/ cycle duration in h)	802	425	-88.41
Cycle time (costs): Join	1d:3h:45min:14s (5937)	1d:02h: 36min:04s (5453)	-11.9 (-8.88)
Cycle time (costs): Form	7h:38min:27s (3175)	7h:06min:59s (2899)	-8.03 (-9.52)
Cycle time (costs): Dry	4d:9min:20s (13076)	3d:48min:40s (10047)	-29.44 (-30.15)
Cycle time (costs): Crash	1d:28min:48s (3583)	6h:49min:26s (2828)	-25 (-26.7)

B. Discussion of Results

Business process simulation performed using business process modeling and simulation software was performed here to assess the effect of process element changes on process performance. Here, the context of virtual engineering, which relies on data management and exchange was analyzed. The goal of the to-be scenario was to design a continuous, sequential collaborative process for automotive parts simulation and thus to improve process performance. Therefore, a data standard was developed to make data exchange and its use of the CAE more efficient. Subsequentially, processes of the actors needed to be adjusted. As this is a costs- and time consuming transformation, its effect on process performance was measured using time and costs indicators in a process simulation.

Results in Table I show that the sequential flow of the process increased the process cycle duration by almost 50 per cent. Nevertheless, the other performance indicators such as process costs, process execution time as well as cycle times of the subprocesses were decreased resulting in a better performance quotient of the process.

In the context of collaborative processes implementation of a common standard can be difficult as process members need to adopt their IT- and business infrastructure. Using the simulation it is now possible to outline the time and cost related benefits for process participants, creating a common ground for discussion on the adaptation of the standard.

VI. CONCLUSION AND OUTLOOK

In this paper, the question has been addressed how data format standardization can affect process performance and structure. Business process simulation has been chosen as a method to assess performance changes in terms of time and costs. The results show that introducing a data format standard led to a continuous process flow that induced positive implications on process performance not only for the main manufacturing enterprise but also for the service partners.

Results of the business process simulation showed that the re-engineered to-be process provides a better performance quotient due to both number of activities and cost reductions. Cost and time benefits are also passed over to simulation partners. This positive development is supported by the subsequential analysis of quality measurements performed with the simulated parts from the as-is and to-be process as well as real-life parts. These results provide insights that are crucial for managing collaborative processes. They show that measurements performed on virtually simulated parts in the to-be engineering process are more precise and allow insights into characteristics of the constructed parts that were not possible using data derived in the as-is process [8]. These research results can be used to assess the need for data standardization initiatives. Thus, future work will include a more extensive research on product costs and quality changes due to the data format standardization.

Nevertheless, limitations of the presented research are obvious: only one process has been analyzed and only limited feedback from process management was collected. Also, the effects on the role distribution in the process as well as knowledge transfer that have been changed due to the changed standard need to be explored in the future research. Furthermore, future research need to include the analysis of the use of semantic technology such as RDF or OWL as they can provide an increased interoperability in collaborative processes and compare process performance difference to the performance gains induced by the use of XML documented here.

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Evolutionary Process Engineering: User Guide and Case Study for Adequate Process Support

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***Abstract*— Evolutionary Process Engineering describes the development of business processes over time with the objective of increasing quality and performance, in order to meet – among other things – accreditation requirements. Maturity models like the Business Process Maturity Model support quality management and are perceived as convenient measurement for this evolution. In this paper, we follow up the investigation of how much technical support for process execution is adequate in dependency of specific maturity stages and which implementation (e.g., system-controlled approach like Workflow Management System or human-controlled approach like Checklist) complies best with the respective quality requirements. A user guide is introduced that assists practitioners stepwise with the application of the maturity model in order to design adequate process support. The user guide is demonstrated and evaluated within the scope of a case study about the introduction of a university degree program. By this means, also exceptional cases such as deviations from the development path recommended by the maturity model are discussed. It becomes apparent that the process quality can be enhanced without implementing the highest available degree of technical support for the whole process.**

Keywords – Process Evolution; Process Support; Quality Management; Business Process Maturity

I. INTRODUCTION

Business Process Management highly benefits from the development of the "computerization" described in [6] that enables entire technical integration and automation across enterprise boundaries. However, the spectrum of possibilities to support process execution is broad and it became evident that modern technology does not necessarily contribute to process improvement. Technical process support should rather be aligned with the currently demanded maturity (i.e., what is the required competency, capability or level of sophistication of the process implementation [4]). Maturity models (e.g., Business Process Maturity Model, BPMM [14]) therefore provide orientation and describe well-established development paths. In our previous work we already pointed out implications of quality requirements on the degree of process support [13]. We investigated the spectrum of technical support for process execution, in particular to what extent information systems are involved, e.g., for information, monitoring, guidance or control purposes. Therefore, a maturity model extended by a dimension for process support was introduced. Its maturity stages describe which process support is needed to implement and prove the quality requirements efficiently. Admittedly, there are some difficulties arising from the practical application of maturity models in general: They indeed specify exactly what is necessary to reach their maturity levels but often lack in recommendations for concrete actions how to do so [9]. Furthermore, they are not provided with workarounds if the development by default does not seem to be appropriate for a special use case. Therefore, in this paper, a user guide is introduced and evaluated that is of assistance to practitioners with the application of the maturity model in order to identify adequate process support step by step. Besides the determination of a suitable degree of support it is also exemplified when it is not worth to achieve the suggested maturity. The user guide finally depicts how to identify a suitable implementation approach. Existing approaches and field reports about the evaluation and introduction of an information system as process support like [10], [3] and [11] are mainly focused on the domain of Workflow Management Systems, while in this paper, the whole spectrum of process support, also including human-controlled approaches, is considered.

The paper is structured as follows: In Section II the conceptual approach is described. In Section III the approach is applied to an example process and the results of the case study are presented. In Section IV the findings are summarized and further research activities are discussed.

II. APPROACH

The approach is based on a maturity model that has been developed in [13] to determine the most suitable degree of process support considering both the expected process quality and the requirements to the underlying process model. The objective of the approach is to support the application of this maturity model by guiding the user through the evaluation and decision process. The user guide is composed of phases, activities and results and additionally provides users with appropriate methods and tools. With the application of the user guide, a concrete enactment approach providing appropriate process support can be identified.

Firstly, process support is defined and the main enactment approaches are introduced (Section A). Secondly, the maturity model as well as its three characteristic

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dimensions (process quality, process model and process support) are summarized (Section B). Thirdly, each step of the user guide is explained (Section C). Finally, supporting methods and tools are presented (Section D).

A. Process Support

There are many different types of processes, e.g., administrative or skill-intensive ones, making various demands on process support, e.g., through information, monitoring, guidance or control. For this reason the comprehension of process support used in this paper is determined. Therefore, the spectrum of process usage and the main enactment approaches covering this spectrum are introduced.

Following the concept of process usage developed in [8], approaches for process support can be classified according to the degree of IT assignment (enactment dimension) and the degree of freedom (execution dimension). While external enactment at the one end of the spectrum implies planning and driving the process without using any information system (e.g., paper-based), internal enactment at the other end means that the process is defined and executed more or less under the control of an information system (e.g., a business process management software suite). The degree of freedom ranges between flexible and rigid execution. Process support is classified in terms of whether it allows process participants to decide on their own which execution step they want to perform next (flexible execution) or if it does not permit them to deviate from the pre-defined path (rigid execution).

Within the scope of process support described above four representative enactment approaches are classified (see Figure 1.):

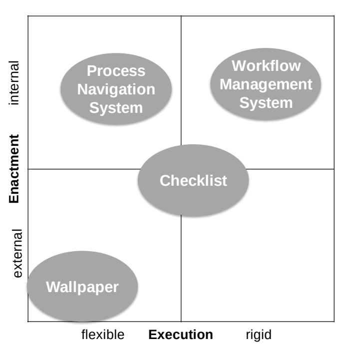

Figure 1. Approaches for Process Support [8]

- Wallpaper: The process model is used as it is, e.g., printed out as wallpaper, outlined on a flip chart or published online as process graphic in wiki. Even if the model is provided electronically the process itself happens completely “offline” (external enactment). Participants are in charge of the way the process is actually performed (flexible execution).
- Checklist: The checklist contains a serialized list of process steps to be performed as well as expected results. After a task has been finished the responsible person signs the respective list entry. This approach is versatile and can be applied both paper-based and electronically (external and internal enactment). Depending on organization and implementation the checklist contents and the order of the entries are binding or not (rigid and flexible execution).
- Workflow Management System (WfMS): WfMS in the traditional sense strictly execute the process as it has been modeled (rigid execution) and thereby interact with human users and other information systems via defined interfaces (internal enactment).
- Process Navigation System (PNS) [5]: In contrast to WfMS the PNS approach grants the participants to decide on their own how to perform the process (flexible execution). It suggests possible execution steps and points to constraints. The PNS therefore is rather perceived as a decision support system (internal enactment).

B. Maturity Model

Maturity models constitute helpful instruments for organizations to increase the capability of specific areas, such as the management of business, processes and IT [4]. They are able to determine the as-is situation (descriptively, e.g., “how much” process support is currently implemented?), to identify improvement measures (prescriptively, e.g., what would do well to provide more suitable process support?) and to benchmark performance across processes and organizations (comparably, e.g., in what way process support of process X differs from the one of process Y?). They contain a series of maturity levels that represent a development path. Each maturity level (ML) is defined through characteristics and their respective values [1].

The model presented here aims to determine and to evaluate the degree of process support and to reveal necessary adjustments. A ML results from the measure of the process quality, the scope and detail of the process model and the degree of process support. The process quality (e.g., according to BPMM) can be applied to process results and accordingly the way they are created. While a low maturity just demands to achieve the results (for example a document) anyhow, a higher maturity requires creating them properly (e.g., accurate format and structure) and in time, or furthermore measuring their performance (e.g., processing time or consumption of resources) systematically. The maturity of the process model differentiates which perspectives (e.g., organization or behavior, see [7] for details) are specified and if those can be interpreted and executed by information systems, e.g., a workflow system, or not. The maturity of the process support finally depends on how the process model is enacted, or, to be more precise, to what extent the process is executed beyond the control of an information system. In contrast to conventional maturity models such as the Business Process Maturity Model (BPMM) that generally aim at a continuous increase of maturity [9], the approach presented in this paper is not intended to strive towards the highest level (e.g., to automate as much as possible) but rather to establish the most reasonable one, e.g., by creating a widely accepted process support that accurately ensures and also proves the quality

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that is demanded by the customer. This means to aim at fitting both process model and process support to the current quality and performance requirements.

C. *User Guide for Adequate Process Support*

The user guide that will be introduced in this section constitutes an assessment method for the maturity model mentioned before. It contains three phases which in turn are divided into activities respectively. Each activity produces a specific result that is processed in subsequent activities. The creation of the results is supported by specific methods and tools. In the following the content of the user guide (see TABLE I.) is described in detail.

TABLE I. PROCEDURE MODEL

Phase	Activity	Result	Method / Tool
A. Preparation	1. Select Process	Scope	-
	2. Structure Process	Process Sections	-
B. Evaluation	1. Evaluate Process Sections (As-is)	As-is Maturity	Maturity Level Checklist
	2. Evaluate Process sections (Ref.)	Reference Maturity	Maturity Level Checklist (Quality)
	3. As-is/Reference Comparison	To-be Maturity, Need for action	Best Practices for Deviations
C. Decision	1. Consolidate To-be Maturity	Spectrum of Process Support	Maturity Portfolio
	2. Derive Implementation	Enactment Approach(es)	Maturity Portfolio

Phase A serves as preparation of the actual evaluation and leads to the subject matter. The first step (A1) is to select the process scope. The second step (A2) is to divide up the process into process sections so that the evaluation can be accomplished as clearly as possible in terms of quality. In the end it should be possible to assign one distinct quality ML for each process section. Since there is no generally admitted practice to break down a process, this activity has to be accomplished case-related, e.g., by separating creative, human controlled parts from administrative, well-structured system controlled parts.

Phase B comprises the evaluation of the process in two respects. On the one hand, the as-is maturity is evaluated (B1). The maturity characteristics (quality, model and support) are rated independently for each process section in the first instance. The ML checklist (see TABLE II.) contains the requirements for each characteristic and ML and thus is considered as criterion. On the other hand, the reference maturity is determined (B2) for each process section. Therefore, the maturity for both process model and process support is due to the to-be process quality (e.g., when a process should meet the quality requirements of ML3, the process model and the process support should also cope with ML3, not more or less). Again, the ML checklist can be consulted. Finally, the as-is maturity is reconciled with the reference maturity (B3) in order to determine the to-be maturity and to identify appropriate need for action. In general, the reference maturity should be adopted, unless there are justifiable reasons. Recommendations for how to proceed in case of deviations between as-is and reference maturity are given in Section II.D.2.

The previously determined to-be maturities are the basis for the decision that is made in phase C. At first, the to-be maturities are consolidated with the help of the maturity portfolio in order to identify the spectrum of process support (C1). Therefore, each process section is classified according to internal or external enactment and flexible or rigid execution using its to-be maturity. Since some MLs, from a quality point of view, can be construed as both rather flexible and rather rigid execution, it has to be decided for each process section which execution type is appropriate. At second, a suitable implementation is derived (C2). Each process section has to be assigned to an enactment approach that complies with the demanded maturity and execution type. Process sections within the same quadrant of the portfolio can be unified.

D. *Methods and Tools*

Below, some methods and tools are introduced that are intended to support the activities of the user guide.

1) *Maturity Level Checklist*

The ML checklist serves as measure for the maturity assessment (see activities B1 and B2 of the procedure model in TABLE I.) of process quality, process model and process support, which are the characteristics of the maturity model presented in Section II.B. A ML is considered as applicable if all requirements are fulfilled. In turn, a process section is awarded the highest applicable ML. Below, the maturity stages according to BPMM and their requirements (see checklist in TABLE II.) are described using the procurement of coffee beans as an example. The example process consists of the process steps need recognition and demand planning, supplier selection and ordering.

For ML1 the results have to be achieved, which means that coffee beans are available. It doesn’t matter who is buying the beans and where. As for the process model it is completely satisfactory to describe what has to be purchased (data perspective), e.g., sort and package. Process support consists of publishing this information, e.g., by means of a bulletin board flyer near the coffee dispenser.

ML2 additionally demands proper results in time, e.g., to avoid that coffee beans become short in supply or several people purchase independently of each other. Therefore, the process model is extended by the steps to be performed (functions), e.g., dial a number, a schedule (behavior) and responsibilities (organization), e.g., allocation of purchaser by calendar week. In point of process support, deviations from schedule are recognized, e.g., by the responsible person signing each order transaction on the schedule.

Consistent and stable results according to ML3 can only be established by using a reference process. To make sure that each process instance produces similar results, e.g., with respect to coffee flavor, procurement costs and time of delivery, the standard path (generally the behavior) has to be specified, e.g., which supply channels are to be used or how to accept and store deliveries. The specification of all required perspectives is necessary to enforce that the execution is consistent with the reference process. Compliance can be supported by task assignment, tool suggestion and templates.

ML4 requires measurable results (e.g., reliability, adherence to delivery dates) and furthermore to take corrective action in case of an unexpected turn (e.g., replacement purchase or change of supplier). The process model therefore must incorporate KPIs that are collected and analyzed by the process support. In order to anticipate deviations process support must handle exceptions (if they are predefined) or at least allow for them (if they are not / cannot be predefined).

ML5 calls for continuously improved results (e.g., reduce dead stock or combine orders). In order to implement improvements, the process model must deal with changes (e.g., invocation of new electronic market place) either through altering the formal specification or – if the new procedure cannot be expressed – through extending or switching the modeling language. Process support is considered to identify necessary improvements through suggestion or execution of suitable process steps and moreover to make sure that these improvements are incorporated into the reference process.

TABLE II. MATURITY LEVEL CHECKLIST

	Process Quality	**Process Model**	**Process Support**
ML1	Initial: Results have to be achieved	Results are effectively represented textually or graphically (data perspective)	Information about expected results are provided
ML2	Managed: Proper results have to be achieved in time	Functional and behavioral perspective is specified (schedule) Organizational perspective is represented (resources)	Deviations from schedule are recognized and reported
ML3	Standardized: Consistent and stable results have to be achieved	Standard path is defined completely All required perspectives are specified (reference process)	Tasks are assigned Tools, applications and services are suggested or automatically invoked Templates are provided or automatically processed
ML4	Predictable: Results have to be measurable and corrigible	KPIs are defined	KPIs are measured and analyzed statistically Deviations are anticipated
ML5	Innovating: Results have to be improved continuously	Formal specification can be altered (automatically) Modeling language can be extended (manually)	Suitable process steps are suggested or executed automatically Improvements are incorporated into reference process

The maturity stages described above are presumed to be suitable for the majority of processes but they are not universally valid. This is due to because the gaps between MLs are sometimes too big for the resources of an organization to close and it is not always worth to implement all requirements of a ML [9]. For this reason the ML checklist should not be perceived as binding but rather as recommendation and orientation. Maturity models also often lack in workarounds if not each requirement as prescribed by the ML is achievable or actually reasonable. In the next section some best practice examples are given for scenarios that break ranks and do not mesh with the maturity grid.

2) Best Practices for Deviations

As support for activity B3 of the procedure model in TABLE I. some general recommendations for the handling of deviations between as-is and reference maturities are made in this section.

If the ML of the as-is process support is lower than the reference quality maturity, the as-is support should be enhanced, unless the quality can be achieved and proved all the same or there is no gain of efficiency. For example, to align the procurement of coffee beans to the taste of the consumers (continuous improvement according to ML5) it makes a difference if the process is designed for a countrywide restaurant chain or a company's kitchenette. While the restaurant chain would actually analyze customer behavior through performing a web-based opinion research and thus automatically align its sourcing strategy (ML5 process support), as for the kitchenette it would rather be sufficient to make a yearly survey through posting up a tally sheet next to the coffee dispenser (ML1 process support).

If the ML of the as-is process support is higher than the reference quality maturity, it should be checked if the process is adversely affected by the usage of the current execution support system. This may be the case if a certain process could achieve better results by granting the participants more flexibility instead of prescribing them each single step, e.g., by the WfMS. However, to come back to the kitchenette example (ML1 quality), it is also conceivable that – maybe due to corporate guidelines or just because the required software functions are implemented anyway – the coffee bean orders are processed by the central procurement system (up to ML5 process support) instead of keeping an account of them on a handwritten shopping list (ML1 process support).

Process execution support, especially in conjunction with the usage of information systems, is in need of an explicit representation of all relevant information. So if the ML of the as-is process model is lower than the reference process support maturity, the as-is process model must be enhanced.

According to modeling principles, as stated in [2], only those facts should be modeled that are relevant and economically reasonable for execution support. So if the ML of the as-is process model is higher than the reference process support maturity, it should be reviewed if the current design of the process model providing larger scale and greater detail as actually needed is reasonable. It may be reasonable, for instance, if other processes or information

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systems share it or a higher ML is considered in future anyway. Otherwise, unessential contents should be removed or not be maintained any more.

3) Maturity Portfolio

Basically, all requirements of the ML checklist (see TABLE II.) can be fulfilled without using any information system and – as described in Section II.D.2 – each combination of maturity levels with respect to quality and process support is generally possible. However, observing the 80/20 principle, an increase in quality is accompanied by a certain enhancement of both the process support and the usage of information system. With the help of the maturity portfolio presented below it is possible to assign a given to-be maturity of process support to a searched approach for process support (compare activities C1 and C2 of the procedure model in TABLE I.). As mentioned earlier in Section II.A, the idea of classifying approaches for process support into flexible or strict execution and internal or external enactment goes back to spectrum of process usage developed in [8]. The integration of maturity levels was accomplished in [13]. The new portfolio view (see Figure 2.) arises through merging the maturity levels and the approaches for process support into the spectrum of process usage. It enables the assignment of a given ML to a certain approach for process support and vice versa.

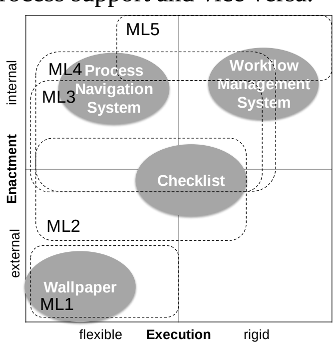

Figure 2. Maturity Portfolio

Enactment approaches that are identified in this way can be regarded as adequate process support, because they meet the requirements for process usage concerning execution and enactment requested by the respective maturity.

III. CASE STUDY: INTRODUCTION OF A UNIVERSITY DEGREE PROGRAM

In this section, the case study is presented in which the user guide approach is applied. The data for the case were attained through conducting interviews with the executing staff and studying the process and quality manual.

A. Preparation

The case study deals with the process of introducing a degree program at an example university. Breaking down the process results in the following process sections that are subject to the evaluation:

- P1 Form a degree program concept
- P2 Elaborate the degree program
- P3 Reach a decision on university level and request for state ministry agreement
- P4 Prepare introduction

B. Evaluation

The as-is process model consists of a textual and graphical reference process description of input and output documents (data), process steps on activity level (functions), responsibilities (organization) and sequence and conditions (behavior) using a formal modeling language that enables to define process models formally and clearly. Consequently, the as-is maturity of the process model is to be evaluated as ML3 for all process sections.

The first process section is to form a degree program concept. After determining the degree program type and the coordinator the degree program description is created by the faculty. Upon approval by the school council the capacity plan is prepared by the QM (Quality Management) department. Both documents are reviewed by the executive board of the university. In case the degree program concept is followed up, an external evaluation under participation of the QM department is accomplished and the capacity plan is refined. Finally, the concept is forwarded to the department of academic administration. Particular attention is paid to the content of the resulting documents. The concept must be convincing in form and content to satisfy the decision makers. Therefore, miscellaneous checklists and statistics data are provided to ensure consistent and stable results. On the contrary, the real development process (deadlines or applied tools, for instance) is disregarded. Consequently, from a quality management perspective, purely the achievement of results is required (ML1). However, with respect to the output documents (data perspective), ML3 quality is worthwhile (to-be). Currently, process support is limited to information about expected results (ML1). Even though ML3 process support is recommended for achieving ML3 quality, there is no need for action here, because the compliance with the reference process can be established anyway and also be proved through dated receipt stamps and signatures on the respective documents.

The second process section deals with the elaboration of the degree program and is organized as a collaborative project. It takes about 8-10 weeks and is scheduled backwards from the school council meeting. Within the first 4-6 weeks, the degree program documentation is elaborated by the school, the chairs, corresponding committees, the dean and the coordinator. Four weeks before the meeting, the documents are delivered to the department of academic administration for the purpose of a preliminary check. There are three weeks left to work in change requests. One week before the meeting, the final documents have to be submitted. In prior to that, the detailed resource plan is elaborated by various departments. Furthermore, the dean informs the student parliament about the new degree program. From a quality perspective, beside proper results there are also due dates to be adhered (ML2). Again, the process is focused on the output documents and therefore should comply with ML3 likewise. In order to observe deadlines, process support should be enhanced to ML2.

Waiving ML3 process support including task assignment is not detrimental to the success, because the process is rather collaborative than coordinative and the quality of the results is assured nevertheless.

The third process section is concerned with the approval of the degree program by various authorities one after another, at first on university level and then on state ministry level. In each case the degree program documents are presented. In the event of rejection, the coordinator or the school is provided with editorial remarks for revision. In the event of acceptance, the next authority decides on the degree program. Firstly, the school comes to a decision. Secondly, the presidential committee is passed. Preferably before the resolution of the senate, the statement of the university council is obtained. At least one week before the meeting of the senate, the documents are brought before the senate. In case of acceptance the documents are forwarded to the state ministry. The degree program is then either approved or approved conditionally or declined. Finally, all stakeholders are informed and the degree program rules are published. Currently, ML2 quality is reached. The participants meet due dates and communication channels. However, the process prescribes a strict order and each application for a degree program should be handled equally. In order to head for a more standardized procedure, the process section should be raised to ML3. Therefore, the current process support should also be enhanced (ML3) as recommended by the maturity model, because not only the output documents but also organization and behavior have to comply with the reference model.

In the last process section the introduction of the degree program is prepared. Various activities are initiated simultaneously but independently of each other: design and distribution of flyers, information of the student advisory service and other departments, appointment of responsible persons, long-term course planning, preparation of examination procedures and other degree program details. Responsibilities are clearly defined. ML1 quality seems to be sufficient here, because due dates are negligible. Consequently, also ML1 process support is reasonable, because the tasks are well-defined and there is not much of coordination effort.

In TABLE III. the evaluation results are summarized.

TABLE III. EVALUATION MATRIX

Process Section	**Process Quality**	**Process Model**	**Process Support**
	As-is → To-be	***As-is/Ref. → To-be***	***As-is/Ref. → To-be***
P1	ML1 → ML3	ML3/ML3 → ML3	ML1/ML3 → ML1
P2	ML2 → ML3	ML3/ML3 → ML3	ML1/ML3 → ML2
P3	ML2 → ML3	ML3/ML3 → ML3	ML1/ML3 → ML3
P4	ML1 → ML1	ML3/ML1 → ML3	ML1/ML1 → ML1

C. Decision

The process sections P1, P2 and P4 mainly focus on the respective results. Their time limits are either disregarded or perceived as directives. Furthermore, the actual arrangement and design of the degree program is in need of a certain creative scope that cannot be pre-defined. The quality is in the coordinator's and the faculty's interest. Consequently, a flexible, human controlled execution support seems to be more reasonable than prescribing each single step according to a rigid process model. However, within the deciding steps of process section P3 equal treatment for each degree program request has to be ensured. In order to standardize the organization and the behavior and to establish favorable terms for reaching the desired quality a rigid execution support is advisable. Consolidating the to-be maturity levels of the process support accordingly results in two categories: P1, P2 and P4 are mapped to external flexible process support, while P3 is mapped to internal rigid process support (Figure 3.). The assignment of the process sections to the recommended enactment approaches is visualized in Figure 4. and will be explained below.

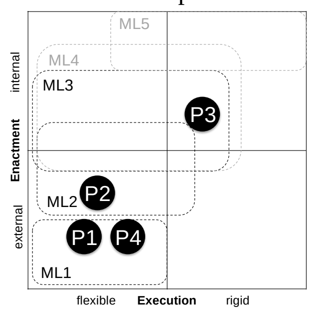

Figure 3.
Spectrum of process support

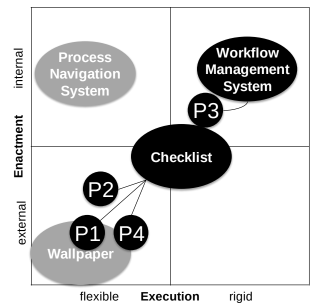

Figure 4.
Enactment Approaches

Regarding external, flexible process support, two enactment approaches come into consideration: the wallpaper and the checklist. The checklist seems to be more appropriate, because the wallpaper is not able to provide ML2 runtime support as demanded by P2. Even though for P1 and P4 mainly the results count it is important that actually all essential activities are performed and their resulting documents contain all required information. Therefore, the checklist approach could be designed as follows: On the one hand, there is a paper-based checklist on process level with a list of process steps to be performed. It is maintained by the coordinator and is intended to support him in keeping track of the project. In case of deviations, corrective action is taken manually, e.g., by phone or e-mail. On the other hand, there are checklists on document level, either paper-based or electronically, depending on the availability of the respective data. Each document header is provided with a bullet point list of the required content parts. The list entries are signed by the respective authors and thereby serve both as orientation for the persons in charge and as proof of conformity to the reference process (ML3 quality for data perspective).

Concerning internal, rigid process support, again two approaches are possible: the Checklist and the WfMS. Here, the WfMS seems to be more appropriate than the checklist, because the approval workflow, the task assignment, the data logistics and the collaborative access to documents can be clearly defined and actively controlled by WfMS standard functions. This approach is especially recommended when – as in the case of the example university – an already existing

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communication and collaboration platform providing basic workflow functions can be used. The workflow that has to be implemented is initiated by the coordinator when the documents have to be brought before the school council (end of P2). It ends with the agreement of the state ministry and the publication of the degree program rules (end of P3).

IV. Conclusion and Future Work

In this paper, a user guide was introduced that is intended to lead practitioners through the procedure of identifying adequate process support. It was showed how to determine the as-is situation, in particular how much support is currently provided and which quality level can be reached. Furthermore, it was pointed out how to identify appropriate need for action for both standard and exceptional cases of process evolution. On the one hand, best practice maturity stages were introduced that are meant to be a guideline in most instances. On the other hand, also exceptional cases were discussed that are not in line with the common process evolution. Moreover, it was presented how to reach a decision on the question which enactment approach is most suitable for the demanded quality and execution type. Finally, the application of the user guide was presented by using the example of the degree program introduction. The case study revealed that the highest degree of process support is by no means the most reasonable one and that the process quality can rather be enhanced through providing an adequate degree of process support at the right place.

Our future research is concerned with the question how the approach can be further improved in order to provide an even more specific assessment of quality requirements and their impact on process model and process support. One starting point would be to initially evaluate each process perspective (data, organization, behavior, etc.) independently from each other. Another starting point is to differentiate process support by execution support (e.g., guidance) and documentation support (e.g., log generation). Generally, we aim for a more comprehensive evaluation of the conceptual approach in different domains and branches. Moreover, our activities head for the further specification and development of the conceptual approach presented in [12] that is intended for the technical support of process evolution, in particular for the acceleration of transitions between maturity levels through attaining process models during execution.

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Aligning Riva-based Business Process Architectures with Business Goals Using the i* Framework

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Abstract— **The i* framework has been widely used to derive business process models as an attempt to fulfill business strategies in the business/IT environment. However, in a dynamic environment the derivation methods do not easily adapt to radical changes required either in goals or process models due to the absence of a business process architecture that permits business processes improvement. The current approaches for business process architecture modelling, and particularly the Riva-based method, lack the integration of business goals for both deriving the process of business process architecture development and/or aligning business goals to a pre-existing business process architecture model. In this paper, we propose a novel approach that is i*-based to align a Riva business process architecture with business goals, and vice versa, with full traceability in both directions to tackle the above shortcomings. This approach has been initially evaluated using the Cancer Detection pilot study in the Cancer Care and Registration process in Jordan. This goal-driven alignment has demonstrated a systematic bridging of the gap between goal-oriented and business process models in a dynamic environment. Moreover, the business goals integration has improved the Riva business process architecture development process and produced new knowledge for the as-is Riva process architecture and its associated business process models, where many are run as software services.**

Keywords-Goal;Riva; Business Process Architecture; i* Framework; Business Process Model.

I. INTRODUCTION

The business/IT alignment discipline has attracted many researchers in the last two decades [14][15]. Their contribution aims to increase the competitiveness of enterprises where software systems are developed to meet the continual changes in business needs in terms of plans, objectives and processes. The current approaches to Business Process Architecture (BPA) [10] modelling, and particularly the Riva-based method, contributed to the business/IT alignment and in fact to the Requirements Engineering (RE) processes by deriving candidate software services along with associated capabilities in [14].

The Riva BPA [10] method aims to blueprint the current overall chunking of core Business Processes (BP) that stem from the business an organisation is in [10]. Ould has asserted the existence of invariant process architectures for organisations that are in the same business [10]. However, the Riva-based method lacks the integration of business goals for deriving the process of BPA development, and/or aligning business goals to a pre-existing BPA model. This shortcoming has resulted in an inability to determine some core elements that initiate Riva-BPA development and/or to assist in redesigning an as-is BPA to adapt to organisational business changes. This shortcoming and its consequence have weakened the generation of an optimal BPA design and/or have obstructed further improvements. And according to Ould's previous assertion [10], they might in turn diminish the competitiveness in the long term due to many enterprises that are in the same business with different business goals that might generate different BPA models.

In this paper, we develop a novel approach that is i*-based [6] to align business goals to a Riva-based BPA, and vice versa, with full traceability in both directions. This complement is anticipated to improve the BPA development process and hence to generate new knowledge to BPA and associated BPs where many are executed by software systems. The Cancer Detection (CD) process pilot study, as a part of the Cancer Care Registration (CCR) process in Jordan's health care sector, validates this work.

The paper is structured as follows, Section II presents the required background. Section III applies the current Riva method using the CD pilot study. In Section IV, we propose using an i*-based approach for aligning Riva-based BPAs with business goals using the CD study. A discussion is carried out to assess the alignment approach in Section V. And finally, Section VI concludes the work.

II. BACKGROUND

This section starts with a brief description of the pilot study that is the Cancer Detection process. Then it presents the related background, with regard to the i* framework and the Riva-based BPA and associated BP models respectively, with a brief analysis afterwards.

A. Cancer Detection Process: A Pilot Case Study

In this paper, the Cancer Detection (CD) process, which is a sub process of the CCR, is employed as a pilot study in order to compare the proposed approach with the Riva approach [9][10]. The CD process was designed to address two main objectives that are considered as sub goals of the parent goal "improve administration of cancer treatment". The first goal is diagnosing patients and the second is determining their cancer type and site. Five roles are involved in this process to fulfil the aforementioned objectives: Patient, Receptionist, Doctor, Lab and the Imaging Department. A detailed BP workflow model has been illustrated using RAD and BPMN in [9][16][14].

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However, a corresponding goal-oriented model that represents the strategic view has not been addressed yet [17]. Due to the detailed representation of the CD process, the paper validates the alignment using a partial and simple comparison of the goal and BPA models.

B. Business Goals and the i Framework*

Business objectives or goals have been defined in various ways either from the business or system perspective in [2] [3][6][4][13]. However, the authors agreed to adopt what they judged to be the most comprehensive and related definition for this paper. So business goals are precisely defined as "*the high level objectives of business, organisation or system that capture the reason why a system is needed and guide decisions at various levels within enterprise*" [1]. In this context, goals have to be addressed not solely with respect to technological needs, but also with respect to organisational ones in social style of cooperation. Therefore, business goals are anticipated to guide BPA design decisions for an enterprise.

The i* framework is classified under the problem-oriented RE school that aims to understand and highlight associated problems within business structure, processes and systems [3][5][12]. Other goal-oriented approaches join this school with the i* framework (e.g., NFR framework [13] and [3][5]).

In particular, the i* framework aims to understand early on during the requirements phase the current situation of a business organisation in the form of a network of dependencies among actors [6][3]. It is based on two types of strategic models. The first is the Strategic Dependency (SD) model, which illustrates a network of dependencies in external relationships between actors where the depender depends on a dependee to achieve a dependum, whether it is a goal, soft goal, task or resource [6]. Actors are active entities that could be humans (e.g., physician) or non-humans (e.g., e-learning system). They either hold intentions to attain dependums and/or abilities to achieve them. The second model in the i* framework is the Strategic Rationale (SR) model, which elaborates the abstracted SD for a better understanding by modelling internal relationships within actors using means-end and task decomposition links. In reality, the aforementioned steps are carried out in parallel. While re-engineering a BP, this has produced better design alternatives in delivering the actors' interests.

The authors have adopted the i* framework as an agent- and goal-oriented approach due to its ease of adaptability and its richness of business-oriented concepts that may motivate an early integration with other business models with full traceability. The i* framework has been widely applied in re-engineering the detailed workflow of BPs [11]. However, the i* framework lacks the ability to derive and/or re-engineer a BPA that manifests how BP fragments are interacting and steers their improvement. This inability has been revealed because of the absence of an adaptable and viable BPA modelling approach that is compatible with the i* framework.

C. The Riva-based Business Process Architecture and associated Business Process Models

The Object Management Group defines a business architecture as "*a blueprint of the enterprise that provides a common understanding of the organisation and is used to align strategic objectives and tactical demands*" [17]. They agreed that a business architecture must encompass five key views that are: business strategy view, business capability view, business process view, business knowledge view and organizational view [17]. Ould proposed the Riva methodology to create a BPA and associated core BPs as a blueprint that aims to address the second and the third views stemming from the business an organisation is in [10]. This methodology is required in an enterprise in order to manifest the BP's collaboration where many of them are run as software services. Thus, it assists in their improvement and development.

The Riva-based BPA is based on brainstorming the Essential Business Entities (EBEs) that are the subject matter of the business an organisation is in [10]. This BPA is generated after applying the following steps [10]: 1- brainstorm for EBEs that characterize the business an organisation is in. An EBE could be either physical (e.g., book) or abstract (e.g., module). 2- filter the previous EBEs to ones that have a lifetime that an organisation is interested in and call them Units of Work (UoWs). 3- link UoWs to one another via dynamic relationships, namely "generates" to make up the UoW diagram. A one-to-one or a one-to-many cardinality must be associated with each dynamic relationship. 4- the UoW diagram must follow some rules to generate the 1st cut BPA that consists of a set of interrelated Case Processes (CPs) that each corresponds to a UoW. Therefore, a UoW diagram is useful to predict the BPA model. A CP generates one or more instances that are managed through a corresponding Case Management Process (CMP) if needed. 5- the 1st-cut BPA is reduced after applying a set of heuristics to generate the 2nd-cut process architecture namely, the Riva BPA [10]. Each process in the Riva BPA is designed using a role-oriented business process modelling approach. The BPMN and RAD are two well know notations to describe a role-oriented BP [16][10].

The Riva method appears to be a good candidate for the desired alignment as it is easy to comprehend and it encompasses all the required business-oriented concepts that are needed to integrate goal models with full traceability. However, the Riva method does not guide the architect in how to meet/respond to new organisational objectives. This is mainly because it develops a BPA from the business an organisation is in rather than the rationales that stimulate this business. This is likely to end with gaps in the BPA due to missing but required Riva elements and/or identified but unrequired ones (e.g., BPs). This limitation may require the Riva method to integrate the strategic view as an attempt to fulfill business goals in its as-is BPA model via a systematic alignment approach.

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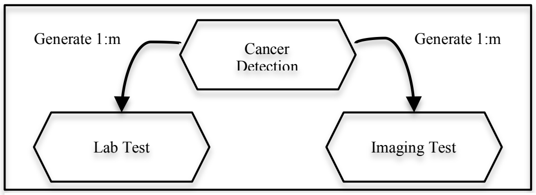

Figure 1. The Cancer Detection Non Goal-based UoW Diagram.

III. Deriving Cancer Detection Process Riva-based BPA

This section applies the current Riva approach presented in Section II on the CD study. The Riva BPA has been already established with its core elements (e.g., EBEs and UoWs) and evaluated in [14].

The current Riva approach that designed this BPA stemmed from the business rather than from the aforementioned goals. This has resulted in 24 EBEs and 3 UoWs where each UoW corresponds a business process. Figure 1 illustrates the resulting non-goal-based UoW diagram that is used to predict the BPA. The authors agreed to compare it with the goal-based UoW diagram rather than using the 2nd-cut architecture for comparison. In Figure 1, the cancer detection UoW generates the other two UoWs. Limitations of this approach have been already presented at the end of Section II.

IV. Aligning the Riva-based BPA with Business Goals Using the Cancer Detection Example

This section presents the proposed alignment approach that aims to re-engineer and/or improve the already established Riva BPA model using the i* framework along with CD study. The re-engineered BPA model is produced from a set of designed activities that constitute the alignment process as depicted in a coarse grain manner in Figure 2. The proposed alignment process inputs the as-is Riva BPA and associated role-oriented Goal-based Business Processes (GBPs) to generate i* models that will in turn be aligned to output a goal-based BPA. The five-core activities of the alignment process are overlapped and iterated as shown in Figure 2 as to be discussed in detail in the next sub sections. The second and third core activities generate associated goal-oriented dependency models where a depender depends on a dependee to achieve a goal dependum. In both activities, setting a goal and assigning it to an associated depender and dependee will be carried out in a parallel manner. However, three extra activities constantly overlap with the core ones to adjust the alignment: (1) reusing role-oriented GBPs, (2) reusing as-is BPA and (3) building the actors' hierarchy. Feedback is required between all the above activities, as an overlapping activity will assist in performing the overlapped activities if needed. For example, the design SD model activity (C) assists in performing the design SR model activity (D), as depicted in Figure 2. As Figure 2 shows, the alignment process starts either to immediately design the Business Strategy (BS) model, or not immediately by reusing role-oriented GBPs to deduce the Highest Business Goals (HBGs) to then design the BS model.

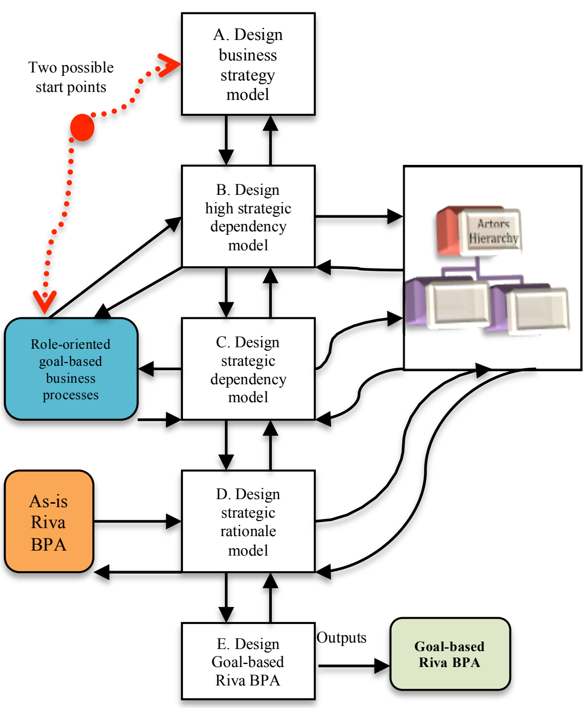

Figure 2. The Alignment Process Designed Activities for Integrating Business Goals to as-is Riva BPA.

A. Designing the Business Strategy (BS) Model for CCR

In this first stage, the boundary of an individual organisation and its associated Highest-Business Goals (HBGs) are agreed using the canonical list of goal types provided in [7]. A business organisation could be an enterprise, a department, a main process in a business sector or even a group of individuals that are collaborating to accomplish at least one HBG, which refers to an ultimate main business goal. The modelling notation is inspired from the use case modelling in the software engineering discipline due to its flexibility in initiating early and easy communication between stakeholders [8].

With regard to the CD study, Figure 3 depicts this model where the business organisation, which appears on the left, aims to achieve its HBG, that is to improve the CCR business process, which is denoted by the top ellipse on the right side. This HBG is deduced from lower goals that are inferred from the main objective statement of CCR, that is:

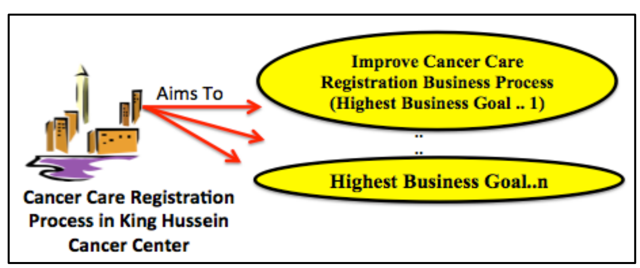

Figure 3. The BS Model for an Individual Organisation in the Kingdom of Jordan

"to improve the Administration of cancer treatment" and to improve "collection of information about cancer cases"[9]. Using the canonical list of goals and these two [7], the authors conclude that the HBG is improving the cancer care registration business process. The BS model is not immediately generated as the authors started the alignment process from reusing role-oriented GBPs. This work complements the work done on bridging the gap between business process models and system models in the semi-formal automation of generating use-case models from business process models without consideration of business goals [8].

B. Designing the High Strategic Dependency (HSD) Model

This phase elaborates each HBG into associated sub goals namely, Immediate Highest sub Goals (IH-G). The IH-G set is a new term derived from the previous phase to generate a first goal-oriented dependency model. The HBG is decomposed using a decomposition relation to be satisfied by a number of achieved IH-Gs as shown in Figure 4. As from the HBG perspective, the IH-G set is defined as the set of immediate decomposed goals that make up the HBG parent. And from a Goal-based Business Process (GBP) perspective, the IH-G is defined as the main objective for a number of collaborating GBPs that aim to meet the IH-G parent. The HSD is similar to the SD model in the i* framework but with actors that are either a key (e.g., Patient) or set of roles (e.g., Cancer Care Team). It is required as it derives the i* strategic models.

In the study, the generated IH-Gs **dependums** (e.g., administration improvement of cancer treatment) must have **dependers** (e.g., patient) and **dependees** (e.g., cancer care team) that are linked via dependency relations to make up a goal-oriented dependency model as depicted in Figure 5. The CD process is embedded in the bottom dependency in Figure 5 as will be shown in the next activity. The two dependums are sub goals of the HBG in Figure 4. Very few EBEs have been detected using the as-is Riva (e.g., patient) due to the high abstraction of the HSD model.

C. Designing the Strategic Dependency Model

In this stage, the i* framework gradually starts to emerge by elaborating prior goal-oriented models. However, this requires further refinements as we have denoted the parallelism in defining goals and actors.

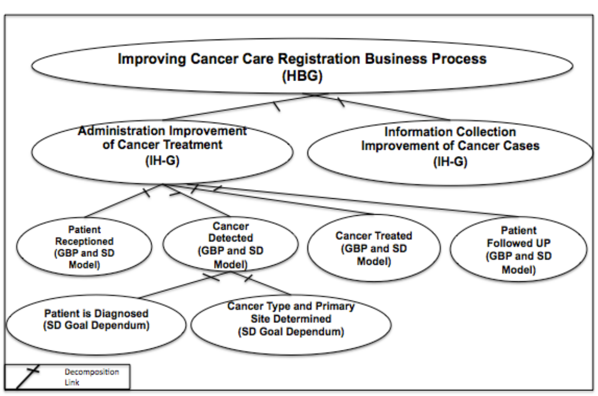

Figure 4. The Hierarchal Network of Goals

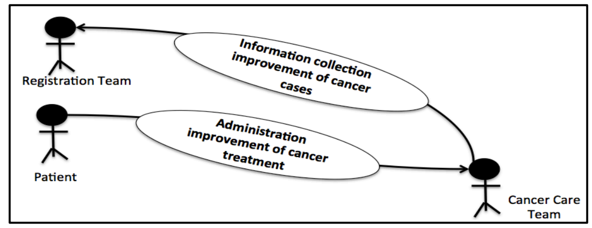

Figure 5. Partial HSD Model for the CCR Process

1) Discovering the Corresponding Goal-based Business Processes

This sub phase aims to look for interrelated GBPs that fulfill a corresponding IH-G parent implying that it is **a business process itself with associated goals** in order to adjust the aimed alignment. Therefore, each IH-G parent will be decomposed, using decomposition links, into a set of GBPs that are collaborating with each other to fulfill the corresponding IH-G parent. Figure 4 depicts the cancer detection as a GBP that collaborate with its three siblings to fulfill their parent. In the next sub section, for each role-oriented GBP there will be a corresponding SD model.

2) Deriving the SD Model from the Corresponding GBP

The SD diagram models a corresponding GBP in [6] followed by a one-to-one relation between the GBP and the SD model. The GBP is fulfilled by a consequent decomposition of goals, as shown in Figure 4, that are depicted in the form of dependencies with their associated dependers and dependees to design the SD model. The goal dependencies will be only illustrated in the SD model as the rest of lower business-oriented concepts will emerge later in the form of operationalizations (e.g., tasks and resources) in the corresponding SR-model as below [13].

Finally, the as-is EBE list from the pre-existing Riva BPA will assist to detect EBEs that exist in this phase rather than brainstorming them to adjust the alignment. Also, the SD model might generate a few new EBEs that are likely to be the goal dependums. This phase will iterate for each corresponding GBP.

Consequently, the CD GBP corresponding SD model is depicted in Figure 6 where its goal dependencies and associated actors are extracted from the CD GBP's goals and roles [9]. For example, a patient depends on a doctor for a cancer-diagnosed goal where the patient and doctor are

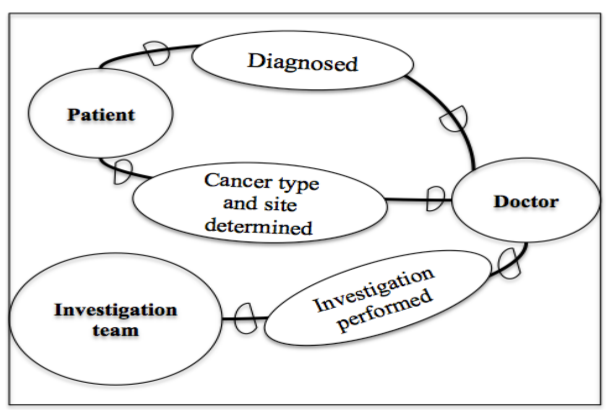

Figure 6. The SD Model for Cancer Detection.

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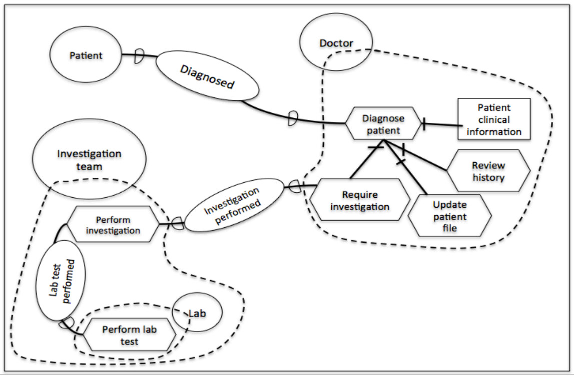

Figure 7. Partial SR Model for Cancer Detection Process

detected as pre-existing EBEs. Figure 4 illustrates how the cancer detection is decomposed into these two sub goals using two decomposition links. These two sub goals turn out to be two EBEs that do not exist in the as-is EBE list. Therefore, they are derived rather than being detected from the as-is EBE list. In Figure 6 the investigation-performed goal dependency appears later on while designing the corresponding SR model.

D. Designing the Strategic Rationale Model

The SD goal dependencies will be achieved from an actor point of view. Therefore, the corresponding SR model fullfills the SD goal dependums by designing the internal structure of an actor's abilities in the form of tasks and resources that are lower than goals in their abstraction [13]. The internal structure of an actor is designed using two relationships: (1) means-end and (2) decomposition links. The SD goal dependum in the goal dependency is elaborated into sub goals, tasks, or resources to be satisfied as discussed in |Section II. The first relationship aims to make the means satisfy the end and hence to model alternatives. The second aims to decompose a goal, resource or task into sub parts as discussed in Section II.

In fact, the actual alignment emerges here with a higher number of detected EBEs using again the as-is EBE list and this demonstrates the overlap between designing the SR model activity and reusing the as-is BPA. An EBE could be an actor, sub actor, goal, task, or a resource in the SR model. Moreover, the means-end and the decomposition relationships will assist in delivering the alignment between goal models and a corresponding Riva- based BPA with traceability. If it appears somewhere in the SR model that an actor will depend on another to achieve either a task or resource, then it must be embodied in a goal dependency to be part of the previous corresponding SD-model.

With regard to the CD study, its SR-model elaborates the previous SD-model and detects more EBEs from the as-is EBE list. Figure 7 partially depicts how a doctor achieves the cancer being diagnosed SD goal for a patient through a set of decomposed tasks and resources. However, somewhere the doctor will depend on a new actor, the investigation team, for investigations to be performed as a new goal to assist in achieving the cancer being diagnosed goal. Hence, this demonstrates the overlap in reusing its as-is BPA, designing its SR and designing its SD models in the proposed alignment process. Finally, this denotes that the goal dependencies in the SD model are not conclusive as new SD-goal(s) will have the opportunity to emerge somewhere while modelling its SR model as shown in Figure 7.

E. Optimising the As-Is Riva BPA

In the previous activities, and particularly while designing the SD and associated SR models, EBEs have been detected and matched using the as-is EBE list. This detection activity is required to address the alignment rather than brainstorming for EBEs. However, a few new EBEs are likely to emerge which did not exist in the as-is EBE list. These new EBEs (e.g., some SD goals such as patient is diagnosed) will join the as-is EBE list to alert for a required re-engineering process for the as-is BPA with the respect to the new EBEs. The as-is BPA will be refined to design a model with full traceability namely, goal-based BPA.

Finally, the as-is BPA of the CD is now improved after integrating the three new strategic EBEs that are cancer patient diagnoses, cancer type and site determination, and investigations performed. Based on the Riva method heuristics, only the first and the second EBEs turns into UoWs as they posses a lifetime the CCR is interested in. The output of this approach appears in Figure 8.

V. DISCUSSION

This section discusses the proposed approach benefits and limitations through comparing two cancer detection UoW diagrams as qualitative results. The first UoW diagram, which appears in Figure 1, was established using the Riva method in [10]. The second diagram is generated after re-engineering the first using the alignment process as shown in Figure 8. EBEs have been manually detected in the alignment approach by matching the goal-oriented entities with the as-is EBE list.

The reader should note the increased number of EBEs, from 24 to 27, and UoWs from, 3 to 5. As a qualitative evaluation, this new partial UoW diagram adheres to our business strategies and presents new important knowledge because it has been learned from Section II, a new UoW corresponds a new BP. Therefore; the two new UoWs have generated two new BPs in the goal-based BPA.

With regard to addressing the OMG views, the new UoW diagram addresses the first three views instead of two because it is established using the process's rationales. This is anticipated to benefit the requirement engineers in eliciting highly complete, consistent and correct functional requirements. With regard to the BPM, the approach attempted to deliver well-defined BPs in the BPA that stem from business goals and consequently an elegant BPM lifecycle that is well-designed and configured.

The authors asserted the alignment strategy of Riva BPA with goals against the derivation strategy of BPA from goals. This desired order does not establish the BPA from scratch using goals yet it reengineers it to accommodate with rapid business goal changes. Hence, a reengineering process reuses the as-is models in order to accomplish an improvement where required with minimal architecting effort.

Integrating the dynamical Riva, with the goal-oriented approach has given the latter an opportunity to engage in a

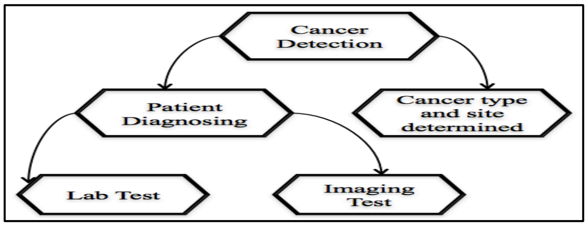

Figure 8. The UoW Diagram After Integrating Business Goals

dynamic environment. Thus, the i* framework is likely to be compatible with the rapid changes of business goals and process. The complexity of the alignment process reveals the overlap between the activities, as one will call another when required. However, these consequent overlaps merit the accommodation with changes that might emerge either in goals or EBEs. Finally, the proposed approach is limited to individual organisations rather than interrelated ones. The non-functional requirements in the aforementioned models are not aligned yet (e.g., security).

VI. CONCLUSION

In this paper, we have proposed a systematic novel approach for aligning a non goal-based, already established Riva BPA, which is a pre-existing BPA, with business goals using model-based *goal-driven approach*. This work is proposed as an attempt to answer the shortcoming of the Riva BPA method in addressing business process and organisational strategic goals. The work was evaluated using the cancer detection pilot study [9]. The UoW diagram has been assessed and has generated new BPs that stem from the related goal models. Any difference that appears in the UoW diagram must immediately modify the required cost and effort to meet the new design requirements. Also, any further manipulation on goals will immediately encourage and alert the business architect and the requirements engineer to align the as-is BPA with these goals. Hence, this enhances systematically the requirements elicitation activity ahead with advanced analysis and traceability mechanisms to detect any gaps in satisfying goals.

Furthermore, a significant corollary of this alignment is demonstrating the adaptability of the Riva-BPA method to bridge the gap between goal-oriented and business process modelling approaches with the ease of managing the concepts mapping challenge between the two paradigms.

Finally, the authors tend to evaluate the work with more examples to verify its validity. In our next stage work, we will be addressing soft goals by marrying this approach to an NFR framework [13]. Another further work is the necessity for developing a tool to automatically detect EBEs while generating the goal models. It is likely this will attain a faster alignment process execution. Finally, we plan to enrich this approach with a semantic representation using OWL-DL as a further evolution of [14].

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Factors Influencing Pervasiveness of Organisational Business Intelligence

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***Abstract*—Organisations can derive great value from the effective use of business intelligence (BI). The pervasive use of BI can help improve decision making by providing business users with relevant information, which will ultimately lead to better organisational performance and efficiency. However, organisations still struggle to derive the full benefits BI has to offer. The purpose of this study is to gain deeper insight into the factors that influence pervasiveness of BI, specifically in South African organisations. This is an inductive, exploratory study with data collected through semi-structured interviews across various industries. Thematic analysis was used in order to determine the main factors contributing to the pervasiveness of BI in the participating organisations. The major themes that emerged included executive buy-in, strong business focus and ownership, perceived value, education, communication and support. An incremental, phased approach when implementing BI and information quality were also prominent themes. These diffusion factors that promote or impede pervasive BI in the organisation are also discussed through the three contexts of the Technology-Organisation-Environment (TOE) framework. The Organisational context was found to be the strongest influencer of BI pervasiveness in these organisations.**

Keywords-business intelligence; pervasive; diffusion; TOE framework.

I. INTRODUCTION

For the last four years, business intelligence (BI) has been rated as the number one "*application and technology development investment*" [1], having been in the top three every year since 2003. Various leading international consultancies give it similar prominence. Why does BI continue to retain this top rating? Why have companies not completed their BI implementations (as with, e.g., ERP), and moved on to other "*key issues*"? It is clear that many BI implementations are incomplete or unsuccessful, and can only be regarded as delivering full value when BI is pervasive in their organisations. This research explores the BI experiences of a number of South African organisations that have travelled far along the BI road, in order to uncover the key factors that have made BI pervasive there.

The paper first gives some limited background to aspects of the BI area, then explains the research methodology adopted. Interview data is then analysed to obtain key factors of pervasive BI. This is further discussed with reference to the technology-organisation-environment (TOE) framework and other literature, and the paper then concludes.

II. BACKGROUND

Business Intelligence is a collective term describing the business systems and applications that organisations use to support their decision making processes. Through the use of information technology, BI allows organisations to gather, store, analyse and disseminate large volumes of data, in order to make better and more informed business decisions [2][3]. More concisely, "*business intelligence systems provide actionable information and knowledge at the right time, in the right location, and in the right form*" [4, p .176].

Although the first use of the term "Business Intelligence" is generally attributed to Howard Dresner of Gartner in 1989, H.P. Luhn published the article "*A business intelligence system*" in a 1958 IBM journal [5]. Since that early era of IT, business intelligence has evolved in many forms. Academically the "*umbrella term*" has until recently generally been decision support systems (DSS), but lately academia has also adopted the term BI used by industry.

Space limitations do not permit a detailed review of the styles and functional components of BI. A good summary is given in [6]. Usage of BI may be classified as enterprise vs departmental BI [7] and operational vs tactical and strategic BI [8]. Recently there has been a move to real-time or right-time BI [4][9]. BI technologies may be divided, e.g., into back-end and front-end [10] or technologies enabling (respectively) organisational memory; information integration; insights and decisions; and presentation [11].

The main back-end components are the data warehouse and data extraction, transformation and loading (ETL) systems that populate it [7][12]. BI front-end components comprise tools used by business users to interrogate the data stored in the data warehouse. The most commonly used tools enable ad hoc querying, reporting and analysis. Other front-end tool sets offer the following functionalities: Online analytical processing (OLAP); Dashboarding and scorecarding; Performance management; Predictive analytics and data mining; Alerts and notifications; BI portal and MS Excel integration [2][6][7][11][13].

Pervasive Business Intelligence

Given lack of a consistent definition of pervasive BI in the literature, the following is given: Pervasive BI is the ability to deliver the right information at the right time to business users across all levels of the organization, in order to make better decisions in all processes at all times. It provides users in different functional areas with the necessary visibility into their key business metrics, as defined by their strategic objectives, whilst providing insight

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and understanding into how it impacts on the organisation as a whole [9][14][15].

The value of pervasive BI lies in its ability to create performance transparency in the organisation through clear and consistent communication of management's strategic objectives. Insight into the organisation's key performance indicators (KPI's) allows managers to react in a timely manner to opportunities or issues that may occur, thus creating a competitive advantage [14]. Value also lies in the improvement of key business processes [15] and improved information quality [10], time and cost savings through automated delivery of information to users, and reduced IT infrastructure costs due to optimised storage and processing of data [9]. Often these benefits are not clear to business executives as they are intangible and therefore difficult to measure [3].

III. Research Methodology

The objective of the research is to determine factors that can assist organisations to be more successful in achieving pervasive use of BI. This led to the following research questions:

- What are the main factors influencing pervasive BI?
- How do these factors fit into a TOE framework?

A. Research Purpose, Philosophy and Approach

The underlying philosophy of this exploratory research was interpretivism, as it aimed to gain a deeper understanding of factors influencing the pervasive use of BI within South African organisations, based on the experiences and organisational contexts of the participants [16][17]. The qualitative data provided the researchers with rich, descriptive responses that facilitated in-depth understanding, and the approach was inductive as the researchers populated the TOE framework with the factors that emerged from the data collected. The research timeframe was cross-sectional.

B. Research Sample

To gain good insight into pervasive use of BI (not merely adoption), it was important to obtain data from organisations with an established BI programme. The researchers used purposive sampling to choose five large organisations from different industries (including retail, insurance, telecommunications and health services) with mature BI programmes established between nine and 15 years ago. The decision was made to involve fewer organisations in order to be able to interview multiple people within each organisation, and gain multiple perspectives regarding each organisation's BI programme. The researchers conducted interviews with eleven participants who all had a very good understanding and substantial experience of BI. They included users at executive, tactical and operational levels, as well as BI practitioners who had implemented BI solutions.

C. Data Collection and Analysis

Semi-structured qualitative interviews comprised of open-ended questions allowed the researchers to ask additional questions based on the interviewee's responses, and to enable the interviewees to elaborate further on their

Table I. Coding Extracts

Code	Participant	Data Extract
Education and support **Business Ownership**	PG	I think that other key thing that we did was, we gave the ownership of training to the business. So those business champions that owned BI in the various business units also make sure that they had a group of people there that would provide training on the tool.
Incremental approach	PA	starting small, and delivering something and actually showing people the benefit and then getting momentum or gaining momentum from there is the way to go. If we'd gone Big Bang, nobody would've signed the check; I mean there's not a chance.

responses [17]. The list of interview questions was derived from related BI literature, and an interview protocol served as a guideline to ensure all issues were covered. This comprised areas such as: reliance on BI in decision-making, degree of internal use, degree of information sharing, degree of external use, degree of information integration, number of subject areas in data warehouse, data latency, BI alignment to corporate strategy, governance, influence of BI on users' actions, and vendor knowledge and support. Interviews of 60 minutes plus were conducted at the interviewees' premises.

Thematic analysis and coding were used to uncover themes and patterns in the data [18][19]. This inductive approach allowed for "*research findings to emerge from the frequent, dominant or significant themes inherent in the raw data, without the restraints imposed by structured methodologies*" [19, p. 238]. Table I provides an example of related codes for data extracts from two of the participants (who were given labels from PA to PK).

The resulting pervasiveness factors were also viewed through the lens of Tornatsky and Fleischer's Technology-Organisation-Environment (TOE) framework [20] – chosen as it is broad and does not impose restrictions on the possible diffusion factors that might have emerged during analysis. Two widely used models for adoption, assimilation and diffusion at the firm (as opposed to individual) level are the TOE framework and Rogers' Diffusion of Innovation Theory (DOI) [21]. The TOE framework identifies three aspects of an enterprise's context that influence the process by which it adopts and implements a technological innovation: technological context, organizational context, and environmental context (this aspect not included in the DOI theory). These three elements present "both constraints and opportunities for technological innovation" [20, p. 154]. The TOE framework has a solid theoretical basis, consistent empirical support, and has been used for adoption and diffusion of amongst others: EDI, open systems, websites, E-commerce, the Internet, ERP, e-business, and knowledge management systems [22].

D. Other Aspects

To establish validity the researchers clearly described the data collection and analysis processes; and categorisation and coding of data was carefully documented. All data was collected from credible sources involving experienced people from industry. Due to the purposive sampling technique and sample size the study's findings cannot be generalized or considered representative of all South African organisations, but rather give insight into the phenomenon of pervasive BI. Participation in the interviews was voluntary, approval was obtained from the respective organisations, and full confidentiality was observed.

IV. DATA ANALYSIS

During the data analysis process, five major themes emerged: senior executive buy-in; business involvement and ownership; education and support; the importance of an incremental, phased approach; and information quality, form and availability. Each of these represents multifaceted aspects, so despite limited space a few examples are given of sub-themes to ensure most are represented. Some minor themes also emerged as possible influencers of pervasive BI within the participating organisations. These themes were not common across all participating organisations, but are included to ensure a holistic analysis. Interview participants will be referred to as PA, PB, .., PK.

A. Senior Executive Buy-In and Involvement

A prominent theme is top executive buy-in. All participants confirmed senior executive support and involvement as critical to success of any BI implementation. PA, an experienced BI manager of a large insurance company, stated "*one of the main, main, main things is getting top management buy-in. Without that you are sunk*". PI, a retail BI manager, suggests that "*BI needs to be changed from top down. You shouldn't grow it bottom up*". PG, another retail BI manager, says "*Try at the most senior level - I don't think you'll always get it at CEO level - but certainly at the executive committee level.*"

1) Executives' perception of BI

PJ, manager of the enterprise data warehouse (EDW) in a telecommunications company, states that executives are "*taking information for granted; they don't realise that you have to put in a lot to get valuable information out*". PG describes the perception of executives in his organisation as follows: "*I think they perceived it to be of value, but they also had a perception that BI didn't deliver. And I think that's because, especially in the legacy environment, it took very, very long for things to get done.*"

2) Obtaining executive buy-in

PA mentions they "*decided to basically give him* [CEO] *something first, even though from a business perspective it wasn't probably the biggest value add, but it's scored a lot of executive points.*" PG stresses the CEO-CIO link: "*Our CEO and CIO had a very close relationship, broader than just BI, I think the CEO got a greater appreciation of how IT can provide business advantage, and I think they saw BI as one of those key strategic types to enable that.*"

3) Executives' active use of BI

In almost all cases participants reported limited usage and involvement by senior executives. PA suggested: "*I don't think an executive is going to use BI as much necessarily as somebody at an operational level. But they could use one piece of information, once a year and make a critical decision that impacts the whole business.*" Executives will generally rely on the next layer of management to actively use the information and they only want to "*be fed back summaries or be notified of decisions, they don't want the blow-by-blow of what's happening*".

B. Strong Business Focus and Ownership

In all instances participants recommended that the main focus should be on the needs of the business, who should take ownership of the BI programme. "*You should have your most influential and most relevant executives across the business stipulate what their requirements are ..... and when BI meets that requirement everything else will follow*" (PI). PK, a senior IT executive in health services noted that their BI "*was more an IT initiative*", but despite that, they would not develop or implement anything without "*full sponsorship and ownership from that business discipline*."

1) Establish business ownership

Business should drive and own the decisions made in terms of the organisation's BI strategy and initiatives. "*The business owns the information, so there's no decision making or sign-off of a solution without business buy-in*" (PI). PG suggests that key individuals should be identified in the business, but with executive sponsorship: "*While there was senior executive sponsorship, there were key senior managers or executives in the business that owned BI for that business unit.*"

2) Obtaining business buy-in

Establishing business ownership requires business buy-in, an important facilitator of pervasive BI. Ideally a BI programme should be initiated from the business side, but participants' BI programmes originated as both business and IT initiatives. One organisation's participants clearly stated it was an IT initiative, whereas PA stated: "*They came to us and said 'We need BI'. So that's a whole different ballgame, they were kind of sold up front*". PG recommends approaching business users "*seen as business process champions*" who "[understand] *the business process*" and ideally "[understand] *a little bit about IT*".

3) Understand business need

All participants agree that a good understanding of business requirements and how business wants to use the information is essential to ensure BI delivers business value. The insurance organisation identified business champions, and makes "*Subject Matter Experts*", available to the BI business analysts (PB). The telecommunications company developed a "*BI SDLC*", featuring much "*prototyping with the users*" (PE), and gets the true business users involved as early as possible. The retail organisation focuses strongly on self-service BI, equipping business users with the flexibility and tools to explore their own data and through a prototyping approach express their information requirements (PG).

C. Education, Communication and Support

These appear to be strong influencers of pervasiveness of BI. All organisations had invested much resource and effort to establish a dedicated training and support programme for business users. These programmes educated and supported users not only in the use of the tool, but on the information itself and how to interpret and use it in daily decision making activities. Most participants agreed that education in the interpretation and application of the information was much more critical to the pervasiveness of BI than the features and functions of the tool. PI stated: "*quite frankly, without that* [training and support], *they wouldn't get half the value they get from BI*", and PA noted: "*I also think the whole education, training, support and communication side of things is absolutely vital……. Because that is what I really believe is the key to really pervasive BI*."

1) Education and Training

Four of the organisations reported that business users often struggle to use information correctly in their decision making activities. PE found that "*they could be pulling dimensions around and having great fun with the tool, in a sense, but they're doing it for the wrong reasons…they're not thinking beyond the use of the tool*". PC describes training as "*a slow and ongoing process*" that requires patience and perseverance, adding that "*you can't repeat it enough*". Multiple training methods were used to accommodate different types of users. PJ suggests a mixed training session, with a group session in the morning and one-on-one sessions in the afternoon. "*A lot of the executive training was one-on-one*". PD believes that one-on-one training sessions are more effective as "*there's too much internal competition sometimes*" and "*they are more likely to clam up*". In some instances business users "*outsourced*" training to their personal assistants.

2) Communication and marketing

Three organisations reported having dedicated BI marketing and communication resources and processes: "*the more effective you can be in telling people what is happening, branding it, and really making it part of the business, is absolutely key*" (PA). Regular update sessions communicate changes and improvements to the system, with group sessions or electronic newsletters for more complex changes (PH).

3) Support

Business users also need dedicated channels to provide feedback and ask questions if they are unable to locate or interpret information. All organisations provided support mechanisms for their respective business communities, that assist business users with both tool and business related queries. PC commented that educating, mentoring and encouraging business users require a lot of patience and perseverance. PD noted the challenge in finding the right type of person: "*there have been very few that are well cut out that can be working as trainers, mentors, general support; and general communication, marketing all together - effectively rolled into one*".

D. Incremental, Phased Approach

All participants agreed that the best approach is to establish a solid, overall architecture and design, then proceed to incrementally build sections of it; preferably focusing first on areas that will add most value to the business. Continuously delivering business value was a recurring theme in interviews. "*You have to be selling it purely on what is the incremental value you're giving each step of the way and you build it up and you make sure that you've got the capabilities when you need them*" (PD). PA concurs, saying "*incremental delivery is much more attractive to the business*". Benefits of BI are not always tangible and make it difficult to quantify ROI. An incremental approach that continuously delivers value to the business helps address this challenge. PD comments that "*delivery must really be on a small, manageable topic that you can deliver in six months. Max!*", whereas PA suggests "*nothing longer than three month increments*". PG describes their delivery cycles as a staggered approach with some overlapping of phases, with each phase between six and eight months.

E. Information Quality, Format and Availability

BI provides value when it delivers the right information, at the right time and in the right format. But challenges are that users at different levels in the organisation need information at different levels of detail at different time intervals, and people have different preferences of format, display and interaction. These challenges were expressed in nine of the interviews.

1) The need for a data warehouse

All participants expressed the importance of a data warehouse for large scale deployment of BI. PG states: "*I think that is the foundation and cornerstone*". Three organisations have an EDW in place that supported reporting across multiple business processes. The other two had a data warehouse per company, but it was not fully consolidated, as the diverse business streams of the respective companies in the group did not warrant this. PA explains "*it depends on how much commonality there is between the various business units and how much opportunity there is for sharing, from a data and from an information perspective*".

2) The right level and format of information

PD suggests that organisations should look critically at what they are trying to measure and decide "*at what level is it useful and when does it become true, but useless*". Another challenge is that business users don't always know what information they need, or struggle to define accurate measures that will be useful in monitoring their business. The format the information was delivered in also influenced whether business users made use of the information. "*You must identify the various users and have various presentation methods for the various groups of users. I think that is the key*", comments PJ.

3) Data quality and availability

Data quality and consistent delivery of accurate data were stated to be important factors. "*Source the data in a timeous fashion, and make it available, accurately, to the user*", mentions PH. PB comments that it is important for users to trust the information: "*as soon as they don't trust the information then whatever you've done is gone*", but PE notes: "*I don't know if the data governance part is really appreciated on an executive level*".

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F. Perceived Value

Value is a frequently recurring factor threading across the themes discussed in this section. Participants used the term "*value*" repeatedly in their discussions around business focus, education, data quality and using a phased approach, e.g., "*You have to be selling it purely on what is the incremental value you're giving each step of the way*" (PD), and "*Start off by showing value first*" (PB).

G. Minor Themes

In addition to the major themes discussed so far, some minor themes emerged that also play a role in the organisations' drive for pervasive BI.

1) Vendor involvement

Participants felt it important to have a close working relationship with the BI vendor(s), as BI is a long-term project. PG explains: "*There's a road you need to walk with BI, it's not something that evolves in any organisation overnight, and that's why you need to pick those strategic partners*". However PA said: "*I think that companies are way too reliant on the vendor and they shouldn't be. I think they need to get skills in house, so build them up*."

2) BI tools, infrastructure and standardisation

PE explains that "*while the tools are very important, what's more important is how you utilise and implement the tools*". Self-service varied across the organisations, being seen as a promoter of pervasive BI by some, and a deterrent by others. Performance has a big influence on perceived user experience and is highly dependent on infrastructure capacity and network bandwidth (especially in country areas). Standardising on a single vendor's BI tool was not considered to be a big driving factor in whether business users made use of BI. Cost appears to be the biggest factor driving BI tool standardisation.

3) Technology Cost

Participants reported that companies were always searching for the cheapest solution to make information available. Four organisations had an enterprise licence agreement in place with their respective vendors. Cost appears to be a bigger obstacle in smaller organisations.

4) Regulatory compliance

While regulatory compliance had not been a major influence on the pervasiveness of their BI, participants noted that it was now playing more of a role in BI programmes, and would be a future influencer of pervasiveness.

V. DISCUSSION OF FINDINGS

Based on the earlier definition of pervasiveness, it appears that the participating organisations are relatively successful. This section discusses the factors influencing (impeding or promoting) pervasive BI that emerged from the study, in context of the TOE framework [20].

Table II shows the factors influencing pervasive BI that emerged from the study, summarized in terms of the three aspects of the TOE framework. Most are positively related to pervasiveness, and all but technology cost, vendor relationship, and regulatory compliance are "internal".

TABLE II. FACTORS INFLUENCING PERVASIVE BI BY TOE

Diffusion Factors	
Technology	- Technology Cost
	+ Infrastructure capacity
	+ Use of BI Tools
Organisation	+ Perceived value
	+ Executive buy-in & involvement
	+ Strong business focus & ownership
	+ Education & support
	+ Incremental, phased approach
	+ Information quality, form & availability
Environment	+ Vendor relationship & support
	+ Regulatory Compliance

A. Technology Context

The three diffusion factors listed under the technology context influence the extent to which BI is used across the organisation, and the diffusion of self-service capabilities. The strongest (negative) diffusion factor emerging in this context was the licence cost of BI tools. Most organisations had enterprise licences, which helped to mitigate this. All participating organisations were large, which made acquiring an enterprise licence feasible.

Slow performance impacts negatively on user experience, discouraging future use. Organisations have to plan ahead to ensure their infrastructure can cope with increased demand as BI becomes more pervasive in the organisation [7]. Most challenges experienced were due to network bandwidth limitations, particularly affecting self-service capabilities.

Organisations all invested in BI tools from leading vendors, including IBM Cognos, Business Objects, Qlikview, SAS and SPSS. They all attempted to standardise the tool sets used, but this was not considered to be critical to the pervasive use of BI. This is in contrast to literature that places a strong focus on BI tool standardisation [7].

B. Organisation Context

Several diffusion factors relating to the organisation context emerged. A recurring theme is the importance of BI's perceived value to the organisation. The strongest factor, described as critical, is the importance of executive buy-in and sponsorship to an organisation's BI programme. Establishing business ownership was another strong organisational factor. All participants reported that organisations need to involve business as much as possible and make sure their needs are addressed; thereby ensuring BI is delivering value. These factors are consistent with key success factors reported in the literature [2][7][9], and were significant influencers driving alignment between the BI strategy and the corporate strategy.

Ongoing education, communication and support were considered to be essential in helping business users get most value from the information provided by the BI tools. Business users empowered with the right information to manage their business will ultimately make better decisions [14][15]. This will further encourage their use of BI and lead to a culture of fact-based decision making.

Participants strongly recommended a phased, incremental approach that continuously delivers value to the organisation. Organisations should focus on areas of maximum impact, with each subsequent phase driven by a strategic business objective. This correlates with the literature [2].

All participants rated data quality of critical importance to ensure adoption and continued usage. Good data governance and the implementation of a single, trusted data repository are recommended [2][9]. In all instances a data warehouse was the source system for the BI implementation and was believed to be a cornerstone of the BI solution.

C. Environment Context

Participants reported that regulatory compliance is starting to play more of a role in their BI programme. A factor that emerged in this context was the importance of having a strategic, long-term relationship with the vendor. Both vendor relationship and regulatory compliance are potential future influencers in the degree of BI use.

VI. CONCLUSION AND FUTURE WORK

Pervasive BI is achieved when BI forms an integral part of the decision making activities that occur within the business. BI is used in various ways in different organisations, and what one organisation might consider being pervasive BI might vary significantly from the next organisation's definition of pervasive BI.

It appears that the participating organisations rely heavily on BI in their decision making activities and continuously attempt to encourage a culture of fact-based decision making. These organisations align their BI strategy with their organisation's strategic goals, and BI receives strong support and buy-in from top management and the business areas for the value it generates. Ongoing education, communication and support, quality information and an incremental approach were also important in facilitating the pervasive use of BI within the organisations.

The T, O and E factors that influence pervasive BI were also researched as part of this study. The findings showed that the "O" context was the strongest influencer of BI pervasiveness in these organisations, as opposed to Technology, and the "E" context the least. It is hoped that this study will provide researchers and BI practitioners alike with some new perspectives into factors that promote pervasive use of BI; and also provide better insight into optimal use of their BI investment, facilitation of fact-based decision making, and improved performance for the organisation. Future research may look at how this develops in the light of the opportunities and hype of Big Data.

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