Using the Fractal Enterprise Model for analyzing and predicting effects from introducing IT solutions

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Abstract

Due to complexity in today's business environment, aligning strategic goals with IT systems requires an analysis of the effects which the introduction of IT solutions brings. Enterprise Modeling (EM) can be used for the multidimensional analysis of an organization in order to bridge the gap between business and IT. Choosing a suitable EM technique is a challenging task, as standard modeling tools used in IT-world may be too IT-oriented and have limited ability to compare non-IT enabled business with IT-enabled business. The goal of this experience report is to test the fitness of Fractal Enterprise Model (FEM) and the FEM toolkit created with the help of ADOxx for the task of analyzing and predicting the effects of introducing IT systems into the business. A business case is examined where an IT project in an accreditation agency operating in European higher education area is analyzed. Different data collection methods were deployed, among them document study, semi-structured interviews, and own observation. The paper provides preliminary guidelines for practitioners for building FEMs for the situations before and after the IT introduction phase and analyzing/predicting effects based on them.

Keywords

Enterprise Modeling, Fractal Enterprise Model, ADOxx, Organizational Change, Digital Transformation

1. Introduction

In today's competitive and dynamic business environment, organizations need to constantly transform themselves by introducing IT solutions that enable effectiveness and efficiency in terms of business goals, organizational structure and processes. This can help them to deal with complexity, which has been reported to be a serious business problem [1]. The current experience report aims at sharing our experience in the field of Enterprise Modeling for the task of analyzing and predicting effects of IT introduction into the business. For this purpose, it examines the use of Fractal Enterprise Model (FEM) and the FEM toolkit which was built with the help of metamodeling environment ADOxx [2].

Enterprise Modeling (EM) is a practice that among other things supports the multidimensional analysis of an organization in order to bridge the gap between business and IT, therefore achieve the so-called Business and IT Alignment (BITA) [3]. It is generally perceived as an effective way to enhance coordination within an organization [4], achieve the desirable state through new digitized processes and ensure that IT investments add value and are aligned with business strategy [5].

Analyzing the effects of IT introduction is not a trivial task, as they may relate not only to the processes in which IT is being introduced, but also to other parts of the organizational activities that are also affected by a change [6]. Aligning business goals with IT systems requires an analysis

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of the effects that IT introduction brings, regardless of whether they are positive or negative. Due to the complexity of modern organizations, creation and use of IT systems the functioning of which the management can understand is a demanding task. According to [7], EM is essential to provide the management with enterprise models that are understandable and suitable for their decision-making processes. The importance of analyzing the effects of introducing IT is not restricted to the introduction phase. It can be beneficial to predict the effects before the introduction has started, during the phase of choosing the right IT system among several alternatives, or when a decision on introducing a specialized system has been reached. This can help plan measures to facilitate changes in advance [8].

According to [6] one problem that is observed in IT projects that affects business processes is that only the most visible processes are part of investigation from the management side, which might not represent the full picture of the enterprise, but provides rather a partial or half-documented knowledge. Another challenging aspect is that business process architecture is primarily designed to present well-defined processes, with little emphasis being given in analyzing the whole organization and identifying all existing processes.

For choosing a suitable Enterprise Modeling (EM) technique that provides management with reliable information, some requirements/criteria can be set. Firstly, it should provide a holistic view on the operations of an organization, meaning that it could help identify all the areas of the business that could be affected by providing enough concepts for building the holistic models [7]. Secondly, it should be understandable for business people that lack a technical background in computer science [7] or at least being understood without extensive training [9]. Different modeling techniques can be used for a variety of business decision-making and purposes, where each modeling technique (i.e. BPMN [10], ArchiMate[11]) is aimed at examining a specific aspect of an organization. Standard modeling tools used in IT-world may be too IT-oriented and have limited ability to compare a non-IT enabled business with an IT-enabled business. Another issue is that traditional EM tools face the challenge that the new models that are created might have limited connection to the old one or cannot properly show all capabilities and assets of an organization [6], making the comparison between existing business processes and the ones to be introduced after IT intervention difficult.

Thus, there is a need for a modeling technique that could provide means for analyzing all effects of IT introduction, and the Fractal Enterprise Model (FEM) seems promising in this respect. According to [12], FEM bridges the gap between the visualization of as-is and the development of a new process architecture of an organization. By building enterprise models of the relevant parts of the business, the comparison between the state before and after IT introduction is enabled in a more formal way.

The research question we try to answer in this paper is: *"In what way can FEM be used for analyzing and predicting effects from IT introduction?".* The research question is sought to be answered on an example of an accreditation agency of 20 employees operating in the field of accreditation, certification and quality assurance in higher education. The transformative IT project of the accreditation agency that is being examined is related to the introduction of a new software for supporting accreditation procedures in higher education (called from now on "easy job"). The new system serves to improve the internal management routines.

Note that the focus on testing FEM for the task, does not mean that other EM languages cannot be used for this task, or FEM is the most optimal solution. The scope of this paper is limited to FEM, as this technique seems promising for finding all areas in an organization that are/would be affected by the change. Also, we are not expecting FEM to be useful for calculating effects in economic or other terms. Other techniques are needed to analyze all changes that new IT brings into organization and express them in economic, cultural, or some other type of measurements.

The rest of the paper is structured in the following manner. Section 2 presents the knowledge base, including a short description of FEM, and the business case. Section 3 introduces as-before models of the business case and presents the methodology that was followed when building them. Section 4 presents as-after models, and analyzes the differences. Section 5 reflects on the main findings, answers the research question, and discusses limitations.

2. Knowledge base

2.1. A short introduction to FEM

Fractal Enterprise Model (FEM) is a modeling technique that shows interconnections between business processes and assets that an organization manages [6]. The name fractal is referring to the recursive nature of the model. Building of FEMs is supported by a graphical environment called FEM toolkit [7] that is based on the metamodeling environment ADOxx [2]. According to [6], FEM has been initially developed for finding all or the majority of the processes within an organization. Through the expansion of FEM in several case studies, it has been revealed that FEM can be used in planning organizational change and transformation [6,7]. An example of a FEM related to our business case is presented in Fig. 1, which will be discussed in the next subsection.

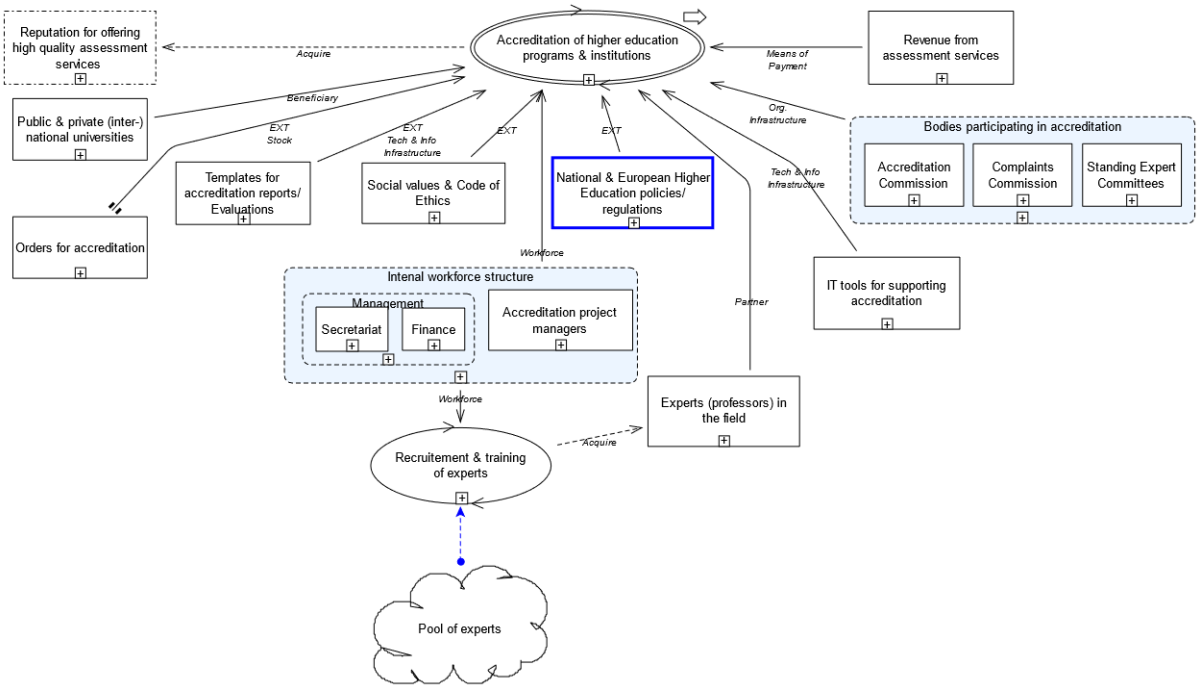

Figure 1: A FEM representing a general outline of organization in our business case

FEM has four types of nodes: *business process, asset, external pool* and *external actor*, the latter is not used in this paper. A process, depicted as an oval in the notation, represents a repetitive behavior. An asset, depicted as a rectangle, represents a set of things that are engaged in the behavior and play a certain role in it, thus ensuring that the behavior continues to be repetitive. There are two types of relations between processes and assets – *used in* and *managed by*. A *used in* relation between a process and asset means that the asset plays a certain role in the process. The relation is visually represented by an arrow with a solid line that goes from the asset to the process. A *managed by* relation between an asset and a process means that the process changes the set, i.e. adds or removes elements or changes their properties. The relation is visually represented by an arrow with a dashed line that goes from the process to the asset. To identify which role the asset plays in the process, or how the process changes the asset, a label is added to the relation.

There are 8 labels for *used in* relation:

1. *Workforce:* people employed in the process who belong to the given organization.
2. *Partner:* external agents participating in the process, they can be other organizations or people not employed by the given organization.
3. *EXT* (EXecution Template) - any kind of regulations that determines the activities flow in the process, e.g. software development methodologies, process maps, manuals, etc.

4. *Technical and Informational Infrastructure*: equipment, software systems, databases, etc. used in the process.
5. *Stock:* stock of materials, products, used in the process.
6. *Organizational Infrastructure:* departments, teams, etc. of an organization that participates in the process.
7. *Means of payment*: monetary funds used to pay stakeholders, suppliers.
8. *Beneficiary*: people or organizations that benefit from the process.

There are three labels for *managed by* relation:

1. The *acquire* relationship refers to the process of adding a new element to the asset.
2. The *maintain* relationship refers to the process of keeping existing assets "in shape".
3. The *retire* relationship refers to the process of excluding elements that are no longer used in the process.

An *external pool* represents a set of things, active or passive, from which an organization can acquire some elements, or to which it can add some elements. An external pool can be connected to a process via a blue dashed arrow with a round dot start. The arrow shows which process draws from the pool or adds elements to it.

A standard way of building FEM is starting from a process of interest and going down using architypes (patterns) for extending the model downwards. An architype is a template defined as a fragment of a model where labels inside ovals (processes) and rectangles (assets) are omitted, but arrows are labelled. FEM has two types of architypes: process-assets architypes and an asset-processes architype. A process-assets architype represents the kinds of assets that can be used in a given category of processes. There are several architypes of this sort. The upper part of Fig. 2 presents a so-called generic process-assets architype, which can be applied to any process. There are also specific process-assets architypes.

The asset-processes architype shows the kinds of processes that are aimed at changing the given category of assets. There is only one such architype, which is presented in the bottom part of Fig. 2. In the FEM toolkit an architype is invoked by clicking on the plus sign in the bottom of a process or asset shape. This will lead to additional elements being added to the model. More on architypes, FEM and FEM toolkit see in [6] and [7].

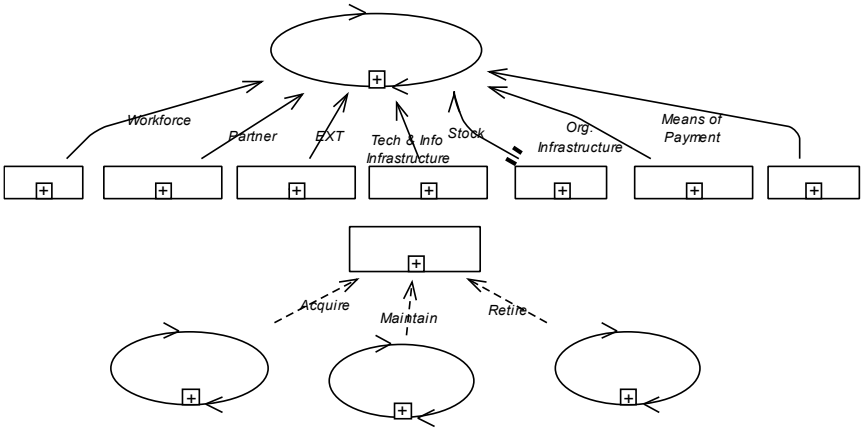

Figure 2: Upper part – a process-asset architype; bottom part – the asset-processes architype

2.2. Business case

The generic FEM model of the examined business case is presented in Figure 1. To build it, the authors started with the primary process that delivers value to a beneficiary and then identified the assets (resources) that are needed to manage the process. For the identification of assets, the first author carried out an empirical investigation based on her experience in the agency and complementary documents that describe the processes.

The main process of the accreditation agency is the accreditation of programs or institutional accreditation of public/private universities through external assessment by peer-review completed by experts in the field. The objective of the agency is to offer high quality assessment services to higher education institutions nationally and internationally (shown with dashed acquire) by attracting more universities. Main beneficiaries are public and private national and international universities. Part of the IT infrastructure are the IT tools for supporting accreditation procedures. The primary process of the accreditation agency can be decomposed into three processes: the program accreditation, the supporting processes, and the institutional accreditation. The focus will be on the first two since institutional accreditation is similar to program accreditation.

During the recent years, the agency has been undergoing a transformation process triggered by changes in the national and European laws, therefore the management considered it necessary to redesign the processes related to the support of accreditation procedures through a so-called *easy job* project, which will be in the focus of this paper.

2.3. A framework for analyzing effects from IT introduction

As has been mentioned in Section 1, an enterprise model alone does not have enough information for calculating the effects of introduction of IT in quantitative or even qualitative manner. What it can help with is to highlight areas of change that can be far beyond the processes in which new IT systems are being introduced. For doing quantitative and qualitative predictions, we need another framework which can be used after all areas of a change have been discovered. In this work, we use a framework from [13] as an additional framework for analysis of the effects from IT systems introduction into practice. It was developed by analyzing 80 research papers and grouping the effects from IT investments into 25 categories. Table 1 presents the criteria from [13] that we have used in the current research.

Table 1
Criteria for analyzing effects of IT introduction (based on [13])

Criteria for analyzing effects of IT introduction		
Resources of the business		
Human resources	Decision making	Better decision support, shorter time to reach decisions, less uncertainty and complexity
	Learning and knowledge	Increased knowledge of persons, competence development
	Organizational culture	Higher job satisfaction, increased involvement from management, improved organizational culture
Non-human resources	Information	More accurate, more available, more detailed, easier to interpret information
	Technology/tools	Improved non-IT tools and machinery in production technology
Structure of the Business Organization		
Components of the business	Strategy formulation and planning	Better ability to develop long-term strategies and activities planning
	Efficiency	Shortening of times/work, reduced paperwork or administrative tasks, automation of work
	Productivity	Doing more with same resources
	Cost reductions	In processes or departments, less expenses

Criteria for analyzing effects of IT introduction		
Connections between components	Communication	More types of communication, more open dialogue
	Flow of products/services	Improved flow between processes
	Control and follow up	Improved reporting possibilities, better evaluation of options
Transforming and making structural changes	Change management	Improved ability to restructure, add or remove processes
	Integration and coordination	Improved coordination and integration of different parts and better planning among departments
	Flexibility	Adaptation to changes in market conditions

3. Building as-before models

3.1. Data sources

Fig. 1 represents a general model of operations of the accreditation agency. This model was extended by creating a number of more detailed models for relevant parts of the business. Some of these models are presented and discussed in this paper. The models were build based on the following kinds of information:

- Internal documents, such as protocols and meetings minutes of the accreditation agency, have been used to understand the role and scope of the accreditation agency operations.
- Four interviews were conducted with the accreditation agency general manager, quality assurance manager, process manager and external IT company to understand processes and roles and how they are affected by introduction of new IT systems. They were conducted individually with the participants in a semi-structured format. In addition, unstructured and informal discussions were conducted with the participants of the processes when the needs aroused.
- Lastly, after presentation of the results to the stakeholders, two unstructured interviews were conducted with the general manager and process manager.

3.2. FEM for the easy job project

The easy job project concerns the introduction of new IT systems in the supporting processes. The general model for this part of the business activity is presented in Fig. 3. To connect this model to other models built for the business case, we use the *ghost* feature of the FEM toolkit. The ghost feature allows to present the same element in several places, in the same model or in a different one. The feature allows to split a complex model in parts by creating a package of interconnected models. A second occurrence of the same element has a thick arrow in the right upper corner of the shape that represents the element. A new occurrence of the same element can also be presented in a decomposed way. The decomposition is shown by a shape with the dashed border that contains other shapes (see Fig. 1 and 3).

As shown in Fig. 3, there are four main supporting processes for the accreditation procedures: (1) "Financing & Accounting handling" with basic IT tool the finance and accounting software; (2) the "Monitoring of program accreditation procedures"; (3) "Tracking of employees' working hours" with a software called “Timetac”, and (4) "Monitoring of servers & storage capacity" that uses physical servers and cloud storage. From the above, the "Monitoring of program accreditation procedures" will be further decomposed and examined in the next section, since it is the main process affected by the “easy job” software.

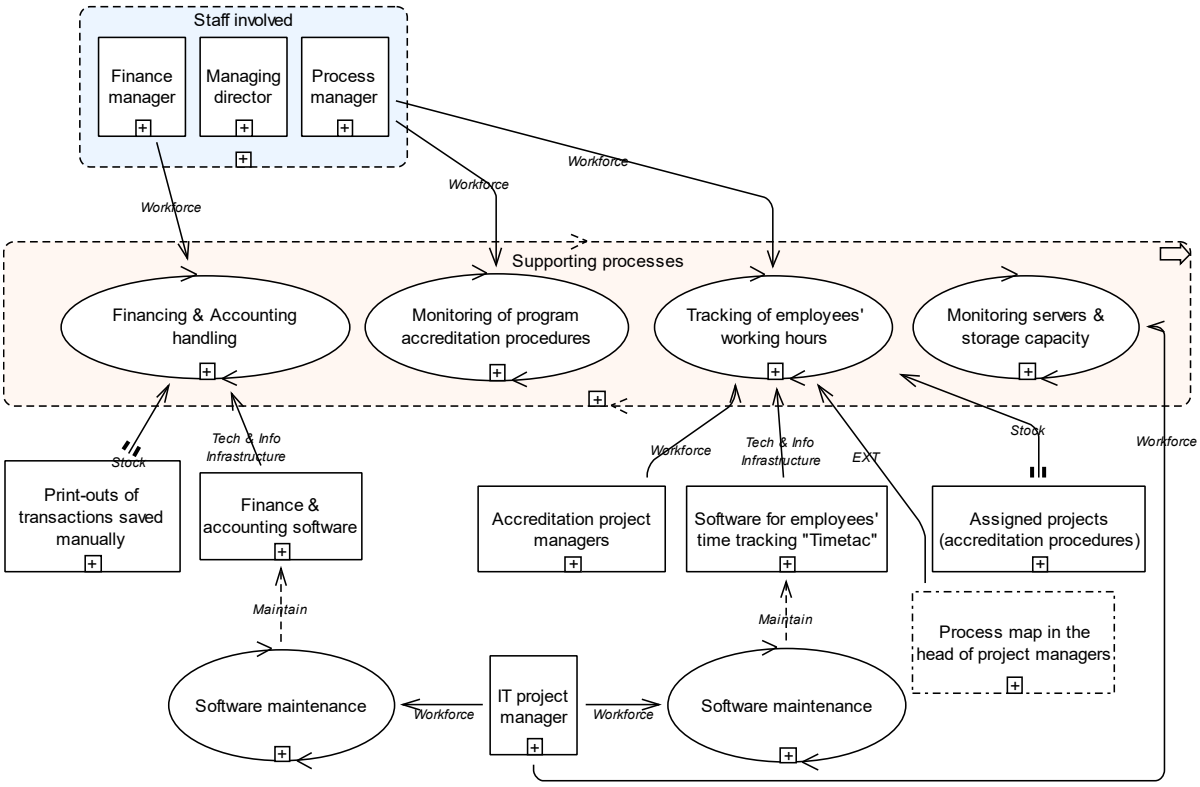

Figure 3: Supporting processes with IT tools (as-before)

During the interviews with the management, it was discovered that the current IT infrastructure used for accreditations is not in a good shape, since different software tools and database monitoring tools (e.g. Access, Excel) are used for completing the tasks involved. This impedes planning and execution of accreditation routines in an effective and efficient manner and leads to the time-consuming processes that are either non-automated or only partially automated.

An external IT company was commissioned by the accreditation agency to introduce in autumn 2022 a new software called “easy job” that will serve as a "one-stop shop" for the supporting processes related to “Financing and Accounting handling”, “Monitoring of program accreditation procedures” and “Tracking of employees’ working hours” of the agency.

3.3. FEM for monitoring of program accreditation procedures

The monitoring of program accreditation in the as-before state is presented in Fig. 4. There are a number of different tools used in this activity, but they do not automate the processes sufficiently and do not provide enough data for analytics. The activity mostly uses general Microsoft tools, such as Word, Access, Excel. More specifically it uses:

- Access database of accreditation procedures. It serves the planning of the whole accreditation procedure by setting milestones in Access and calculating employees' workload.
- Moodle “archive” linked to the agency’s website. A version of Moodle specifically designed for the accreditation agency for archiving accreditation reports and publishing them to agency’s website (used since 2018).
- Database of experts in an Excel file. It supports the nomination of peer-review experts.

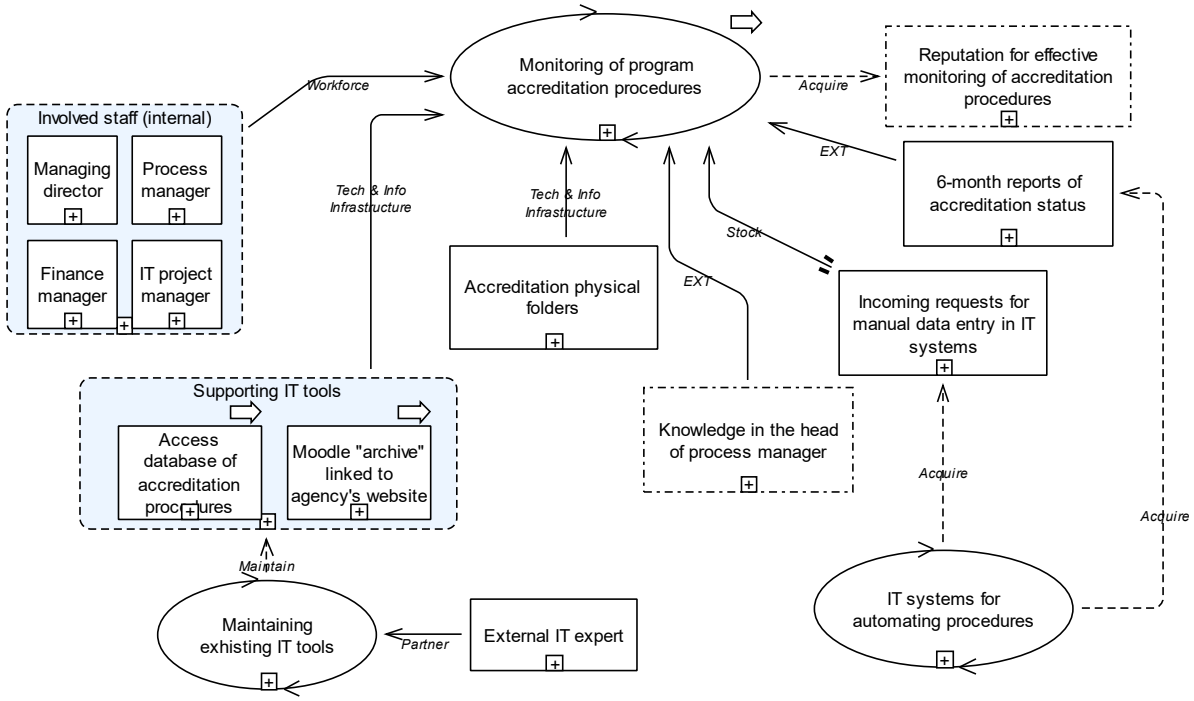

Figure 4: Monitoring of program accreditation (as-before)

4. Building and analyzing as-after models

4.1. FEMs for the as-after situation

The FEMs for the situation after the new systems have been introduced into practice are presented in Fig. 5 (corresponds to Fig. 3) and Fig. 6 (corresponds to Fig. 4). For tracking changes, the affected assets and processes are marked by special background colors in Fig. 5 and 6. The assets/processes that underwent changes are marked with the light orange color, and new assets/processes that have been added are marked by the light blue color. Additionally, the assets that will be disappearing in the new state can be marked with grey color in the as-before models, which is not presented in Fig. 3 and 4.

The details of changes are as follows:

- Financing & accounting handling: is replaced by "easy job" software. The new software offers the possibility of saving automatically all transactions in digital folders. This is also reducing the need for printing the documents, which can now be sent to external auditors directly as digital files (environmental friendlier solutions).
- Tracking of employees' working hours: is also replaced by "easy job" software that replaces the "Assigned projects" and "Process map in the head of project managers" by providing resources overview per employee/per week and tasks/timings in Gantt Charts. The new features enable better resource-planning by the management and provide project management solutions for accreditation managers in a homogeneous way (milestones, tasks tracking for each accreditation step).
- Monitoring servers & storage capacity: provides the agency with storage capacity to support all processes. The process is handled by an external IT company (partner), freeing time for IT project manager. The IT company will maintain the new system and provide storage solutions. This change is expected to provide more reliable services and support from experts in the field.

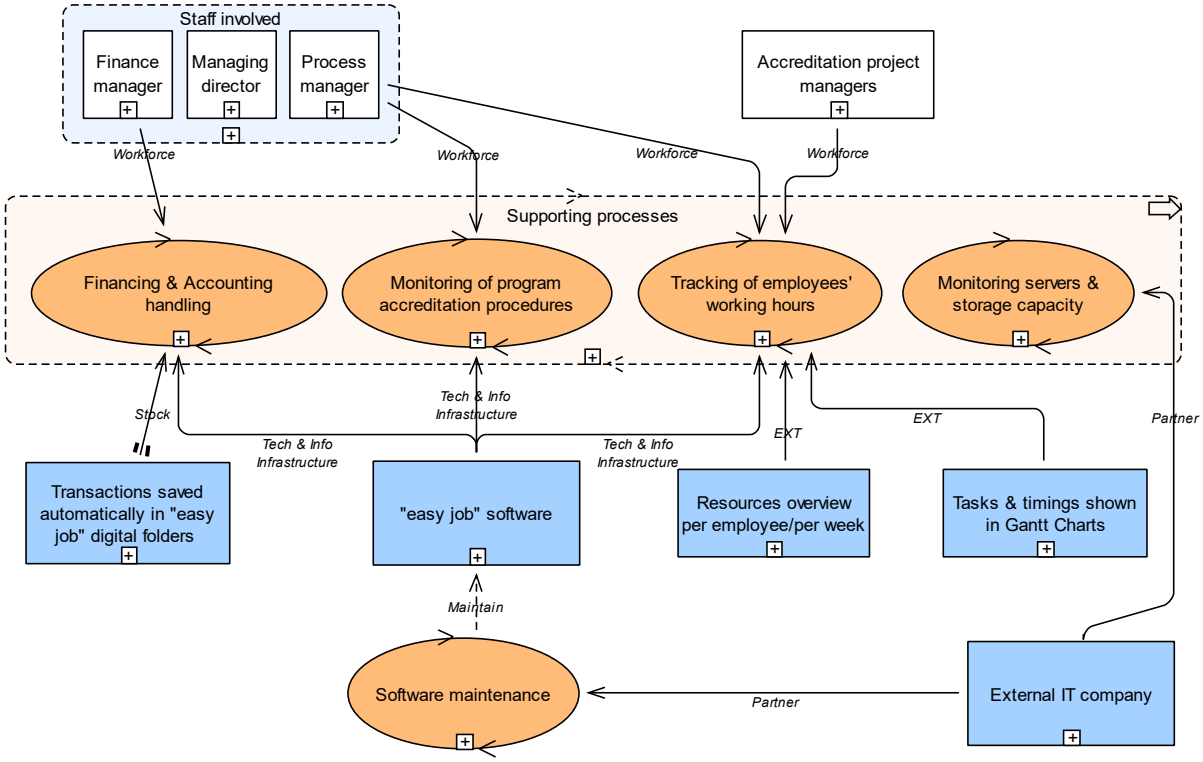

Figure 5: Supporting processes with IT tools (as-after)

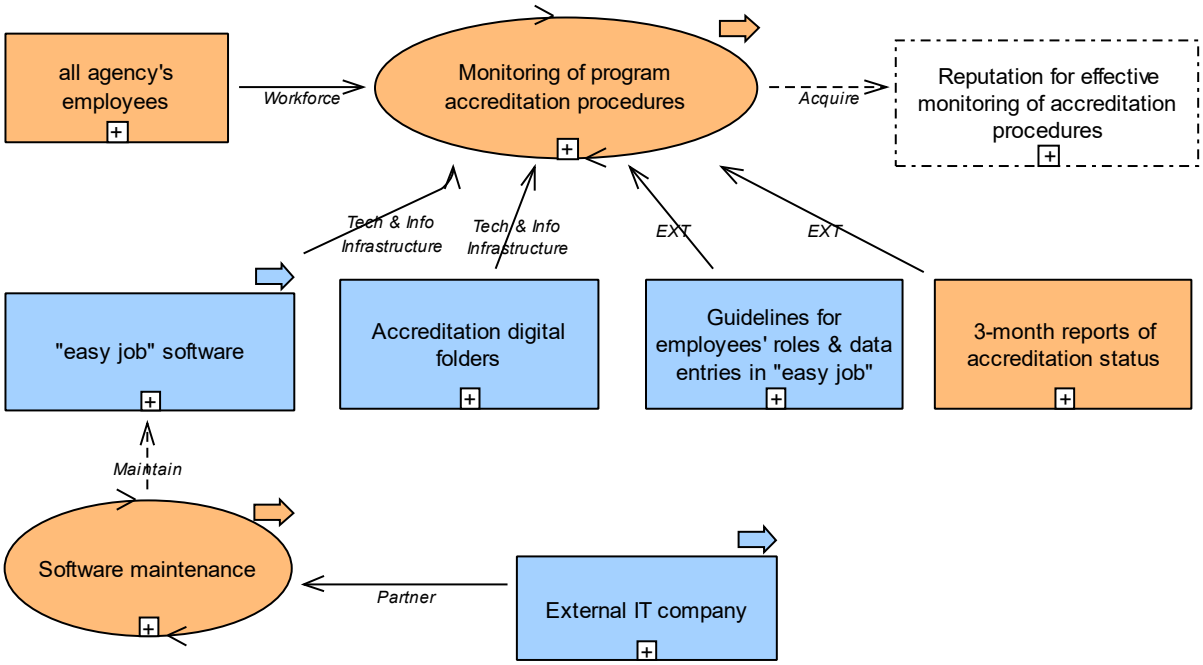

Figure 6: Monitoring of program accreditation (as-after)

4.2. Analyzing potential problems during the introduction

Based on the comparison of as-before and as-after model, we can generate the following questions related to the introduction of the new tools:

- *Workforce question*. How can employees contribute to the monitoring of accreditation procedures and coordination of tasks? This can prove a challenging task since employees are usually reluctant to use new tools and change their routines if they do not clearly see the benefits from their involvement.
- *Tech & Info Infrastructure question*.
  a. *Access database of accreditation procedures & Moodle archive will disappear*. How can replacement of Access database and Moodle by "easy job" can take place smoothly? Moving data from Access database to "easy job" is expected to be a demanding task since all accreditation procedures are currently monitored in Access.
  b. *Physical folders of accreditation procedures will have to be replaced by digital folders*. How much digital space will be needed and how the conformance with regulations/auditing processes will be reassured? The IT project manager will have to provide predictions on the size of digital folders in order to have enough space for cloud storage and cooperate with external IT company on this issue.
- *Procedural (EXT) questions*. The new software will provide management with more detailed and precise information on a daily basis, enabling 3-month prediction of workload. How difficult this transition can be? The transition will require internal communication and training of employees regarding the new software and which data should be extracted to make the 3-month reporting useful for decision making.

4.3. Prediction of effects after the introduction

In Table 2, we present the most important expected effects from the introduction of new systems in the easy job project. They have been obtained based on the analysis of difference between as-before and as-after models, as well as on the criteria presented in Table 1.

Table 2
Analysis & prediction of effects of easy job project

Gammelgård et al framework	Affected asset	FEM asset category	Type of change	Expected result	FEM model/figure
Supporting processes					
Components of the business (strategy formulation and planning & productivity)	Process map in the head of project managers	EXT (tacit)	Removed	Improved activities planning through charts, doing more with same resources due to identifying resources availability.	Figure 3
	Tasks & timings shown in Gantt Charts	EXT	New		Figure 5
	Resources overview per employee/per week	EXT	New		Figure 5
Components of the business (efficiency)	Print-outs of transactions saved manually	Stock	Removed	Reduced paperwork and automation of tasks.	Figure 3
	Transactions saved automatically in "easy job" digital folders	Stock	New		Figure 5
Monitoring of accreditation procedures					
Human resources (decision making)	6-month reports of accreditation status	EXT	Removed	Improved decision making.	Figure 4
	3-month reports of accreditation status	EXT	Changed		Figure 6
Components of the business (efficiency)	Physical folders of accreditation procedures	Tech & Info infrastructure	Removed	Use of digital folders that lead to less hard copies,	Figure 4

Gammelgård et al framework	Affected asset	FEM asset category	Type of change	Expected result	FEM model/figure
	Digital folders of accreditation procedures	Tech & Info infrastructure	New	therefore more sustainable solutions.	Figure 6
Non-human resources (information)	"easy job" accreditation monitoring software	Tech & Info infrastructure	New	Improved data quality.	Figure 6
Transforming and making structural changes (integration and coordination)				Creation of "one-stop shop" solution instead of scattered IT systems.	Figure 6
Components of the business (efficiency)				Less dependency on programming skills due to easily adapted interface of "easy job" by internal staff.	Figure 6
Connections between components (communication)	Involved staff (all agency's employees)	Workforce	Changed	Involvement of all staff in using "easy job" through training that creates enhanced internal collaboration and alignment to common business goals.	Figure 6
Connections between components (communication)	Involvement external IT company	Partner	Changed	Better collaboration with external IT company than being dependent on one person's external IT expertise (past). It also frees up internal resources (IT project manager).	Figure 6
Components of the business (efficiency)	Incoming requests for manual data entry	Stock	Removed	Improved data quality, automation of work.	Figure 4
	Knowledge in the head of process manager	EXT	Removed		Figure 4
	Guidelines for employees' roles & data entries in "easy job"	EXT	New		Figure 6

5. Discussion

5.1. Reflections on the project experience

From the EM perspective, this experience report is a test of fitness of FEM for analyzing and predicting effects of IT-introduction. It is also an investigation of how this EM technique can be used for these purposes. The primarily goal of the project was to check if we could use FEM and the FEM toolkit for the intended purposes and in which ways.

To be of use for the intended purposes, firstly, the modeling technique should help identify the areas of the business that could be affected by providing enough concepts in the modeling

technique for depicting these areas. For depicting the as-before and as-after process architecture of the accreditation agency the following features of FEM and the FEM toolkit have been used:

- The process-assets and asset-processes architypes [6,7], that help to build the model of relevant parts of the organization.
- The ghosting features provided by the FEM toolkit [7], that help to divide a complex model in parts and provides a possibility for browsing through them. The feature helps to find the source for a ghost and trace assets and processes that serve more than one purpose.

Secondly, it should help make a comparison between as-before and as-after models on the right level of details. In contrast to other business modeling techniques, FEM can show connections between as-before and to-be models, without models being too IT-oriented. In FEM, the comparison is enhanced by a special feature "subclassing assets or processes" based on various dimensions by using specific background colors to denote specific elements of the model [7]. This feature has been used to identify what has been added, what has been changed and what has been removed as the result of IT introduction. In terms of applicability, FEM is suitable as a basis for calculating effects of changes that are spread through different part of the business, as it takes into consideration the wider environmental context. It might not be applicable if the change is limited to changing the software without changing anything else.

There are some limitations on the usefulness of FEM in assessing and predicting the effects. FEM helps only in finding areas that have been changed (or are to be changed). There is a need for other methods to assess the financial, and other impacts of the change.

The limitation of the project itself is that we have only used one modeling technique for the purpose. The results show that it is quite useful, which does not exclude that some other technique could be as useful, or even better. A systematic comparison with other modeling techniques that could serve the same purpose is required to understand which technique is better suited for the task. This comparison is planned for the future.

5.2. Preliminary procedure for analyzing & predicting effects

As part of experience sharing, the steps followed in this small-scaled project can serve as preliminary guidelines for analyzing and predicting effects of IT system introduction with the use of FEM. The guidelines consist of the following steps:

- **Step 1 Intervention understanding**: Define problem and scope of a planned organizational intervention.
- **Step 2 Processes & assets**: Identify the processes-sub(processes) & assets that are directly or indirectly affected by an intervention.
- **Step 3 Building before intervention FEM model**: Build a FEM model as-is or as-before (in case the intervention has been completed) to the depth needed to understand the planned IT intervention.
- **Step 4 Building after intervention FEM model**: Build a FEM to-be or as-after (in case the intervention has been completed) to the depth needed to understand the planned IT intervention.
- **Step 5 Comparison of models:** Compare the as-is/as-before with to-be/as-after models by noting which assets and processes have been removed and which have been added. In the FEM toolkit, this can be made visible through the subclassing feature of the FEM toolkit. More specifically, the disappearing processes and assets in the as-is/as-before model can be highlighted by the grey background color, new processes and assets in the to-be/as-after model and changed processes can also be highlighted with specific colors, e.g. light orange and blue.
- **Step 6 Calculating the effects**: Based on the differences between the models, possible effects can be derived based on investigating directly affected, non-directly affected, removed (i.e. freeing resources due to automation), or added processes and assets. This can be based on the highlighted by specific background colors elements of FEMs that show

the following categories of changes: (a) removed, (b) new or (c) changed asset/process. In the planning phase, the calculated effects can be used for decision making including approval, amendment, or rejection of a specific change.

- **Step 7 Evaluation of intervention:** This step is related to completed interventions. It includes investigation of whether the calculated effects correspond to the reality and if not, why.

The preliminary procedure above can be considered as an answer on the research question posed in introduction, namely: *"In what way can FEM be used for analyzing and predicting effects from IT introduction?".* The above steps can be used by enterprise architects, modelers, process managers in order to visualize, report and document changes in IT projects of transformative character. This procedure was tested in a larger project in the accreditation agency, but due to the size limitation, we cannot discuss the results in this paper.

The procedure defined above can produce positive effects in completing the introduction of new IT solutions. It can help in removing stress from employees and minimizing the resistance to change, e.g. by properly informing and training the staff affected by the change, as well as identifying potential side-effects that have not been expected from the beginning.

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