Business Process Management for MES Deployment: Some Lessons from a Bearings Manufacturer Experience

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Abstract. Industrial company's physical production and information systems have to be adapted in the digital transition context from the automatized Industry inherited from the 70's to the Industry 4.0. The information system must namely be completed by the deployment of new software solutions such as the Manufacturing Execution System (MES). Controlling this MES deployment is a critical point where structuring frameworks such as the Business Process Management (BPM) can be a solution. Indeed, the BPM allows managers to deal with the company changes, and allows to control them thanks to an iterative cyclic approach. Moreover, recent developments introducing agility in BPM have enabled it to take into account a high level of uncertainty as well as the promoting of team collaboration. Starting from this idea, this article explores this method in an industrial context given by an aeronautics bearings supplier company. This company is deploying a MES solution for a new high-tech manufacturing plant. After a first informal MES deployment for a pilot plant, the company would like to deploy this MES in a systematic way to all its other plants. Starting from some observations made during the ongoing MES deployment, this paper proposes to explore BPM as a means to assist managers and key users in optimizing the existing knowledge and improving the current practice for its further reuse. Then some recommendations coming from this experience are made for helping companies involved in such a MES deployment.

Keywords: MES deployment, Business Process Management, Case study.

1   Introduction

Digital transition is today a key point for industrial companies [1]. The corresponding challenges concern global sustainability, process reproducibility despite the growing customization, induced manufacturing flexibility, product genealogy management, human-sensitivity and responsibility, team collaboration… Thus, companies have to adapt their physical production and information systems according to the innovation possibilities provided by the Industry 4.0 context, while experiencing a high level of uncertainty about the suitability of these innovations [2]. To do this companies have to

develop the intermediate level of their information system located between the strategic level ensured by the Enterprise Resource Planning ERP and the operational level ensured by SCADA as shown in the Computer Integrated Manufacturing pyramid. It is the role of the MES as mentioned by the MESA definition: "*The MES delivers information that enables the optimization of production activities from order launch to finished goods. Using current and accurate data, the MES guides, initiates, responds to, and reports on plant activities as they occur. The resulting rapid response to changing conditions, coupled with a focus on reducing non-value-added activities, drives effective plant operations and processes.*" [3]. Even though MES is not a recent information system element, there is now a renewed interest in it for numerous companies which are today seeing it as a prerequisite for their digital transition. Thus they have to deploy this system according to more or less precise requirements due to their lack of maturity concerning the digital transition. In this context how can they do this to change in a controlled way? To do this they need a formal framework to anticipate the problems, to control the deployment and to continuously improve the results. By focusing on enterprise processes, BPM [4] can be considered as such a framework. Indeed, it has been applied to other parts of the information system such as the ERP for instance [5]. BPM applied to MES deployment process in a company has not been really documented, very few papers have been published dealing with both MES and BPM approaches [6][7]. Our idea is that BPM can help to understand the critical MES aspects and to manage its deployment until its further improvements. Moreover, applying agility facet to BPM can be a way for dealing with changes and uncertainties that are generally associated with the operational MES deployment. Agile BPM also allows the company to continuously adapt the deployment given the difficulty to have a complete overview of the problem since the deployment start. As a first step of this association MES-BPM, the proposed approach is based on the analysis of a current industrial practice, namely the one of a bearing manufacturer and aeronautics supplier in its digital transformation. Such an analysis will lead to deduce some lessons and recommendations.

This study subscribes to the general issue of relevance of using information system tools for the manufacturing systems control. In particular, this paper deals with the following question: "*How (agile) BPM does benefit to a MES deployment in a manufacturing company?*" In this sense, this paper is organized as follows. Section 2 presents the BPM general principles with a particular focus on the agility aspects. Then, the testimony of the NTN-SNR company regarding the MES deployment is given Section 3. This deployment is thus revisited by BPM and agile BPM. Recommendations and benefits related to agile BPM enactment within MES deployment process are discussed Section 4, before concluding on this preliminary work.

2 Business Process Management and agile BPM

Business process management (BPM) is a discipline in "*operations management in which people use various methods to discover, model, analyze, measure, improve, optimize, and automate business processes*" [8]. There has been a growing interest in
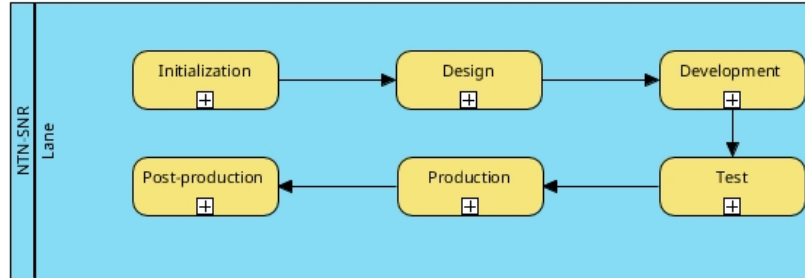
BPM during these last decades, because BPM allows to assist organizations to increase productivity, improve operational quality and efficiency or save costs [9]. Business analysts often consider BPM as an *" enabler of enterprise digital transformation"* [10] [11]. Research results in BPM coming from different domains (*i.e.* computer science, management science and information systems [12], and have proposed a large variety of models, methods and tools that support the design, enactment, management and analysis of business processes.

There are various BPM process lifecycles proposed in the literature [13], most of them being based on the DMEMO (Design, Model, Execute, Monitor, and Optimize) cycle. When unplanned events occur, dynamic feedback from process practitioners is required and process has to be dynamically adapted [14], since DMEMO-based lifecycles are inappropriate. In this case BPM must be adapted, such as the Agile BPM coming from the software development lifecycle management methodology (SDLC). It is an iterative approach where actions are taken in many smaller iterations in all phases in a similar way to the PDCA cycle [15]. Agile BPM promotes collaboration among process stakeholders, multiple iterations resulting in several versions of a given process and tries to avoid organization silos. Agile BPM aims to combine strengths of traditional BPM approaches (process control, process consistency and repeatability, customer satisfaction) and needs for adjusting business processes to a constantly changing context of conditions and customer demands. Agile BPM frameworks are proposed combining pillars from both the Scrum method and BPM [16] [17]. Authors highlighted that *"...the controlling of indicators plays an important part in order to evaluate the changes and from this to derive new follow-up steps. Agility requires continued intensive communication between all participants, creates transparency on the progress, transfers responsibility to the team, forcing radical prioritization"*. In agile BPM the Define, Model and Execute phases can be merged into one, and thus the cycle is divided in a series of smaller development cycles [18]. So this brief review shows that BPM can be adapted when an agile approach is relevant to deal with the addressed problem. Let us now illustrate these ideas through the MES deployment in the NTN-SNR company.
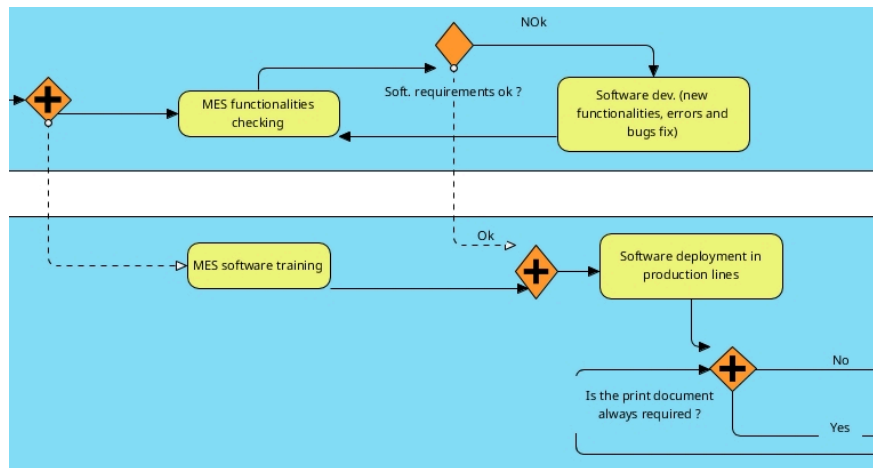
3　　The NTN-SNR case study

The NTN-SNR company is a bearings supplier for the aeronautics and automotive industry and produces a large variety of bearings in about 15 manufacturing plants. Involved in its digital transition, it had begun with the MES deployment in a traditional project management method in a pilot plant. From this first experience's limits (delay, lack of functionalities, over budget, non-quality), company wished to control the further plant MES deployment thanks to BPM. In order to do this, key users and managers were interviewed in order to *a posteriori* infer the BPM from their first deployment using the BPMN 2.0 models[1] (due to the complexity of such models, they cannot be detailed in this paper). Figure 2 shows the MES macro-process deployment model.

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[1]　　BPMN 2.0 is an ISO standard notation for process modeling [19].

4

Fig. 2. The MES deployment macro-process model.

Figure 3 details a Production phase sub-process fragment with back and forth between MES software editor and NTN-SNR. The overall macro-process reveals a traditional (sequential) engineering process revealing two main lacks: it is less efficient than concurrent engineering such as the SDLC [20], results are unpredictable knowing that BPMN 2.0 cannot anticipate the diversity of situations that may arise.

Fig. 3. Back and force between the NTN-SNR company and the software editor (extract of a BPMN 2.0 process fragment of the AS-IS Production activity).

BPM exposes another problem concerning relationships between the MES software editor and the NTN-SNR teams: during the deployment process, editor had to adapt and improve the software several times in response to NTN-SNR needs. There were numerous unplanned and unanticipated demands that were empirically managed, resulting in delays, with time consuming and unsatisfactory situations. According to this diagnosis, BPM shows that the MES deployment process should be considered as a flexible process which must be dealt in an agile way.

4   Recommendations and benefits

Some recommendations and benefits can be seen as a consequence of this industrial practice: the MES deployment in the aeronautics plant and its analysis, and though the use of agile BPM. These recommendations resulting from our work are listed in table 1 and permit to answer to the question *"How (agile) BPM does benefit to a MES deployment in a manufacturing company?"*.

Table 1. Proposed recommendations and benefits.

Recommendation benefit	Details
Consider process modeling	The process modeling will help the company for knowledge capturing, process standardization: processes can be more robust, optimized and reproductible, and also help teams in understanding the entire process, favoring uses to be agreed upon in the required activities, necessary resources, assets, collaboration between actors, etc.
Consider the TO-BE process as an agile process	Deployment process has to integrate agility principles using management precepts of the Scrum method. Knowing the strong background of NTN-SNR IT unit in the Scrum, this agile method must be considered as a framework for the MES deployment process. MES design, development, test, production and post-production phases (see Figure 3) must be managed, using iterative Scrum workflows (product backlog, sprint planning, daily Scrum, sprint review, sprint retrospective, backlog refinement). Moreover, the team must be organized according to the Scrum roles (*i.e.* product owner, development team, Scrum master.
Consider the BPM lifecycles diversity	Agile BPM approach [18] is well adapted for dealing with unanticipated, unplanned and unknown situations. By merging the Model, Define and Execute phases, agile BPM may facilitate relationships between NTN-SNR and the MES software editor, and the alignment between the NTN-SNR IT and manufacturing services. Once the first deployment instance is sufficiently improved, other process instances will be started, each corresponding to a specific NTN-SNR plant. For these other processes, it will be probably better to follow the traditional BPM lifecycle.
Consider globally the organization and human resources management	Agile BPM enables team collaboration, increases actors' responsibilities and implication, develops new actors' skills and knowledge. Applying agile BPM in a MES deployment process will also avoid silos; instead, agile BPM facilitates the convergence between the manufacturing, the IT and the organization management services. Agile BPM may also help in enacting some liberated company aspects in a traditional and hierarchical company.

Consider the norms and standards enactment	BPM and BPMN are key factors favoring continuous improvement [21], ISO/IEC 19510:2013 when MES is a means for the ISA 95 implementation that allows to control manufacturing by exploiting real-time manufacturing data. Combining these two aspects promotes agility, flexibility and adaptability of the company required for the context changes and the customer satisfaction improvement according to the current standards.
(Re) Consider process description languages	Introducing flexibility in MES deployment is a key issue. BPMN is not suitable when agility is mandatory and for processes that work in environments where participants have a large autonomy. Thus, other process description languages may be more relevant *(i.e.* CMMN [22], Declare [23], pi-Diapason [24] and be used either in conjunction with BPMN, or as BPMN replacement.

From these recommendations, the company can now deploy the MES to the other manufacturing plants, avoiding past mistakes and being able to control this deployment.

5   Concluding remarks

The renewed interest for the MES, viewed as a prerequisite of digital transition, leads companies to deploy it to address both customer and manufacturing company expectations which are new. This paper presents some recommendations that should benefit to companies engaged in a MES deployment process; these recommendations are the contribution of this case study analysis and they invite companies to consider both BPM and agile BPM as a means for assisting them in their MES deployment processes.

Very few similar works address both BPM and MES deployment in a manufacturing company. Based on our study and analysis, we believe that agile BPM for MES deployment may be a new trend for digitally aware manufacturing companies. In this perspective, some prerequisites are necessary: (1) the manufacturing company is aware of BPM and agile methods, (2) the MES software editor has to be implicated in the MES deployment process, and has agreed to act as a very close partner in an agile spirit; (3) manufacturing company is ready to move forward to a less hierarchical organization, encouraging collaboration and task sharing between teams, and (4) manufacturing company employee positions are involved, with more autonomy and responsibility. It is then challenging to consider and manage both the needs of flexibility in processes and organization, and the needs of process standardization.

contribution to the NTN-SNR deployment process, BPMN modeling and NTN-SNR employee interviews.

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8

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