Increase collaboration through a new software: the case of the MRO process in Avio S.p.A.

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ABSTRACT

The increasing competitiveness in the global market has lead aerospace company to re-formulate their business model looking to enlarge their core business and increase their competitiveness. Companies have, thus, to improve their processes and guarantee high standard of reliability and efficacy. The Maintenance, Repair and Overhaul (MRO) is an important process for the aerospace sector and requires high level of specialization and management of modules and components to satisfy customers needs and to work in accordance with the international policy and law. The actual study is based on an action research realized by Università del Salento and Avio S.p.A. to improve the company MRO process applying the Business Process Management Methodology and developing a new software. Changes in competitive scenario has lead Avio to improve and support its MRO process and in accordance with Università del Salento have applied BPM to reach higher performance. The realized software integrate different standards in a new framework to support MRO process in aerospace companies. It is based on a J2EE platform, integrates Intalio EE and uses a BPEL engine. The libraries and the front-end tools are open sources. Steps and results are described in the paper.

Keywords:
Maintenance Repair Overhaul (MRO), Business Process Management, Business Process Modeling Notation (BPMN), Tracking system, Workflow engine, BPEL, Six Sigma.

1. INTRODUCTION

The nowadays increasing competitiveness has introduced, the necessity to focus the attention on performance of the enterprise and costs reduction. To lead the company to improve their performance reducing the related costs, organizational and operational aspects of companies are analyzed and re-designed. This appears a relevant need and a common practice in high technological industry such as aerospace.
The aerospace product development involves many actors with the aim to better manage the product complexity and to share costs and risks that avoid a single company to realize a whole product (i.e. a whole aircraft but also module such as the engine). The aerospace products and related modules are complex one [1] since are composed by many sub-parts, customized, with a long product life and high cost of development [1]. Their complexity is also visible in the maintenance repair and overhaul (MRO) activities since requires high level of specialization and the management of many modules and components together with the need to satisfy the customer and to work in accordance with the international policy and law.
Maintenance, repair and overhaul (MRO) is a key process in the lifecycle of an aircraft and of its engine. It is necessary to maintain the systems in a safe and functional condition, so that they can fulfill the operational role that they were designed for. The maintenance process includes regular inspections during the life of an aircraft. The inspection schedule of an airplane varies from checks before each flight to a complete disassembly for a detailed inspection requiring a well organized system that brings together manpower, spare parts and equipment for each maintenance type.

Starting from an action research study [2] the paper wants to describe the technological solution developed to support the MRO process inside an Italian aerospace company: Avio S.p.A.
The action research has been done by a team composed by members of Avio and Università del Salento.
Avio is leader in the development of subsystems and components, mainly turbines and gearboxes, for military and civil air-engines. The acquired technological competences in the sector make the company an accredited and reliable partner for the major OEMs (Original Equipment Manufacturing), such as General Electric, Honeywell, Pratt & Whitney and Rolls-Royce. The company participates with "design responsibility" to the main national and European programs, as the EJ200 for European Eurofighter-Typhoon, and represents an excellence in the propulsive systems with solid and liquid propellant, realizing the 16% of Ariane 5 European launcher.
Avio is very carefully to continuously improve their process also through ad-hoc internal company project such as Cartesio, leading the adoption and application of Six Sigma methods.
In addition to the activities of sub-systems and components realization, Avio works also in the MRO sector for military engine. This activity is done in the plant of Brindisi in the South of Italy and it has been the focus of our study.
In the last years, the core business of Avio in the MRO sector is changed from a "single customer" (i.e. the Italian army) to "many customers" (i.e. 30 customers) distributed around the world and characterized by own policy in the management of the revision activities and of the related agreements. This situation has matured the need to introduce and apply a software application able to track all the MRO activities and to manage all the related objects such as time, issues and planning activities.
As a process the MRO has been analyzed with the use of the BPM methodology that has lead insights and requirements for the software development. The aim of the paper is to describe the followed steps and the software framework that combine different standards in an new and appropriate structure for MRO in the aerospace sector.
The paper is structured in three further sections. Section two introduces some background definition useful to understand the main concepts related to our study. Section three contains the results of our study and describes phases and solutions applied. Section four concludes the paper and treats the main implication of the obtained results.

2. BACKGROUND

The activities performed in a company can be grouped in processes that allow to order the work activities in the time and space and to specify input and output and the related links. A business process is, in fact, a set of activities performed to obtain an output for a specific customer internal or external to the company [3]. It takes one or many types of input to create the output [4].
A business process is composed by different objectives characterizing its work: the resources, the goals, the constraints, the actors/organizational units and the activities. Resources are the set of input used to perform the activities and reach an output, they can be material and immaterial resources. The goals is the aim for which the process exist and it can be express in terms of desired output. The constraints are condition of different nature that limits and guide the execution of a process (e.g. budget, time). The actors or organizational units are who execute and participate to a process and usually they are the owner of one or more activities. Finally, the activities are the sub-parts of a process and all the set of activities allow to reach an output.
Based on the process classification of Porter [5], processes can be primary and support ones. Primary processes contribute to the core business of a company and create relevant value (e.g. inbound logistics, operations, outbound logistics, marketing and sales and service). Support processes are instead related to the core processes and support their execution and management (e.g. procurement, human resources management, technology and firm infrastructure). Processes are shared between primary and support ones based on the type of company and its core business (i.e. a process can be of support for one company and primary of another one). A further classification of process done by Davenport (3) distinguishes between operational and management processes. Examples of operational processes are product development, customer acquisition, production, integrated logistics, invoice management and after sales. Examples of management processes are performance measurement, information management, human resources management, planning , asset management. The Maintenance Repair and Overhaul process is for Avio S.p.A. a primary and operational processes directly correlated with the company core business and on the creation of value for its customers.
Processes need to be managed in order to meet the required performance but often process fail for errors in the design or execution that lead to inadequate performance [4]. To manage company processes, the business process management (BPM) is one of the most appropriated and used methodology. BPM is a methodology "supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents and other sources of information." [6]
The BPM aims to allow to the individuals to control the process and quickly respond to the internal and external changes [7].
It requires the development of the BPM life- cycle [6][7] through 5 phases:

- *Discovery*. It means to understand how the process works with tools (e.g. interviews, as-is process modeling) that allow to explore the process. Metrics are also used to evaluate the process performance and to discovery gaps that need to be eliminated.
- *Design*. It aims to create the to-be workflow of the analyzed process. The to-be is modeled specifying resources, constraints and participants to the process. IT solutions useful to improve and monitor the process are proposed and developed.
- *Execution*. In this phase, the new process is run-up following the guidelines emerged by the design phase in terms of resources, constraints and participants and ad-hoc IT solutions.
- *Monitoring*. It aims to evaluate the performance of the to-be process and a set of metrics are applied to evaluate the performance of the improved process.
- *Optimization*. It aims to solve the weakness emerged from the monitoring phases through a set of actions that could lead the re-start of the lifecycle.

To enable the application of the BPM, IT systems play a fundamental role since permit to support and control the processes [7]. Business process management systems (BPMS) are "a class of software that allows organizations to devise process centric information technology solutions" [8]. Those solutions need to integrate people, systems and data related to a process impacting on the organizational capabilities [8].

BPMSs are developed or improved in the Design phase of the BPM lifecycle and are based on the to-be modeling of the analyzed process. They have the advantage to be developed reflecting the process owner needs and it is very closer to its way of work and needed resources. The business process owner are, thus, directly involved in the design of a new BPMS [8]. In fact, during the performed action research Università del Salento have worked with Avio to realize a software that reflect the work activities and needs of the process owners in order to reach the best results from the whole system.
Therefore, BPMS allows to guide the execution of a process looking to its workflow and activities and to the resources involved.
Furthermore, the application of BPM in a company can come together with other methodologies of process improvements such as Six Sigma. For Hammer [4], Six Sigma is an avatar of BPM since both of them are based on statistical process controls [9][10]. The integration between Six Sigma and BPM it is usually a successfully initiatives that enable to combine the potential of both methodologies to manage and optimize processes [11]. Six Sigma aims to understand the process variance and to reduce errors in order to increase the reliability of the process and satisfy key objectives. Six Sigma requires to gather data and to make controls that are used for different analysis. This aspect is the most important contribution for BPM since it wants to understand the most critical process and solve critical aspects [11]. Therefore, through the combination of the two methodologies, a wide set of analysis are executed on the most critical process for a company. Based on the experience of Avio in Six Sigma application, this integration is also visible and treated in our study.

3. RESULTS: BPM IN THE MRO PROCESS

This paragraph describes each steps of the used approach and the mapping between Six Sigma and BPM methodologies.
The principle at the base of MRO project recognizes that BPM and Six Sigma approaches run as parallel initiatives to realize a competitive advantage. The SS methodology, already used in Avio, is more focused on which processes are the top priority for the business and which problems are the most critical to solve. On the other hand BPM is more effective about task control, activities automation and data gathering. Common points are about analysis of current processes and quality improvement of themselves.
So an integrated methodology has taken advantages from both approaches.
Figure 1 summarizes the mapping between DMAIC[1] cycle used for Six Sigma methodology and BPM.

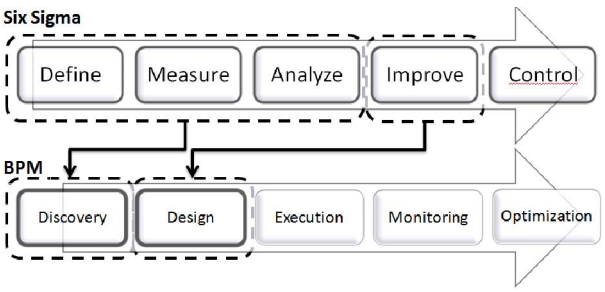

Figure 1: Six Sigma and BPM application in process redesign

[1] DMAIC: Define, Measure, Analyze, Improve, Control

Discovery
The first step in the analysis of existing procedures is the information-gathering, developed through a sequence of interview, aimed to derive key competences for the success of the project. *Tacit knowledge* is very important, more than standard procedures, and on it a great amount of time has been spent, it belongs to the core of sustainable competitive advantage [12].
Acquired knowledge has enabled modelling of existing process and has provided the guidelines to define Key Performance Indicators (KPI).
Used KPIs are cross-sectional in both process and Enterprise's functional areas. All these indicators have been defined for evaluation process's performances, compliance with Enterprise's policy, suitability of the system to satisfy operational requirements, quality of communication between various actors of the process, availability and usability of information required for execution of process. Analysis of results, coming from various measurements, underlines weakness and strength of the process and detects phases and tasks upon which focus the efforts.
These three phases of Six Sigma approach find their natural location in the first phases of process improvement, i.e. AS-IS analysis (Figure 1).
This derives from the definition itself of the first three steps that belong to Six Sigma methodology. In fact they concern about identify the process/product to improve, definition of current performance level and key elements that influence it. Like so the Discovery phase of BPM methodology traces out the same targets.

Design
After preliminary study of AS-IS, Design phase has been started for improvement of MRO process.
Changes have been made to the flow of the process, to the course of some main tasks, to their time sequence and to the nature itself of some activities; a change of information flow has been required in order to improve performance indicators and process's quality, in the perspective to re-engineer all the workflow according to the "Design" step of BPM methodology, like so the "Improve" phase of Six Sigma.
The new MRO process , with all its changes, has been modelled according to BPM philosophy.
Business Process Modeling Notation (BPMN) is the process modelling notation chosen for formally description of MRO process; BPMN is a graphical language widely used in both open-source and proprietary workflow engine software. Design phase is structured in two consecutive steps.
At the beginning, when workflow engine for running process was not yet chosen, a first release of process's model has been developed, without task for interaction tightly coupled with to support information system, then the selected system for the execution of the process is Intalio BPMS EE 6.x. Selection *iter* between various available systems and benchmarking are not discussion topics.
Workflow engine selection opens the way to model all functional facets and tasks for inter-system communication.
Because of the complexity of the process and the hard work to carry out, development and release of system have been partitioned in three sequential phases, with the intent to introduce change gradually, test *in itinere* its effectiveness and optimize development management. The three phases are identified and classified as: receive and storage, overhaul, shipping.

Figure 2 underlines operational *iter* followed in development and release. First thing "receive and storage" phase has been developed and released, and then two parallel activities has been executed: development and release of second phase (overhaul) and execution, monitoring and improvement of first phase.
Similarly, after release of phase two, third phase (shipping item) has been developed and, at the same time, execution, monitoring and improvement of both first and second phases have been carried out.
This approach enabled to put on trial the system directly in the operational environment and to modify and improve a very complex system before its final release.

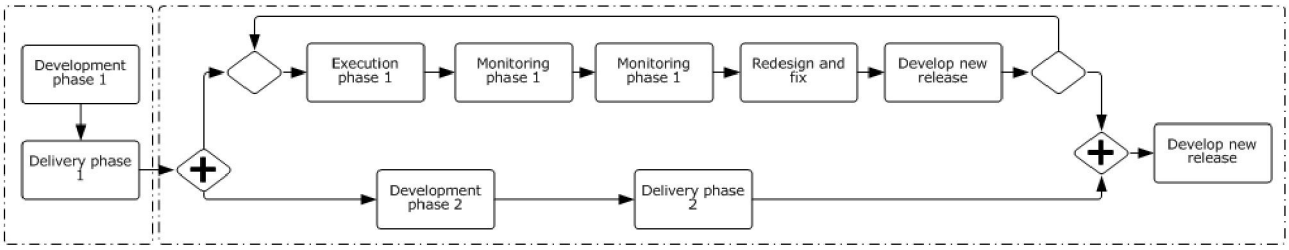

Figure 2: Development process

Execution
After the model has been designed, the execution phase started. Process's steps were very complex to manage as a whole and subdivision described in previous paragraph was very useful, because it reduces the complexity of the system.
Without the help of a workflow engine this step should be very difficult to perform, but Business Process Management System (BPMS) allows an easy automation of process execution. BPMS enabled a controlled execution of MRO process, driving all involved actors in their tasks, reducing decision-making in human interaction and improving communication and exchange of information.
Another important aspect in execution phase is the "Push mode approach" used drive users. In fact there are two parallel ways in our system for notify user his own task:

- worklists displayed after login (pull);
- email system which notify directly by a personal message as soon as the task can be performed (push).

Execution phase started with an initial training time provided to each involved division. The work-shadowing introduced all users not only to use the system but also to take part in the change in progress into the Enterprise.

Monitoring
Process changes musts be correctly implemented and this need can be ensured by a close monitoring phase. In our project monitoring has been performed in each step (receive and store, overhaul, shipping item) and then, in the final release.
This subdivision has enabled monitoring on a great number of sub-tasks, Enterprise division and involved users and, at the same time, has focused attention without lose the way in the width of the system.
Actually monitoring phase is running yet on the completed system, after release of last phase (shipping item). While in development phase monitoring has been used for test effectiveness of the system, in final release it provides information about process efficiency and performances, system and divisions of the Enterprise. It is a long term task integrated in both process and system and has already provided several information to optimize a great number of tasks in the designed process.
Thanks to monitoring, MRO system performed all the following points:

- Management of task and information upgraded in pull/push mode;
- Case management;
- Centralized workstop management;
- Quick centralized visualization of all items, before and after maintain and repair operations;
- Periodic controls management;
- Dashboard;
- Planning management;
- Operational time management.

Optimization
After the software was developed and released, optimization phase starts with the aim to improve the system and add other tools:

- Administrator's advanced functions;
- Business intelligence dashboard;
- Improved interaction with other systems.

While advanced function are mandatory, dashboard and improvement of communication with other system has been explicitly required.
Dashboard, wanted by top management, is necessary to easily measure process's performance; integration with pre-existing systems has been required by officers of many different departments, in order to reduce the need of communication between various departments. It has been realized including the management of information and functionalities that, at the beginning, were not pertinent to the project and were separately managed.

Software Architecture
Process tracking system has been realized through the integration between workflow engine and Java customized web-based application. The first one controls process advancing, according to BPM schema, using a BPEL-based philosophy. It manages the automated steps of the process performed by web services.
The second one provides both the entire support for user's actions (i.e. for all not-automated step of the process) and automated batch processes for data acquisition. Interaction between these two distinct modules has been performed by web services.
According to the need to integrate tracking system into the Information System of the Enterprise, the interaction between new and existing modules has been carried out without a direct access to information and data, but using web services based communication and a common repository.
New developed modules are :

- Intalio Process Manager (release 6.x) – workflow engine for execution of business process modeled in BPMN and stored in BPEL;
- Web Application J2EE – Web front-end and batch process;
- REALM – J2EE compliant service for definition of roles and hierarchy;
- Application DB – database for web-application data;
- Intalio DB – database for workflow engine data.

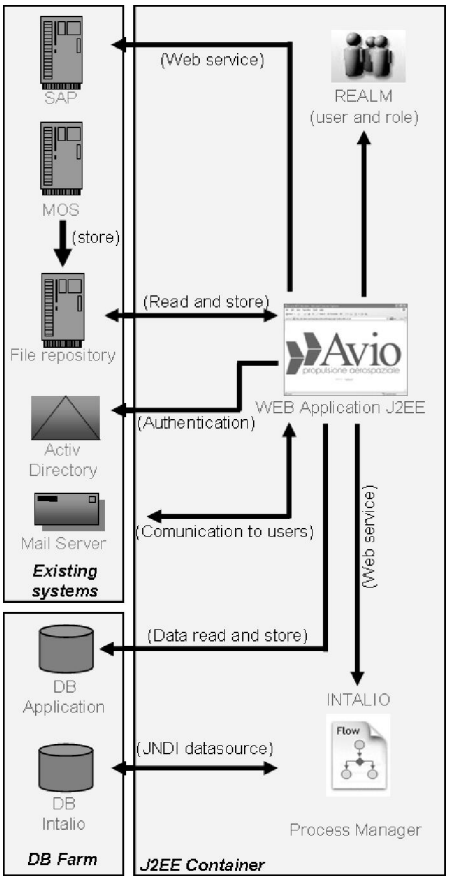

Figure 3: System overall description

All Java components (complying with J2EE 1.4 standard) operate on the same container (Tomcat 5.5) running on open source Linux platform; front-end access can be provided through IE6.0 or later; DB management is assigned to already existing server farm.

Already existing modules which interact with web application and workflow engine are:

- Active Directory – provides the authentication of users;
- Mail Server – used for communicate with all users involved in process, at any level;
- MOS – tracking system for low level detail, it contains all information in a specific part of the process. Communication between MOS and web application requires files repository because of the great amount of exchanged data and because of the data mining required operation.
- SAP – high level business management system.

4. CONCLUSIONS

In the described results, we have modelled the MRO process and developed and executed a Workflow Engine for this process within an aerospace company. To support the process management and the software development we have combined the BPM methodology with the Six Sigma approach.
The first task, analysis according to BPM approach, was very critical for knowledge–gathering, indeed standard procedures are not completely enough for enterprise processes' modelling because of not standardized procedures at bottom and middle level in the organization.
Final process's modelling (Design phase) was realized after choice of Workflow Engine, in respect of guidelines of Intalio Design and Engine. Development was divided in three phases for gradually apply, test and improve the system. After the first release, the execution of system enabled receiving of user's feedback for improvement of the system. So the steps 'execution', 'monitoring' and 'optimization' of BPM approach was realized for each singular phases. After final release, execution, monitoring and optimization concerned the complete system, without the early subdivision in three different sequential phase.
The proposed architecture can be applied also by others company in the aerospace sectors with the same issues and needs of Avio and the described BPM lifecycle phases can be used as reference from same or related studies that aim to improve company process applying BPM methodology.
The Workflow Engine is currently used inside the Avio plant of Brindisi by 100 employees and satisfies with success the following goals:

- Track more than 17 engines models and versions;
- Manage overhaul activities on articles of more than 30 customers;
- Identifies and solves bottlenecks;
- Turns bottom level's tacit knowledge into standardized and traceable procedure;
- Simplifies the monitoring phase through a real time dashboard;
- Improves the information flow between different divisions;
- Optimizes the workforce management;
- Optimizes the planning;
- Reduces the overhaul time.

Therefore, through the MRO tracking system is possible to identify process issues, to fast resolve them and to generally improve the time required for necessary activities.
This system has been the first company action towards a set of changes and improvements in organizational processes. Others actions are planned as also new functionalities for the workflow engine that will be carried out by the team of Avio and Università del Salento.

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