A new maintenance management model expressed in UML

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ABSTRACT: This article shows part of the process of designing and modeling a new maintenance management model completely aligned to the quality management standard ISO 9001:2008 and expressed using the Unified Modeling Language (UML); the features of this modeling language gives the possibility of easily integrate the maintenance process into the general information system of an organization and to create a flexible structure to adapt it to new necessities. This article begins describing the suggested new maintenance model and the methodology used to design it; next are exposed some important concepts about processes modeling and then some of the modeled diagrams are presented: the general architecture, the goals tree diagram, an specific process (Control & Improvement) and a state diagram for the Maintenance Work Order. This paper finishes with the conclusions and the references used during the research.

1 INTRODUCTION

Maintenance has been experiencing a slow but constant evolution across the years, from the former concept of “necessary evil” up to being considered an integral function to the company and a way of competitive advantage.

Since approximately 3 decades, companies realized that if they wanted to manage maintenance adequately it would be necessary to include it in the general scheme of the organization and to manage it in interaction with other functions (Pintelon, 1992).

In this way implanting a high-quality model to drive maintenance activities, embedded in the general management system of the organization has become a research topic and a fundamental question to reach the effectiveness and efficiency of maintenance management and to fulfill enterprise objectives (Prasad, et al. 2006).

On the other hand it is known that for a significant number of organizations every activity or important action realised has its reflection on its information system; it means that the enterprise information system is a basic element to consider for the implementation of a maintenance management system. In fact, the most desirable situation is the complete integration of the maintenance management operations into the general information system (Vanneste, 1995, p.248).

To deal with the mentioned integration, this investigation proposes the uses of the BPM (Business Process Management) methodology, which aim is to improve the efficiency through the management of business process that are modelled, automatized, integrated, controlled and continuously optimized (Object Management Group, 2008). This involves managing change in a complete processes life cycle.

Using BPM methodology it would be possible modeling a particular maintenance management process and afterwards “connect” this model with a general information system. In this way, it would be created a flexible management process that if it needs to be changed to adapt its activities to new necessities, it will be quickly and even automatically modified into the enterprise information system (Framinian, 2007).

This article shows part of the results obtained in the process of designing a new maintenance management model (MMM), completely aligned to the quality management standard ISO 9001:2008 and also expressed using UML.

2 MAINTENANCE MANAGEMENT MODELS

In the historical development of maintenance, diverse authors have proposed what they consider the best practices, steps, sequences of activities or models to manage this function. To begin with this investigation it was done a bibliographical search covering the analysis of some different maintenance management models developed since January 1990 until February 2008.


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A special mention is for the Publicly Available Specification PAS 55, published in April 2004 by the British Standards Institution (BSI) which covers the requirements for good asset management. The model appearing in this standard was also considered for the accomplishment of this investigation.

From the analysis of the mentioned maintenance models (comparing them between them and with the ISO 9001:2008) were identified the elements and desirable characteristics for a new, modern and efficient MMM. These elements are: input-output processes approach, clear methodology of application, generation of documents and records, objectives entailment, incorporation of support technologies, orientation to operate in computer maintenance management systems (CMMS), flexibility to adopt modern technologies (e-maintenance, expert systems, etc), management of material, human and information resources, focus on the constant improvement, cyclical, among others.

All these elements were considered for designing the new MMM. In addition it is important to mention that the model proposed in this article results from its real life application, improving maintenance management schemes in several Spanish companies. This means that an initial validation of the model comes from its practical origin.

Another interesting observation from the real life experience is: although some of the ERP that currently exists in the market have maintenance modules, there are several functions that can be still added to improve the maintenance management.

This proposed new MMM includes those particular functions as novel specific techniques for the maintenance performance. These techniques are described (using use case diagrams, sequence diagrams, object diagrams and other artifacts) in the more profound levels of the new MMM, although in this paper we do not refer to them in detail.

3 NEW MAINTENANCE MANAGEMENT MODEL PROPOSED

An important characteristic of the proposed new MMM is its relationship with the ISO standard 9001:2008. This standard is chosen since it is the international reference for any quality management system, which turns into a generic guide for a process operation in which fulfillment with requirements should be demonstrated, such as the case of the maintenance function. In the same way, PAS 55 offers valuable information about the maintenance management process. The general operation of the new MMM is presented in Fig. 1.

The model begins and finishes with the requirements and satisfaction of the interested parts, here called stakeholders using the concept proposed by Soderholm, et al. (2007) and that is in line with the expressed by the ISO 9004:2008 standard. Also this model is designed to be efficiently used across the organization levels (reminding Pintelon and Gelders (1992) who proposed a model to be executed in three organizational activity levels).

This model is made up of four modules or macro-processes, each one containing inside several processes that are specified in sub-processes and tasks. The four macro-processes are Planning, Support, Maintenance Execution and Control & Improvement. The Planning macro-process is conformed by three processes: Long term planning, medium term and short term planning.
term. The Support processes are: Human resources management, Spare parts and materials management, Infrastructure management and Information management. The Control & Improvement macro-process is composed by Measurement & Assessment process and by Improvement process.

It is to be noted that planning (long term) entails the top Direction of Maintenance. The medium levels perform the support processes and control the maintenance execution. The level that executes maintenance also generates data to be used in the continual improvement of the maintenance function.

In the same way, the structure of this model makes possible the existence of a link among the maintenance function and the other organizational functions.

Into the model proposed, each one of the processes (planning, support processes, maintenance execution and control and improvement) is defined by UML diagrams using the “Eriksson-Penker Business Extensions” that indicate the sequence of activities for the execution of every stage.

Regarding information standards, there is an important not-for-profit trade association dedicated to developing and encouraging the adoption of open information standards in operations and maintenance (O&M): MIMOSA. The Common Conceptual Object Model (CCOM) provides a foundation for all MIMOSA standards, while the Common Relational Information Schema (CRIS) provides a mean to store enterprise O&M information. MIMOSA also provides metadata reference libraries and a series of information exchange standards using XML and SQL. Our model can be considered a management reference model, i.e. describes the processes and the information flows required to properly manage maintenance. Then, this MMM is therefore linked with MIMOSA. In fact, all O&M information handled by the proposed model can (should) be structured according to MIMOSA standards (for instance), although this subject is out of the scope of this paper.

4 MODELING A BUSINESS PROCESS

Business process modeling has been used in industry since the 1990s to obtain a global vision of processes by means of support, control and monitoring activities (Russel et al., 2006), to facilitate the comprehension of the business key mechanisms, to be a base for the creation of appropriate information systems, to improve the business structure and operation, to show the structure of changes made in business, to identify outsourcing opportunities, to facilitate the alignment of the information and communication technologies with the business needs and strategies (Beck, et al., 2005), and for other activities like the automatic documents processing (Kalnins and Vitalins, 2006).

Nevertheless, during the last years, the research in this field has increased enormously and with it and the applications of the technology advances, business process modeling has been used in fields as diverse as: planning of managerial resources (ERP), integration of managerial applications (EAI), management of the relations with the clients (CRM), management of work flows (WFM) and communication among users to facilitate the management requirements (Russel, et al. 2006) (Ramzan and Ikram, 2007).

Some benefits reported from the adoption of business process modeling are: improvement of the accomplishment speed of business processes, increase of the clients’ satisfaction, optimization and elimination of unnecessary tasks and incorporation of clients and partners in the business processes. (Pérez, 2007).

Software process and Business process present certain similarities, being the most common of them the fact that both try to capture the principal characteristics of a group of partially tidy activities that are carried out to achieve a specific goal. Now then, whereas the aim of a process software is to obtain a software product (Acuña and Ferré, 2001), the aim of a business process is to obtain beneficial results (generally a product or service) for clients or others affected by the process (Sharp and McDermott, 2000).

In fact, the origins of the different business process modeling languages are inspired in the software modeling languages; as well a computer approach defines modeling as the “designing of software applications before coding” (OMG), this approach has allowed the development of several languages and applications for code generation and processes automation, which have been notoriously increased in quantity and diversity specially during the last two decades.

There are a large number of business process modeling languages. In a general classification a modeling language can be graphical or textual (Xiao He, 2007).

Considering that the objective of this research is to model a new business process and that it is desired to work with a graphical representation, an analysis of the different options reveal that the better choice is using UML language; which is a standard maintained by the OMG (Object Management Group).

UML was created in 1997 by the called “three friends”: Grady Booch, James Rumbaugh and Ivar Jacobson, who put it to consideration of the OMG, being accepted as a standard since the same year.

UML is formed by nine kinds of diagrams that show a specific static or dynamic aspect of a system (Aguilar-Savén, 2004).

For this research the software chosen to model the system is Enterprise Architect 7.1, an UML analysis, design, documentation and project management CASE tool, including basic UML models plus testing, metrics, change management, defect tracking and user interface design extensions; developed by Sparx Systems. Enterprise Architect 7.1 was chosen because its features and its availability to support this research.

Using Enterprise Architect 7.1, the general steps to model the proposed MMM and that are shown in this article are: (i) definition of the business architecture, (ii) modeling of goals tree, (iii) identification of top value chain process, (iv) modeling of involved processes and activities, (v) tracing required UML.
diagrams to represent specific features of the system (i.e. state diagrams).

5 BUSINESS ARCHITECTURE AND STRATEGY

Figure 2 shows a diagram generated using the Enterprise Architect 7.1 software and that represent the general business architecture of the proposed MMM. This diagram contains the three principal categories defining the architecture: the Business Context (models of all involved stakeholders, mission and vision statements, business goals and physical structure of the business “as-is”), the Business Objects (a domain model of all objects of interest and their respective data), and the Business Workflows (business process drawing on stakeholders, structures and objects defined in the Context and Objects packages showing how these work together to provide fundamental business activities).

Generally the business architecture is organized hierarchically in order executives can observe how specific processes are aligned to support the organization’s strategic aims (Harmon, 2007).

Due there is not a standard to name the process levels, the proposed MMM has its own nomenclature to refer to its hierarchical levels.

Once defined the type of architecture to be used it is necessary to model the system goals as a part of the strategy.

In Fig. 2. General business architecture for the proposed MMM.

Due it is the design of a new system all the goals are of qualitative type.

For this MMM it is considered the main goal as “to improve continuously the maintenance system” and that it depends on the fulfillment of other three goals (identified by a dependency line): to decrease the total maintenance cost, to increase the assets availability and to attend properly the non conformances detected in the maintenance management system.

It is necessary to notice that the first two aims (to decrease the total maintenance cost and to increase the assets availability) are contradictory goals and are identified using an association line between them.

Also the fulfillment of each one of the already mentioned goals depends on another series of hierarchical goals (or sub-goals), which have to be totally or partially achieved, a tag indicates this condition.

The macro-processes, processes and activities described in the model are focused to the satisfaction of the objectives drafted in the goals tree diagram.

6 MODELING THE PROPOSED MAINTENANCE MANAGEMENT SYSTEM

The top value chain process of the proposed MMM (or Level 0 process) is conformed by the already mentioned four macro-processes: Planning, Support, Maintenance Execution and Control & Improvement. Subsequently each macro-process is conformed by processes (Level 1 processes) and each process is subdivided in sub-process (Level 2 processes), finally each process is subdivided in activities (Level 3 processes).

As an example of modeling, in Fig. 4 appears an UML diagram in which the Control & Improvement macro-process (Level 1) is modeled.

Every macro-process and process modeled has some invariable related elements: one or several goals associated using a dependence relation with the stereotype «achieve» (these goals are derived from the goals tree); input resources, output resources, both linked using dependence relations, supply resources with a
dependence relation and the stereotype «supply» and control resources having the stereotype «control».

The mentioned elements are visible in the diagram of Fig. 4.

Inside the macro-process of Control & Improvement there are some other processes (Level 2) and activities (Level 3). To represent them it could be used also an UML diagram or a more specific tool like a BPMN diagram, a simple flow diagram. That decision depends on the project specifications.

Finally Fig. 5 represents an UML State Diagram detailing the transitions or changes of state that an object (in this case a Maintenance Work Order) can go through in the system. This kind of diagrams shows how an object moves from one state to another and the rules that govern that change.

State charts typically have a start and end condition (Milestone Consulting, 2001–2007).

7 CONCLUSIONS

The maintenance model expressed in this work departs from an analysis done to a set of representative previous models, in order to have a new model constituted by the best characteristics observed. The modeling work has involved a research about some basic concepts (business process, modeling, modeling language, business architecture, etc.) to select the most suitable language and software tool for the particular case.

In this paper is presented only a significant part of the modeling process made about the proposed model. The MMM modeled is strongly inspired by the ISO 9001:2008 standard. A future challenge in this area could be the addition of elements derived of the PAS 55 as well as technical tools recommended to the operation of the maintenance function. Increasing the depth
Figure 4. UML Diagram of the macro-process of control & improvement.

Figure 5. State diagram of a maintenance work order.
of a particular process of the model and doing it more specific could add also its value. Code generation (with everything it implies) would be a subsequent objective for this maintenance model proposal and a good opportunity of applying it in a practical case.

REFERENCES


White, S. 2004. Introduction to BPMN. OMG.