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Aurélie Bertin, Daniel Noyes, Philippe Clermont

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BERTIN Aurélie*˒**. NOYES Daniel*.
CLERMONT Philippe*

* Laboratoire Génie de Production / INP-ENIT - University of Toulouse,
47, avenue d'Azereix, 65016 Tarbes cedex, France
** Saft Bordeaux 111, 113, blvd A. Daney, 33000 Bordeaux France
E-mail: Aurelie.BERTIN@saftbatteries.com; daniel.noyes@enit.fr; philippe.clermont@enit.fr

Abstract: Among the continuous improvement tools of the performance in enterprise, the experience feedback represents undoubtedly an effective lever of progress by offering important prospects for a progression in almost all the industrial sectors. However, several reserves to its use slow down the diffusion of its employment. We are interested in the installation of experience feedback system in a partner enterprise. In this paper, we propose an instrumentation of a Lessons Learned System (LLS) by problem solving methods (PSM) and its integration with a product lifecycle management (PLM). These proposals support an improvement of LLS performance and a facility of his application.

Keywords: Experience feedback, Lessons Learned System, problem solving method, product lifecycle management, continuous improvement.

1. INTRODUCTION

Application of continuous improvement principles in companies leads to the use of a set of methods and tools in order to maximize levels of productivity efficiency, product quality and cost reduction.

Problem solving methods that are basic mechanisms of the quality approaches constitute an important part of this set. They underline a high potential of possible improvement if companies succeed in being exempt from the weight of attendant formalism and requirements.

In addition, the consideration of Lessons Learned System (LLS) at several levels of business activity constitutes one of the surest means of increasing the product quality and efficiency. A lot of companies have adopted the LLS in their continuous improvement plan because they are concerned about prioritizing or preserving their immaterial capital.

Finally, still in this logic of continuous improvement, many businesses have chosen to deploy Product Lifecycle Management (PLM) solutions. The aim is to improve the management of the entirety data related to the product, the collaboration among several departments, the definition of the working organization, the formalization of exchanges in order to strengthen the decision making.

In partnership with Saft, leader in the design of high-tech batteries, our work focus is situated within this context, outlined as a "multi-approach" continuous improvement.

The overall objective of our work is to facilitate a LLS through problem-solving methods (PSM) integrated into a PLM system. Several objectives underlie the study.

First, the coupling LLS-PLM will facilitate the implementation of the LLS due to the dynamism caused (or forced) by the establishment of PLM system in the company.

Indeed, even if the interest in the LLS is apparent, it's often laborious to integrate the LLS into businesses.

Secondly, PSM-LLS coupling should allow the exploitation of analysis mechanisms and of reasoning involved in PSM. It strengthens the stages of LLS, notably during the activities of experiences acquisition and formalization.

Lastly, the support of the study is a practical framework of a continuous improvement project in Saft Company. This framework does not alter the generic nature of the approach because it can be reproduced in the shown form in most of the companies.

The paper is organized into four sections.

- Section 2 introduces key concepts of problem solving methods such as the generic framework and the defined Saft PSM methodology which allows to lead several methods.

- Section 3 is devoted to the first steps in achieving these methods and their connection to the LLS. Stress is put on the description of situations making up the experiments.

- Section 4 is dedicated to mechanisms implicated in the process of the PLM.

- Conclusion and perspectives are presented in Section 5.

2. PROBLEM SOLVING METHODS

2.1 Generic Framework

Problem solving is a continuous improvement process ensuring the processing and the resolution of negative events. This process carries out many well-known dedicated methods and tools in literature. As an example we can quote PDCA [Deming, 1986], fault tree [Mortureux, 2005], 5 why, PSDM, 8D…

Each method is made up from of a succession of stages ensuring a progressive processing from the problem description to the explicitation of the implemented solutions recognized efficient. The stages are of variables values according to the accuracy of processing and to the level of abstraction engaged by the method. Furthermore, the complexity level of these stages varies depending on the method strength (investigation spectrum, importance of engaged means, processing duration…). However we can generate a generic framework.

We identify four generic steps always included in any problem solving method. They can be found by aggregation or by discretization of the ones constituting the method itself. They are:

- (I) the problem definition, consisting of the event location, collection and description. It is a paramount step that allows firstly the identification of relevant data and the characterization of the problem in its context, then, the analysis of the problem, to the study of the recurrence and the appreciation of the problem complexity The choice of appropriate problem solving method to use, and the application scale of the implemented solution (sizing of current losses and assessment of return of investment) depends on this step.

- (II) the root causes research, aimed at the key elements identification leading to the negative deviation. This step consists in identifying relevant information and in guiding toward the root cause(s). It invokes very variables levels of complexity according to the needs and the disciplinary synergy required. Furthermore, identifying the root causes often follows an iterative approach.

- (III) the solutions design, aiming for the establishment and categorization, according to exploitable criteria, of curative actions (returning the item to a nominal level of performance) and sometimes of corrective actions (elimination of the root cause) to rectify/restore the work at the best situation. This stage focuses on the resolution objective, the ease of solutions adaptation, the risks reduction and the expected benefits.

- (IV) the action deployment, consisting in performing a choice between potential solutions and planning the necessary activities to implement the chosen solutions. Furthermore, several methods propose specific actions to capitalize the acquired experience.

The problem solving constitutes experience. The experience is clarified as the approach proceeds. The capitalization of created or collected information during the resolution will allow the record of all the necessary data used to process this experience, to finally lie a memory storing of formalized past experiences.

2.2 Defined methodology

One of the first choices made regarding the results of the problem solving method is the methodology taken. Its implicit for a team working systematically with the same method, but it comes often under an adaptation of the solving

methodology's "strength" to implement relating to the complexity related to the problem.

One of the major issues with the choice of resolution methodologies is the evaluation of the problem complexity which is only fully perceived during its resolution. So, it is sometimes necessary to switch to another most appropriate method during the process. Despite the multitude of methods and tools dedicated to the problems resolution, the literature doesn't propose any methodology, based on several levels of complexity, to switch during the processing from a simple resolution method to another more complex or vice versa.

Classically, possible scenarios are: i) to change the decided method during the resolution process, with the resumption of all the processing from a method to another more appropriate to the revealed complexity (figure 1: cases a, b,..., c), ii) to substitute during the process the not yet carried out stages by those of another suitable method (figure 1: cases d, e…).
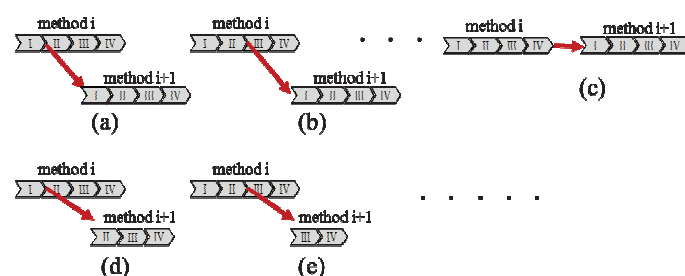

Fig. 1. PSM methods hanging.

In our working context (in Saft) we have developed and implemented a generic problems solving methodology. This methodology is based on Saft's best practices and it allows another approach combining the previous ones.

Established on a common basis related to the first generic stage of the PSM framework (cf. paragraph 2.1), Saft's methodology lets a choice between three completion modes to process the second, third and fourth stages, depending on the complexity level felt: elementary, simple or complex (figure 2).

Fig. 2. Saft's methodology of PMS.

We specify in a BPMN (Business Process Modeling Notation) diagram in figure 3, the constitutive elements of the methodology. Saft tackles a PSM beginning methodology where the grouping stage doesn't correspond to the PSM generic framework stages. This methodology cuts the "Problem definition" stage (I) into two activities leading to a gateway. According to the complexity, the decision leads to the more or less complex fulfillment or not of two major phases. These phases represent the remaining stages of the PSM framework, where the "Solution design" (III) and the "Action deployment" (IV) are merged as the last phase.

The basis of our LLS construction is the capitalization because it will be done both on the stages performed during the method and on its potential outcomes.
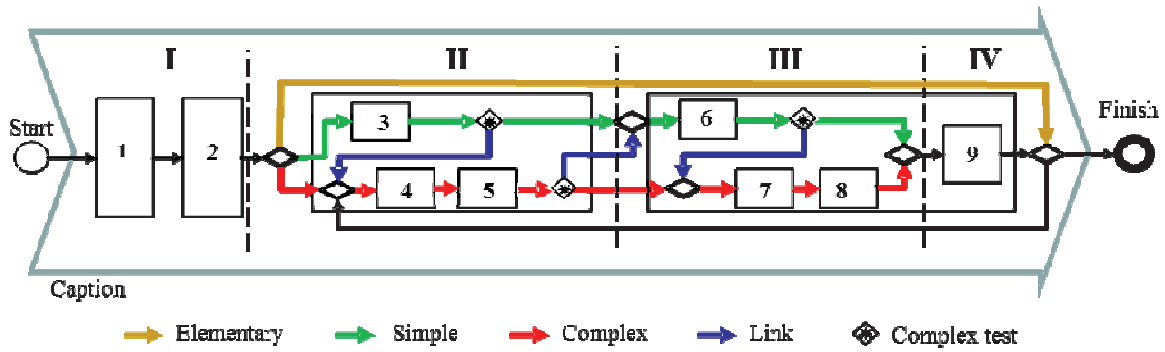
Fig. 3. Problem solving methodology established in BPMN.

Each step of the generic process is supported by basic quality management tools and working methods related to the specific needs. Some usual tools can be used at different stages of our methodology.

Table 1. Methodology instrumentation

Phase		Step		Method & tool
I	Description / Assessment	1	Storage	Dynamic Form 5 why Is/Is not
	Seriousness analysis/ Recurrences	2	Criticality analysis	Technical expertise
II	Causal analysis	3	(pre)analysis	5 why
		4	Detailed Analysis	Causal tree Brainstorming
		5	Selection	Pareto, …
III	Solutions search / Implementation	6	Proposal	Decision analysis
		7	Detailed search	Brainstorming
		8	Solution selection	Decision matrix Pareto
IV		9	Action plan	Project management tools

Since Saft's confidentiality must be respected, we cannot communicate about the tools used by our project industrial partner. Some basic tools, likely committed to various steps of the methodology, are drawn in the Table 1. These tools can of course be specialized according to the corporate culture and its needs.

At every stage of the methodology, the use of corresponding tools ensures to obtain sufficient information to continue into the next step. It provides factual decisions and adjusts the efforts of investigation and the analysis of complexity related to the current case.

3. LESSONS LEARNED SYSTEM

3.1 Generalities

LLS is a process involving strategies and practices used to identify, create, represent, distribute and make possible the adoption of experiences [Meiling, 2010].

Among several proposed definitions about LLS description, we consider the one of Rakoto [Rakoto, 2002] describing the LLS as "a structured approach to capitalize and exploit information coming from positive and/or negative event treatment. It carries out a set of human and material resources having to be managed in order to contribute to minimize errors repetition and favour some efficient best practices".

The LLS is composed of three main phases intended to build knowledge from the generalization of one or several experiences i.e., the response made to the occurrence of an event. (figure 4).
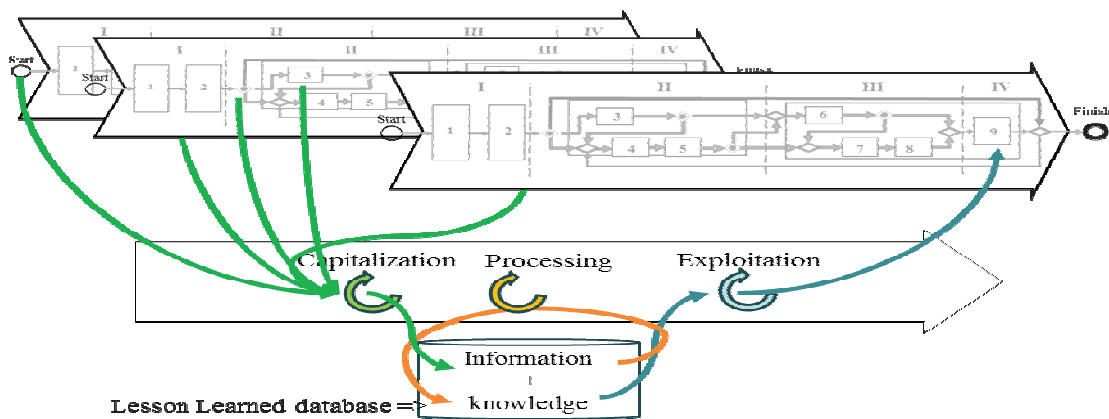

Fig. 4. Lessons learned system process

These three phases correspond to the action of:

- capitalization: location, collection and storage of relevant information related to the description of an event, the process mode and the obtained results. So, each treated event constitutes an experience,
- processing: knowledge creation based on the analysis of the recorded information,
- exploitation: use of knowledge and experiences to improve decision making during current process.

Of course, in our work, experiences are the problem solving as it has been described in paragraph 2.2.

Let us remind that a LLS is positive when it is committed to the identification and the enhancement of good practices. It is negative when used to resolve notable errors. Likewise, its scope is global when applied on the source process or local when the capitalized information is used by other processes.

Even if the LLS principles are easy to understand and its interest of use seems undeniable, its acceptance in enterprise is often restricted to difficulties. Some implementation features are often sources of conflict. According to the literature, the main implementation difficulties of LLS are:

- sociological and managerial, relating to the approach's impact on the actors: understanding of the approach, acceptance by the actors, adaptation to the new working methods ... [Parfouru, 2008],
- technical, relating to pitfalls often linked to the modes used for knowledge formalization (consolidation, structuring, interpretation…) and exploitation (access rights, modification…) [Dechy et al., 2008].

Finally, the LLS is an approach based on experiences capitalization, processing and usage of key information. These experiences can come from past experience or from current business processes. This approach ensures companies to improve their informational property: they can build knowledge on their own specificities about past business activities.

Despite the difficulties encountered during the implementation of such methods, the LLS has a strong added value to improve decision-making and continuous improvement of working methods.

Saft used LLS since a long time and was confronted to several difficulties. A specific study [Bertin et al, 2010] revealed the limitation of the tools and approaches dedicated on Knowledge Management (KM). This audit allowed us to establish Saft's needs i.e. a new solution of LLS compatible with its skills and working behavior.

3.2 Use of a PLM software

As part of improving performance, Saft Corporate initiated a PLM software implementation program (choice of Windchill® PDMLink). Our idea is to exploit the PLM functionalities and the strong sociological change framework to implement an efficient LLS.

PLM is a global software aimed at creating a collaborative environment including all the actors involved into the development cycle of a product. The PLM allows organizing and systematizing common and formal realization processes (called workflow) where the actors responsibilities, rights, roles are defined as input and output data of theses workflows.

Information logged in the common database of the PLM is defined as the repository which implements a structuration of data based on the use of metadata. The data provide information on individuals (objects), classes (all types of objects), attributes (properties of the object), relations (links between objects) and events [Chebel Morello et al, 2008]. This set of varied information is structured in a meta referential.

Applications experts, such as PLM software, correspond to different business needs of actors in the product life cycle. Their main target is to help to technical decision making. Indeed, these applications integrate all informational and technical data about the product during its life cycle [Pol G, et al 2008]. Through the management of these elements, product configuration and documentation, these applications provide a traceability of design process, and product data, and a partial traceability and monitoring of the decisions taken. At each step of life cycle, these applications can help the decision makers with the consistency of the information heritage of the product [Saaksvuori, 2004].

The PLM contains all of the informational references about the product, i.e. business data directly resulting from the experiences induced by the process life cycle. Through its mechanism, PLM is suitable to the integration of a LLS. It allows to automatically supporting many activities relating to capitalization, processing and exploitation. These intrinsic features of the PLM provide a non-intrusive LLS to the user because of its usage in the technical working software.

Thus, PLM tools allow to collect and to structure the generated information during developments, while orchestrating the making-up activities of this process.

It's interesting to use the already existing PLM tool to implement our solution. This is a strategic decision since the technical environment is already formalized and mastered and its actors are confident.

3.3 Relationship with the problems solving methods

Our goal is to deploy a LLS, on one hand, instrumented through a methodology of problem solving and, on other hand, included into the PLM system of the enterprise with the final goal to deal with the events inducing negative drift.

In the four problem solving key stages presented in § 2.1, we have identified the three phases of capitalization, processing and exploitation of knowledge and experiences of the LLS.

The phase of experience capitalization is easily identifiable at each PSM stage. It's in the one hand in the definition problem (I) like the description step of the event and on the other hand in the registration of the entire fieldwork's information collected and recorded in the tools. Thus, capitalization goes beyond the simple registration of the result by considering all

the significant information that describes the problem treatment:

- the complexity and criticality of the event,
- the selected resolution process,
- the identification of involved resources,
- the root causes and their justification (measures),
- the solutions designed and the ones selected,
- the actions of implementation and the planning,
- the recorded results and deviations from objectives,
- the tools and the controls carried out on the result to validate the solution.

Important added value of the LLS is the creation of knowledge; therefore capitalization must be organized in this sense, regarding both the results as the process and means involved to establish the results as the results themselves.

The LLS processing phase concerns the acquisition by the experts of the significant elements capitalized during previous resolutions to generate standards or rules for business processes. These treatments involve the intervention of experts able to generalize an experience in a specific knowledge… while ensuring overall compliance. This treatment can lead to: i) the creation of new knowledge or its update, ii) the creation or modification of technical data (updated technical documents after an expert reflection on a concerned field).

The LLS exploitation phase will allow the actors to directly use the experiences and the knowledge created in the processing phase by recovering the business rules and standards in a new development.

The actor will also be able to exploit this information to resolve the new problem. The method allows access to the capitalized information in the previous processes to study the similarity of a new problem. We can make this process closer to the case based reasoning approach.

Another important added value of our proposal lies in the addition, by use of a PLM tool, of an automated support to this generic methodology.

The objective is to operate the standard features of the PLM to operationalize the defined methodology and to manage in the referential of the enterprise, continuous improvement on the technical data related to the product life-cycle.

4. INSTRUMENTATION HELD BY A PLM

4.1 Changes management

The "Change management" is a standard workflow proposed by the editors of PLM process that, in the case of our study is based on the CMII© standard (Change Management Institute) [CMII, 2010]. The management of the changes is a standardized closed-loop process used to release new information. It involves a series of activities whose purpose is to manage and control all of the changes involved in the evolution toward a desired configuration. The Change management process consists of four interdependent macro-processes that characterize each phase of the change management (cf. figure 5):

- problem report (PR): description of the event by the actor which found the problem,
- change request (CR): description of the event and proposal of solutions by the business expert(s),
- change notice (CN): deployment plan of the solutions selected by business experts,
- change task (CT): statement of work for implementation of the change on the object.

Each of these four processes manages a type of identified PLM data characterized by attributes, involved in a workflow with a dedicated life cycle. The change process is managed by a combination of four change objects. All formally controlled information is processed through the standardized system of management that ensures proper validation, release and audit activities are conducted [CMII, 2010].
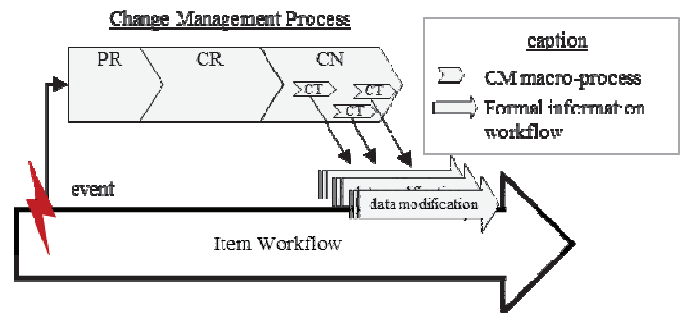

Fig. 5. Modification management process

The business process infrastructure elements are established and characterized by key attributes whose completion can come from:

- the PLM in an automatic way as, for example, information concerning objects related to the changes management or the information of the modification description transmitted from one stage to another,
- selection among drop-down lists for description or context information
- manual entry in the case of the additional information or comments,
- link to an external item to the PLM referential.

The contributions of the PLM use to "automate" knowledge management approach is presented in PLM10 [Bertin & al, 2010].

4.2 Overview of the methodology implemented in the PLM

The change management process is identified as a collaborative core business process [CMII, 2010] which integrates all of the data affected by a change of state: targeting data and process support. The four macro-processes <PR/CR/CN/CT> of the managing may be linked to the four problem-solving stages.

The similarities of construction and definition of management changes and problem resolution process are identified at the level of the formalism of the approach and the objective of the main activities. While the change management process is a series of development's data tasks, the problem-solving process is based on a series of reflections and analysis activities to obtain relevant information. Our proposal is to

include the methodological and reflection activities of the problem solving to the change management process to improve the latter. The basic requirements defined in this standard can be implemented as a manual process, however to achieve the highest levels of throughput and efficiency software tool will eventually be necessary [CMII, 2010].

This articulation PLM - LLS - PSM processes leads to the formalization of a generic problem solving model carried out by the Change Management Process of the PLM process. The inherent activities of the problem solving stages and integrating in the logic of Change Management Process are represented in figure 6.
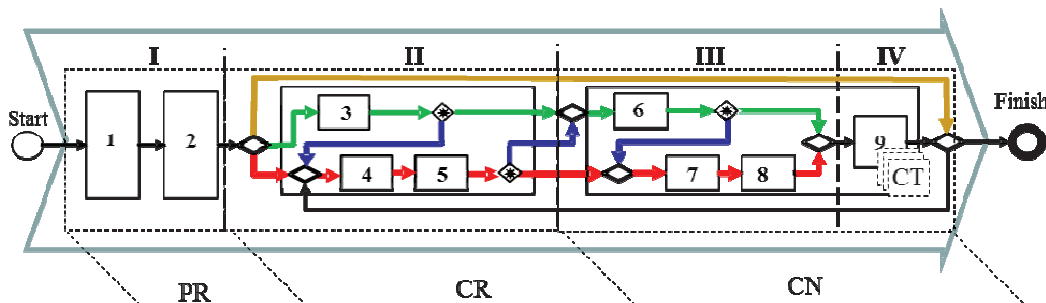

Fig. 6. Articulation between PLM management process and the defined LLS

Key stages of the change management can integrate tools and/or methods included in the problem solving methodology.

4.3 Experience feedback via LLS cards

The PLM allows us to capitalize information and experiences according to a predefined formalism. However, using metadata enables only the structuring and the containing of the information. The contents which is the core of any LLS, is not managed by the metadata. The establishment of a standard frame of statement allows the users to describe experiments using drop-down menus and terms or key elements, easily identifiable in the database.

Thus, we can establish LLS cards with the help of the reported information. They include the synthesis of the contents from the experience. This statement is carried out in an automatic way directly from the tool for recoverable PLM information and in manual means for additional information.

The LLS card processing is an integral part of the resolution process as it is initiated at the launch of the approach and then set in automatic fields. Also its completion and update represents a set of tasks of the solutions deployment plan.

Registered in the PLM base, this card remains to be linked to the objects affected by the change management to enrich the elaborated memory of experiences.

5. CONCLUSION

The theoretical benefits of the combined application of the PSM, LLS and PLM concepts are undeniable.

The first results that we have achieved in the development of the platform in industrial context have confirmed this interest.

In practice, the instantiation of the platform follows a three step approach: the modeling of the PLM field, the characterization of the experience feedback through knowledge management and the instrumentation of the PLM process of change management to bring the LLS

The last step is ongoing and will be followed by the effective operationalization of the platform.

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