Title:
Investigation into Current Industrial Practices relating to Product Lifecycle Management in a Multi-National Manufacturing Company

Authors:
Ismael A. Essop, I.Essop@greenwich.ac.uk, University of Greenwich
Richard D. Evans, R.D.Evans@greenwich.ac.uk, University of Greenwich
Shan Wan, shanwan23@hotmail.com, Nanjing University of Science and Technology
Muni P. Giddaluru, gm85@greenwich.ac.uk, University of Greenwich
James X.Gao, J.Gao@greenwich.ac.uk, University of Greenwich
David Baudry, d.baudry@cesi.fr, CESI/IRISE, Rouen, France
Sara Mahdikhah, s.mahdikhah@cesi.fr , CESI/IRISE, Rouen, France
Mourad Messaadia, mmessaadia@cesi.fr, CESI/IRISE, Rouen, France

Keywords:
Product Lifecycle Management, Knowledge Management, Lessons Learned, Product Maintenance and Servicing.

DOI: 10.14733/cadconfP.2015.379-383

Introduction:
In today's modern business environment, where globalization and cross-region collaboration is required, Product Lifecycle Management (PLM) may be seen as crucial to underpinning corporate ability to meet customers' increasingly bespoke demands in a sustainable and competitive manner. PLM offers companies the capability of a framework to capture, store, retrieve, represent and re-utilize product and process knowledge in order to compete more effectively in today's knowledge-intensive Product Development (PD) environment [2]. PLM, however, is not solely a technological framework; it is seen to offer social and cultural dimensions which contribute to the strategy and competitive advantage of organisations.

PLM systems have gained acceptance for managing all information relating to products throughout their full lifecycle, from conceptualisation through operations to disposal. The PLM philosophy and systems, therefore, aim to provide support to an even broader range of engineering and business-related activities than merely PD. PLM was initially conceived as an academic concept to address the management of data, information and knowledge during product lifecycles, but subsequently has gained acceptance in industry to provide support to a wider gamut of business and engineering practices [9, 13]. Traditionally, product information has been organized and generated by various business functions in an organisation. Functional areas, such as design engineering, manufacturing engineering, supply chain management, sales and distribution, warranty and repair, and accounting all have information systems that reflect the needs of those independent functional areas [5]. The amount of data generated during PD processes is growing faster than ever before. For most aerospace, automotive and defense companies, to store data for 15-20 years is an absolute requirement but creates a big challenge. Sometimes data may be required to be stored upwards of 50 years [13]. To capture product information within an enterprise and between partner enterprises, united, robust and flexible data models are required.

An Industrial Investigation was conducted within a leading power generation manufacturing company in the UK between October 2013 and March 2014 and, for the purpose of this report, the organisation is referred to as 'the Company'. The purpose of the investigation was to gain an understanding of the Company's current practices and challenges in relation to: 1) Communication

© 2015 CAD Solutions, LLC, http://www.cad-conference.net

between internal colleagues and external stakeholders; 2) The Product Development Process; 3) ICT Tools currently used within industry to assist with PLM; 4) Knowledge Management and Sharing; and 5) Product Maintenance Management.

The methodology used during the investigation was informal audio-recorded face to face interviews lasting between 60 to 90 minutes. In total, 17 employees were selected for interview and participants included the Plant Manager, Maintenance Engineers and Assembly Line Operatives. Interviews were conducted on an individual basis by a panel consisting of two PhD students and one post-doctoral research fellow. The interviewers followed a standardized 7-part questionnaire, which asked participants a variety of open-ended and closed questions to identify the knowledge management methods, practices and tools employed within the Company; the findings relating to these questions are summarized in this paper.

The aim of this research is to report on the findings of the industrial investigation and propose a lessons learned-based system which could be integrated into the PLM system currently used by the Company.

Main Idea:

The implementation of PLM not only creates new processes and methods for future PD, but also deals with existing product information. It has been identified, through the investigation, that much information is generated at different stages of PD. In addition, product maintenance requires information and knowledge to come from the beginning of the product lifecycle. As highlighted, huge amounts of data already exists within companies which plan to implement PLM, hence appropriate tools are required to migrate this data and any future data to be organized in a systematic way which enables easier traceability, accountability and secure maintenance; this will allow the Company to address some of the common industrial issues and requirements.

Businesses have recognised that organisational knowledge has an essential role to play in responding to competitive pressures and, for an increasing number of companies, opportunities to establish competitive advantage lie in their ability to enhance ideas and intellectual know-how. By putting their valuable knowledge assets to more effective use, organisations can benefit from innovative PD breakthroughs and improved processes and practices. The formalized and facilitated processes offered by PLM encourage the sharing of knowledge between colleagues and external partners to establish a competitive platform which cannot be replicated by others. The Lessons Learned (LL) process is a key part of Knowledge Management; it is an activity where new knowledge is identified through activity and review and assimilated into future work practices. If an organisation can draw on the lessons learned from employee experiences and neutralize repetitive mistakes, then the LL activity should be given due consideration in New Product Development (NPD).

In order for knowledge sharing to be successful during the entire PD lifecycle, employees must be willing to collaborate with colleagues and their extended supply chain. It is recognised [6], however, that employee collaboration faces numerous barriers in the workplace, which are often due to social or technological factors. Firstly, employee trust is seen as a potential barrier when an employee is deciding whether it is beneficial to engage in collaboration or not, as often they fear that colleagues may take credit for the work they have previously submitted. There is also potential language or cultural barriers which inhibit employee collaboration in multi-national organisations or between collaborating entities; additionally, inconsistencies often exist in corporate policies in relation to employee collaboration, which can result in colleagues being unaware of the procedures and processes to follow when interacting with different sites or business units within the same organisation.

PLM is an integrated, information-driven approach comprised of people, processes, practices and technologies to all aspects of a product's life cycle, from its design through manufacture, development and maintenance, culminating in the product's removal from service and final disposal. By trading product information for wasted time, energy, and material across the entire organisation and into the supply chain, PLM drives the next generation of lean thinking. The goal of PLM is to digitally transform the life cycle that companies use to conceive, design, manufacture, service and improve product offerings; this enables companies to capture product information and knowledge and leverage it in an integrated lifecycle process that improves the efficiency of the whole product lifecycle from start to finish.

© 2015 CAD Solutions, LLC, http://www.cad-conference.net

The maintenance costs of general engineering products account for 15-60% of the total production cost, while high value and complex products, with long lifetimes, are experiencing the maximum percentage [16]; thus, the ability of quick maintenance process making plays an important role in improving maintenance efficiency and reducing maintenance costs.

Product Service Systems (PSS) are taken as an effective way to improve maintenance strategy creation and integrate information and knowledge from other stages throughout the product lifecycle [15]. PSS can be defined as "a system of products, services, network partners and supporting infrastructure that are economically feasible, competitive and satisfy customer needs; it offers de-materialized solutions that minimize the environmental impact of consumption" [4]. From research, new product models have been proposed to connect different lifecycle phases using semantic web ontologies to model product and service-related knowledge. E-maintenance is the concept of the "integration of Information and Communication Technologies (ICT) within the maintenance strategy and/or plan". It can be regarded as "excellent maintenance" or "efficient maintenance + effective maintenance + enterprise maintenance" [8]. In the work of Macchi and Garetti [6], e-maintenance was used to select maintenance policies for complex production systems. Computerized Maintenance Management System (CMMS) are software achieved by using ICT tools, based on e-maintenance concepts, which support the management of maintenance knowledge in industry [11]. However, in real life, large companies still encounter problems with regard to maintenance KM and process planning, because, from one aspect, huge amounts of data/information and knowledge have been generated throughout the long history of PD. Unfortunately, it is a challenging activity for maintenance engineers to find the right product information and even knowledge to meet maintenance requirements. On the other hand, engineers do the maintenance work mainly according to their own knowledge and experience, which makes it hard to find best practice knowledge; then, the current CMMS stores the maintenance knowledge, but the knowledge is not stored in a systematic way and is often hard to retrieve and reuse.

Since the 1990s, there has been increasing recognition that one of the most valuable resources owned by an organisation is its employee and organisational knowledge. Prior to the 1990s, Porter and Millar [10] suggested that the key to a company being successful was in the information it possessed. Nowadays, it is believed that employee knowledge is the key to corporate survival and growth; companies need to maintain and make better and more informed use of their employee, partner and organisational knowledge [3]. The results of the industrial investigation relating to KM included:

- During manufacture, a set of work instructions are produced detailing relevant knowledge in relation to the design, manufacture and assembly process for a complete product. This explicit knowledge is stored on an internal database, which is the first point of reference for operators working on the assembly line;
- It was reported that the company promotes a 'who you know' culture, whereby employees are encouraged to ask colleagues to share knowledge and, if that colleague does not have the required knowledge, ask if they can suggest someone who does;
- Employees confirmed that best practice knowledge is typically stored in spreadsheets and then made available via the touch-screen EASE system. Knowledge is occasionally input into accessible intranet sites, although this is not considered standard practice; and
- The Company does not currently have a standardized method for sharing knowledge relating to best practices, although employees commented that they try to make their knowledge as easy as possible to understand.

Many prominent Engineering organisations nowadays collect LL. The early pioneers of this initiative have been space agencies and military organisations. A significant part of the work related to simulated exercises, after which members were asked to describe what they learned and store this in generic or dedicated information repository. A number of researchers [4, 8] regard LL practices as building blocks of learning in the organisation and agents of knowledge creation; they allow the capture of individual and group experiences into organisational knowledge. Therefore, organisations need to have what Cooke-Davis [1] describe as an effective means of learning from experience on projects, that combine explicit knowledge with tacit knowledge in a way that encourages people to learn and to embed that learning into continuous improvement of project management processes and practices.

© 2015 CAD Solutions, LLC, http://www.cad-conference.net

The current PLM system used in the Company does not have the level of customization to capture LL during NPD. Currently, LLs are only captured at the end of a project and are typically stored in a unstructured way. Consequently, this information is unlikely to be reused during NPD. There is a need to analyze these experiences in an effort to create a feedback-loop to the development process. Since no feedback loop has been established in the Company, many engineers are unaware who may benefit from the insights and experiences captured. A design of a LL module will be proposed and this can be integrated into the existing PLM system; Figure 1 shows the proposed wireframe of the data entry form.

The schematic above is designed for the benefit of geographically dispersed engineers to enter meaningful information at different stages of the NPD project. Careful attention is given to the structure of the form, so that it will assist with the retrieval process later.

Conclusions:

From the industrial investigation, the areas of the PLM system requiring further customization were highlighted. A design for a LL module was proposed, which would have the benefit of capturing meaningful information during the different stages of NPD. With regard to KM, the investigation confirmed that the Company does not have a formalized method or computer-based platform in place for the capture, management and sharing of explicit employee and organizational knowledge; in future, it is planned to develop an integrated social computing tool to assist in this process. Finally, product maintenance processes were reviewed during the investigation and an e-Maintenance system will be developed in future to improve the product service management.

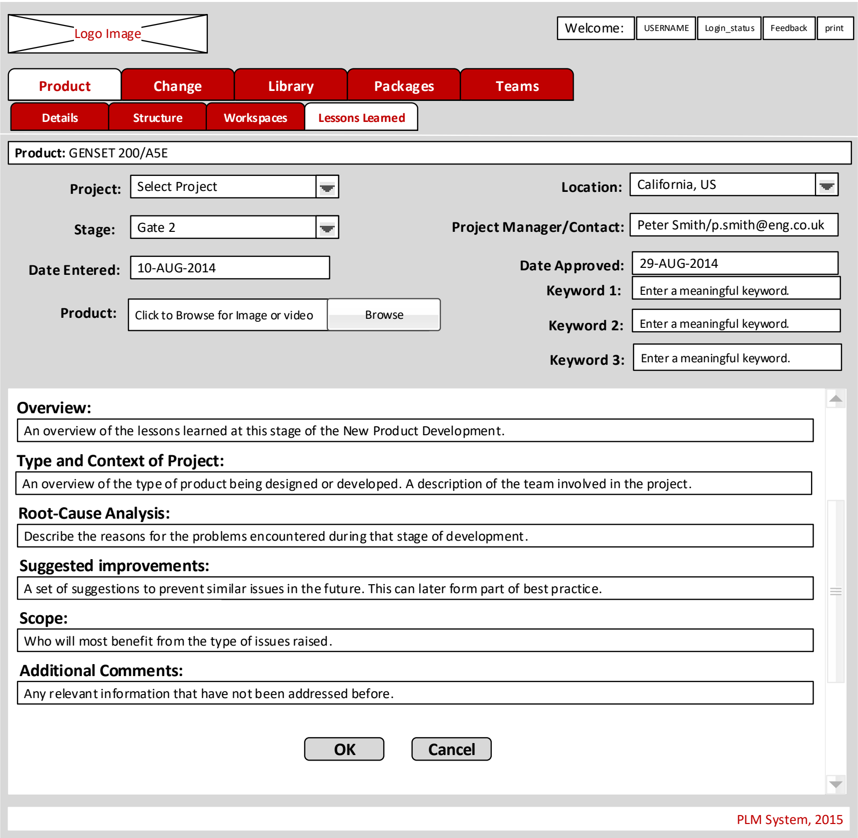

Fig. 1: Data Entry Form for Lessons Learned module.

© 2015 CAD Solutions, LLC, http://www.cad-conference.net

Acknowledgments:
The authors would like to thank all at the collaborating company for their support with this project and their input to the Industrial Investigation. This research is based on work funded by the European Program INTERREG IVA France-Channel-UK under the project entitled "Building an Expertise Network for an Efficient Innovation and Training System (BENEFITS)", under the INTERREG Programme France (Channel) – England, Ref 4177.

References:
[1] Cooke-Davies, T.: The "real" success factors on projects, International Journal of Project Management, 20, 2002, 185-190. http://dx.doi.org/10.1016/S0263-7863(01)00067-9
[2] Dutta, D.; Ameri, F. Product lifecycle management: closing the knowledge loops, Computer-Aided Design & Applications, 2(5), 2005, 577-590. http://dx.doi.org/10.1080/16864360.2005.10738322
[3] Evans, R.; Gao, J.; Owodunni, O.; Shah, S.; Mahdikhah, S.; Messaadia, M.; Baudry, D.: A Framework for Improving the Sharing of Manufacturing Knowledge through Micro-Blogging, in Advances in Production Management Systems, Innovative and Knowledge-Based Production Management in a Global-Local World2014, Springer Berlin Heidelberg, 19-26. http://dx.doi.org/10.1007/978-3-662-44739-0_3
[4] Goedkoop, M. J.; Van Halen, J. G.; Riele, H. T.; Rommens, P. J. M.: Product service systems, ecological and economic basics, Hague, The Netherlands, 1999.
[5] Grieves, M: Product Lifecycle Management: Driving the Next Generation of Lean Thinking, McGraw-Hill Education, 2006
[6] Macchi, M.; Garetti, M.: Information requirements for e-maintenance strategic planning: A benchmark study in complex production systems, Computers in Industry, 57(6), 2006, 581-594. http://dx.doi.org/10.1016/j.compind.2006.02.015
[7] Milton, N. Exploring the concept of organizational learning, KM Review, 11(4), 2008, 8-13.
[8] Muller, A.; Crespo Marquez, A.; Iung, B.: On the concept of e-maintenance: Review and current research, Reliability Engineering & System Safety, 93(8), 2008, 1165-1187. http://dx.doi.org/10.1016/j.ress.2007.08.006
[9] Pol, G., Merlo, C.; Legardeur, J.: Implementation of collaborative design processes into PLM systems, International Journal of Product Lifecycle Management, 3(4), 2008, 279-294. http://dx.doi.org/10.1504/IJPLM.2008.027006
[10] Porter, M.E.; Millar, V.E.: How Information Gives You Competitive Advantage, Harvard Business Review, 63(4), 1985, 149-160.
[11] Ramachandra, C. G.; Srinivas, T. R.; Shruthi, T. S.: A Study on Development and Implementation of a Computerized Maintenance Management Information System for a Process Industry, International Journal of Engineering and Innovative Technology (IJEIT), 2(5), 2012, 93-99.
[12] Shin, M.; Holden, T.; Schmidt, R.A.: From knowledge theory to management practice: Towards an integrated approach, Journal of Information Processing and Management, 37(2), 2001, 335-355. http://dx.doi.org/10.1016/S0306-4573(00)00031-5
[13] Stark, J.: Product Lifecycle Management: 21st Century Paradigm for Product Realization, Springer-Verlag, London, UK, 2005.
[14] Zedwitz, M. V.: Organization learning through post-project reviews in R&D, R&D Management, 32(3), 2002, 255-268. http://dx.doi.org/10.1111/1467-9310.00258
[15] Zhu, H.; Gao, J.; Li, D.; Tang, D.: A Web-based Product Service System for aerospace maintenance, repair and overhaul services, Computers In Industry, 63(4), 2012, 338-348. http://dx.doi.org/10.1016/j.compind.2012.02.016
[16] Zhu, Q.; Jiang, P.: An outsourcing e-maintenance system for improving maintenance of an industrial product service system, Applied Mechanics and Materials, 2009, 1077-1081. http://dx.doi.org/10.4028/www.scientific.net/AMM.16-19.1077

© 2015 CAD Solutions, LLC, http://www.cad-conference.net