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Challenges of information reuse in customer-oriented engineering networks

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ABSTRACT

Project-based engineering companies are striving for innovation acceleration, and lean supply and product processes throughout the product lifecycle. The business orientation of engineer-to-order companies is customer-centric due to the nature of engineer-to-order products, which are tailored and customized according to the specific requirements of each customer. However, this customer orientation may lead to inefficient performance, due to a lack of mechanisms to reuse proven concepts, designs and production facilities, as well as an absence of feedback mechanisms from products in use and service. These challenges have been recognized in earlier empirical research projects conducted in companies providing engineer-to-order products. Based on an exploratory study of the existing literature, this paper aims to identify factors hindering product-related information reuse in an engineering business environment that comprises several networks of actors during the lifecycle of engineer-to-order products. The main challenges of information reuse in an engineer-to-order context are related to reuse situations, which require combining existing information with experience-based knowledge. A typology of factors and challenges of information reuse is built, and organizational development needs at different organizational levels as well as further research needs are identified.

1. Introduction

The benefits and efficiency of using information technology systems in organizations are often justified with possibility of easy information reuse, which may also enable organizational learning (Hansen, Nohria, & Tierney, 1999). However, few existing studies deal with the different types of problems of information reuse that hinder the efficiency of information systems and organizational learning. While information is closely related to the use of documents and information systems, knowledge is tied up with human experience, interactions between people and ideas as a result of human thinking, and involves a combination of human and information systems (McDermott, 1999). This is why information reuse is such a challenging issue, one that requires specific expertise in an engineering business context.

Individual perspectives on the challenges of information reuse from different fields are scattered throughout the literature (Ahmed, Wallace, & Blessing, 2003; Ahmed, 2005; Boh, 2008; Brière-Côté, Rivest, & Desrochers, 2010; Demian, 2004; Goh & McMahon, 2009; Hicks, Culley, Allen, & Mullineux, 2002; Kankanhalli, Lee, & Lim, 2011; Markus, 2001; Wang, Johnson, & Bracewell, 2012). From a theoretical perspective, none of these studies attempt to construct a holistic view of the challenges of information reuse. In light of the limitations of earlier research, the major aim of this study is exploratory and focuses on creating an overall picture and proposing a typology of the information reuse challenges based on a review of the many different perspectives available in the literature. In the end, this will help to identify development needs and some potential solutions to the challenges.

From practical perspective based on research results (Mannonen & Hölttä, 2013; Tekes, 2012), it is clear that companies find information reuse problematic, given the high frequency of product related information requests, which can not be easily fulfilled. Consequently, it is often easier to construct new product designs and implement new supply processes as existing information is not easily available. This problem is especially prevalent in project-based engineering businesses which are typically forming engineering networks. Engineering

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network concepts have been developed in knowledge domains such as global product development, international R&D and global innovation. Two dominant concepts in organizing global product development are integrated product development and distributed product development. Examples of integrated approaches include concurrent engineering, collaborative engineering, Systems Engineering concepts, product lifecycle management (PLM) and coordinated multi-organizational product development. Examples of distributed approaches include centers of excellence, virtual teams, engineering outsourcing and offshoring (Zhang & Gregory, 2011).

Existing approaches to engineering networks are largely product oriented and pay relatively little attention to the intangible, customer-involving and relationship-based nature of services. With the trend of servitization in manufacturing companies and the emergence of service science, manufacturers, particularly those who are engaged with complex and long-lifecycle products and systems, require a better understanding of the nature of services and its impact on the design and operation of engineering networks (Zhang, Srai, Gregory, & Iakovaki, 2009).

As engineering networks work with more or less customer-orientation, the degree of customer orientation in engineering networks is determined by the customer coupling point and the amount of customer-based requirements information. Customer-oriented engineering networks typically produce engineer-to-order (ETO) products contributing to customer value and thus the overall competitiveness of a firm. ETO production is suitable for unique products that have similar features, and the production is based on receiving a customer order and developing a technical specification accordingly. Each product is a result of a project, which means customer orders are often organized as projects (Yang, 2013).

Product design, overall engineering and project management are the core competences of ETO companies, which usually act as main contractors and operate at the international level (Hicks, McGovern, & Earl, 2001). ETO companies often also manufacture their products and may even provide turn-key deliveries, and thus installation and commissioning services. ETO products include a lot of components and subsystems which are manufactured, assembled and installed by other companies. This is why they need to work with various subcontractors or establish partnerships. Working within ETO networks as the main contractor, they have the managerial competency to direct and coordinate the entire project. They also possess relevant know-how, from the basic technology to the architecture of the end product (Tonchia, 2008).

The sales-delivery process of ETO products presents great potential for information reuse, i.e. the reuse of previously validated concept, design, production, in-use and service/maintenance information according to customer-specific requirements. A structure-based product range modeling for design reuse has been introduced for the new component definition phase (Brière-Côté et al., 2010; Costa & Young, 2001). Information reuse together with automated processing requires an integration of technical and knowledge engineering with engineering design and manufacturing phases (Nykänen et al., 2011). The reuse of in-service information depends crucially on effective information feedback processes supported by knowledge and information systems (Goh & McMahon, 2009).

The product lifecylce management (PLM) solutions now available are characterized by efficient data-sharing processes supporting collaboration within extended enterprises. They still lack essential capabilities that would facilitate the reuse of design process knowledge, such as the identification of similar workflows (Hani, Rivest, & Maranzana, 2012). The state of the art practices in information reuse concerning product-related information in design phases is based on using several different IT systems (Saaksvuori & Immonen, 2008), and often there is no knowledge transfer from one design project to another (Wang et al., 2012). Therefore, knowledge is lost and time is wasted when information reuse is not efficiently organized. In practice, information reuse is not a systematic approach in ETO companies and therefore has not been widely studied. Their product development process may lack a formal framework and company culture for information reuse. In some cases, information reuse plays a role in new product development initiatives, but there is not yet a formal approach to achieve it. These problems will be studied in this paper with the following research questions: What types of challenges of information reuse can be identified from the literature? What are the implications of these challenges for the product processes of engineering networks delivering ETO products?

Having defined the topic and research problem, the next section of the paper provides relevant background information and understanding regarding information reuse challenges related to, firstly, the definition of information reuse; secondly, knowledge management, information management and organizational learning; and thirdly, Systems Engineering, a potential approach to build up an information reuse structure and architecture. In Section 3, the framework for studying information reuse challenges and the research process are introduced, and based on this, a typology of challenges classified into four main categories is presented in Section 4. Section 5 discusses the findings and managerial implications of the study from the perspective of organizational development. Finally, conclusions are drawn in Section 6.

2. Background to information reuse challenges in an ETO context

In a context of ETO companies, they know only upon receipt of a customer order what to order or manufacture. That implies a dynamic and complex supply chain with high communication costs. The authors want to define the term of information reuse in this paper, and how it works in the context of knowledge management, information management, and organizational learning. Designing a structure or architecture for information reuse the authors want to describe the Systems Engineering approach. *The authors view* that the Systems Engineering approach *is beneficial for the development of structures for information reuse*.

2.1. Defining information reuse

In engineering processes, information and knowledge are the basis for rational thinking and problem solving (Spur 1989). The information needs of engineers and managers vary according to the different stages of the engineering product lifecycle (E-PLC). The literature distinguishes between the following main stages of E-PLC (Cao & Folan, 2012): design, manufacturing, distribution, use, support, retire (Terzi, Bouras, Dutta, Garetti, & Kiritsis, 2010) and disposal (El Hani et al., 2012). In the ETO product context, the distribution phase typically also includes significant construction and installation works at the user's site, as well as vital testing and commissioning of the product before it is handed over to the client. Fig. 1 presents the following three phases of E-PLC: Beginning of Life (BOL), including design and manufacturing; Middle of Life (MOL), which includes distribution/installation, use and support; and End of Life (EOL), encompassing retire and disposal. Information reuse in general is considered as the reuse of previously created information in later stages of PLC. In addition, information reuse covers information reused for another product in the same stage of PLC. Information from the use stage collected by users of one product can be considered information about the product's behavior in real operation conditions that can be transferred to the beginning of life