

PERCEPTIONS OF AND CHALLENGES WITH KNOWLEDGE SHARING – ENTERPRISE COLLABORATION IN A VIRTUAL AERONAUTICAL ENTERPRISE

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ABSTRACT

The purpose of this paper is to investigate how knowledge is managed and shared within product development in an enterprise collaboration context based on the partnership within the EU FP7 research project CRESCENDO, involving 59 partners from the aerospace supply chain.

This paper is based on a qualitative survey that was sent to seven companies in the European aerospace manufacturing industry, focusing on how they perceive knowledge sharing, and on common problems and challenges with knowledge sharing.

Lack of trust and fear of losing competitive advantage is identified as a problem area. Further, information and communication technology is seen as an important enabler. In this area it is found that it is important to develop strategies for knowledge sharing in alliance with business developers, engineering, and IT architects from several organizations in the extended enterprise.

Keywords: Knowledge Sharing, Enterprise Collaboration, Product Development, Information and Communication Technology (ICT), Aerospace

1 INTRODUCTION

Globalization, increased competition, dynamic and constantly changing business demands are some of the factors that industrial manufacturing companies have to deal with, so also the aerospace manufacturing industry. These demands require companies to collaborate in strategic partnerships and thus they have to improve their knowledge sharing, both internally and collaboratively with other organizations. Enterprise knowledge sharing is understood to be of critical importance to the performance of knowledge creation and leveraging of knowledge [1]. Basically, more engineering and production will shift to suppliers and service providers, further increasing the motivation of companies to excel in global collaboration with such partners. Manufacturing systems can no longer be seen in isolation, rather they must be considered in the context of the total business, linking both up and down the supply chain [2]. Based on this, the companies' ability to share knowledge in a collaborative environment quickly becomes of increasing importance. It is estimated that the value lost due to failed knowledge sharing is \$31.5 billion in Fortune 500 companies alone [3].

In industry as well as in academia, the meanings of terms like collaboration, information and knowledge [4] are disputed, much since interpretations vary across individuals, teams and companies depending on, among other things, the contexts they work in.

The purpose of this paper is to investigate how knowledge is managed and shared within product development in an enterprise collaboration context in the aerospace manufacturing industry.

Following this introduction, the industrial context and the methodological approach is presented. Then the theoretical framework of enterprise collaboration and knowledge sharing is presented. Following this the results of the study as well as discussion and concluding remarks will round off the paper.

2 INDUSTRIAL CONTEXT – THE VIRTUAL AERONAUTICAL ENTERPRISE

The context of this study is the aerospace manufacturing industry, with data collected from the EC funded CRESCENDO [5] research project, where many of the aerospace industry's original equipment manufacturers (OEMs) and first tier suppliers work with academia and vendors of engineering software tools to solve problems to enable development of tomorrow's aerospace products.

Products developed in this sector normally fall within what has been defined as ‘complex products and systems’ [6,7], which is a collective name for expensive, engineering-intensive products and systems [7] that feature many components and require a breadth of knowledge and skills [8] so extensive that a single company cannot have all the technical expertise themselves [9]. Additionally, these products require large investments by the manufacturers in order to be developed. For instance, the price of an Airbus A380 was in 2008 estimated at around \$327 million [10]. In addition, many manufacturers provide large discounts [11] on their products, to enable customers to purchase them, and then takes that back on the highly lucrative aftermarket.

All this combined makes the companies less willing to go into these programs alone. Instead they team up with other manufacturers in partnerships to manage the risks, investments and skills [12] required to bring the products to market.

These risk and revenue sharing partnerships can take on different forms. Common terms in this context are virtual enterprises [13,14] and extended enterprises [9,13]. The main difference between virtual and extended enterprises lies in the longevity and agility of the partnerships [13]. The virtual enterprise is a (relatively) short-term undertaking, where the consortium disbands upon completion, whereas the extended enterprise can be stable over multiple projects. All these projects are also governed by contractual agreements, whereby companies are obliged to stay within the bounds of the partnership and deliver as promised in the contract.

In these partnerships, companies face the challenge of striving for collaboration at a high level of integration, while at the same time they need to make sure that they do not give too much of their core knowledge away, which is essentially their competitive advantage and ticket of admission into the partnership. They may well be fierce competitors in the next program. Essentially, they work in a mode of ‘coopetition’ [15], depicting the coexistence of competitive and cooperative atmospheres. This mode of working is the reality for the aerospace suppliers, which pose other demands than the typical OEM-supplier relationship that is common practice in many other industries.

This will have a profound impact on how product data is managed and how knowledge is shared in these extended and virtual enterprises. From a focal company perspective it is important to strike a balance between not giving away too much, but still enough to provide value to the partners and the customers, that is, to provide a superior product.

3 METHODOLOGICAL APPROACH

In order to achieve the stated purpose, a qualitative research approach was adopted, because the focus was to obtain an understanding of a real-life situation [16]. A qualitative survey, with free text answer options, was sent to seven companies active as OEMs and first tier suppliers in the European aerospace manufacturing industry. Of these seven companies, three answered to the survey. One reason for using a survey approach was to enable access to certain respondents, who were identified by the aid of gatekeepers [17] at the different companies. These gatekeepers had the knowledge of who had experience and expertise, in the relevant functions, which matched the wishes of the researchers. Respondents for the survey were selected from various product development functions in the companies, acting as (e.g. project leaders, development engineers, etc.), as well as people from IT departments (e.g. IT managers and experts within the field of enterprise collaboration). These were selected because they offer the researchers the possibility to view the problem from two often very different and conflicting perspectives.

The identities of the companies and the respondents are omitted as part of anonymizing the data.

The survey consisted of five questions with, as mentioned before, free text response options:

1. How does your organization define knowledge sharing?
2. Can you please list the tools (IT-tools or other applications) you are using for sharing knowledge within your organization?
3. Can you please list the tools (IT-tools or other applications) you are using for sharing knowledge with other organizations?
4. What do you experience as the three top problems when it comes to sharing knowledge when collaborating with other organizations?
5. Does your organization have one or several of the below mentioned strategies (knowledge sharing strategy, enterprise collaboration strategy, collaborative IT strategy, information sharing strategy, PLM (product lifecycle management) strategy, knowledge management strategy) – and who/what department is responsible for developing them?

Question 1 aim to highlight and compare the working definition, if available, of knowledge sharing and how that is perceived in the different companies and in the context of the aerospace manufacturing industry.

Questions 2 and 3 are focused on the tools and other aids that are used for facilitating knowledge sharing both in a company-internal environment as well as between companies, making it possible to identify differences in tools for internal and external collaboration

Question 4 is focused on identifying common problems when sharing knowledge externally, across the extended enterprise. Here it is interesting to compare perspectives from different companies as well as between the both respondent groups, since they are often motivated by different things.

Finally, question 5 aims to identify what strategies the companies have that relates to information sharing, knowledge sharing, and collaboration. This information will be used as a starting point in a later study to map what part of the respective organization that are responsible for developing and coordinating these strategies and is therefore not analyzed in this article.

4 ENTERPRISE COLLABORATION

The reasons for entering into a collaborative partnership can be many. Fundamentally though, collaboration, and in particular enterprise collaboration, is based on the idea that working together will allow collaborating companies to create results superior to what any one entity could have created alone. According to Schrage (1990), collaboration “...is the process of shared creation: two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed or could have come to on their own.” [18, p.140]. As mentioned earlier, developing an aerospace product is a difficult and complex activity, which is challenging for a single company to manage alone.

Essentially, collaboration is full of challenges as well as opportunities. It is important for companies to maximize the opportunities and manage the challenges as efficiently as possible to gain maximum value from it and thus justifying the collaboration in the first place. Some of these aspects are summarized in table 1 below.

Table 1. Challenges and opportunities with global collaboration.

	Opportunities	Challenges
Time difference	24-hour design [19] combining people from different time zones allowing accelerating development.	Difficult to coordinate work, small window of opportunity for synchronous collaboration [20].
Cultural differences	Multiple perspectives and diversity on ideas allowing innovation [21].	‘Cultural conditioning’ [22] impacts building of <i>trust</i> between collaborators.
Distance/ Different locations	Closeness to different market and resources that are beneficial for the consortium. ‘Globalizing local knowledge’ [1].	‘Radius of collaborative colocation’ [23] depicting that people located too far away are less likely to collaborate, especially in a non-planned manner.
Heterogeneity (of systems)		Different companies use different tools (i.e., CAD, FEM, CFD, etc.) for product development, making it difficult to make them compatible. IT security considerations. Data stored across different enterprises. Federation of access.

Enterprise collaboration deals with “the partnering of activities, knowledge and assets by multiple stakeholders in a dynamic environment, with the objective of gaining business advantage.” [24]. On a continuum ranging from independence to close integration, see figure 1, enterprise collaboration in the context of the aerospace manufacturing industry falls within the level of coordination, cooperation, and collaboration [25]. Which type is most suitable depends on the intensity of interaction required in the specific situation [25]. Coordination is about integrating information and contributions from the different partners. Here the level of integration between partners is relatively low, whereas in cooperation this is higher, as they work more with common problem solving, where input from other

partners is important. With cooperation, work is done uniquely by the different partners and then integrated to a common result, whereas collaboration the actual work is integrated. Problems are integrated and solved [25].

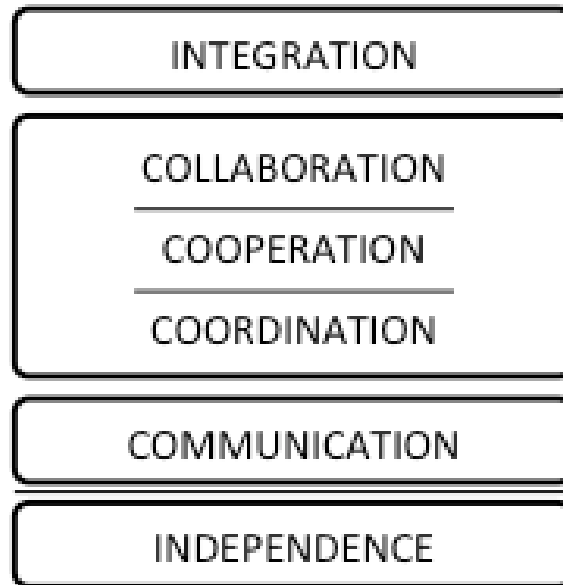


Figure 1. Four levels of interaction.

Enterprise collaboration will, in practice, mean that companies in various positions in the value chain will team up in partnerships [2], such as extended and virtual enterprises that were mentioned earlier in the article.

Knowledge sharing is a key aspect to any strategic alliance, since companies enter them with the ambition to tap into the knowledge bases of other companies.

5 KNOWLEDGE SHARING

There are many ways of defining knowledge. Knowledge can be divided into tacit and explicit knowledge [26]. Tacit knowledge is not easily expressed and closely related to people's experiences and thus difficult to transfer. Explicit knowledge on the other hand can be articulated and more easily formalized. Tacit and explicit knowledge are closely related and highly complementary, where Jasimuddin et al [27] suggest that all knowledge has explicit and tacit parts. Their relationship can often be likened to an iceberg, where the visible, explicit part is supported and given meaning by the hidden, tacit, part under the surface [27], see figure 2a.

Another way to describe knowledge is to distinguish it from data and information, such as in the knowledge hierarchy [28] (also known as knowledge pyramid or DIKW (data-information-knowledge-wisdom hierarchy)); see figure 2b. This view says that (large amounts of) data can be combined to create information, which is used to create a smaller amount of knowledge and then in turn wisdom [28]. Added context and understanding facilitates the transfer from one stage to another, based on, for instance, patterns in the data and information [29]. However, there are also critical views on the knowledge hierarchy, where, for instance, the visual metaphor of data always being the base of information and knowledge is questioned [30,31]. Often it is a top-down approach, where asking questions, based on experience, and wanting to learn new knowledge means that people will probe for data and information, meaning that the hierarchy works in both directions [31]. It is also easy to misunderstand the knowledge pyramid as a representation of the maturity of an organization's or its members' knowledge base. All levels of the pyramid are needed for different purposes, and we recognize that the importance of each level can vary significantly depending on the context of the collaborative situation.

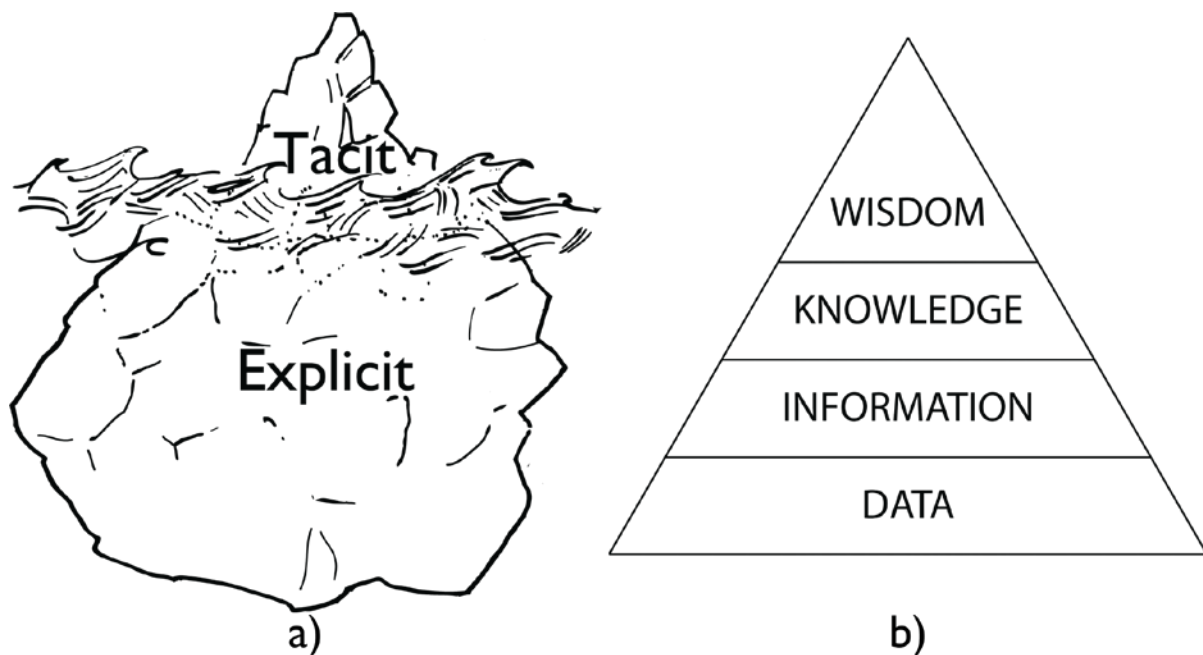


Figure 2: Representations of knowledge: a) tacit and explicit knowledge, b) knowledge hierarchy.

Part of many companies' knowledge management efforts is to get employees to share knowledge and to contribute to their organization's knowledge repositories [32].

Knowledge sharing (KS) is defined by Cummings (2003) as "...the means by which an organization obtains access to its own and other organizations' knowledge" [33, p.1]. At its most basic level, it involves the channeling of knowledge between a source and a recipient [33]. The key difference between information sharing and knowledge sharing can be summarized by the role played by human beings. KS relies on humans taking on the role as creator, carrier, conveyor and user, whereas information sharing can usually happen 'outside' humans and without their influence. As Brown and Duguid (2000) put it, "*knowledge usually entails a knower*" [34, p.119], and they further note that information is normally treated as independent and more or less self-sufficient, whereas knowledge is usually associated with someone (e.g., "where is that information" vs. "who knows that").

KS is closely related to learning, where "...successful knowledge sharing involves extended learning processes rather than simple communication processes" [33, p.1]. This happens in the interactions between different organizations, when creating new innovative products [35].

Whether knowledge sharing is successful can be assessed in terms of how much of the transferred knowledge is recreated in the recipient's knowledge base [33]. As much of the knowledge base is tacit, embedded in people's heads and contextually dependent, this factor will not be a 100% match, and a challenge is to make it as large and as good as possible.

In his review of knowledge sharing literature, Cummings (2003) identified five primary factors for successful knowledge sharing:

- The relationship between source and recipient,
- the form and location of the knowledge,
- the recipient's learning predisposition,
- the source's knowledge sharing capability, and
- the environment in which sharing occurs.

The competitive nature of cooperation [15], that was mentioned earlier as an ingredient in these partnerships, makes it a bit problematic, since knowledge used for cooperation may also be used for competition [36]. Companies may be hesitant to share their knowledge—essentially their competitive advantage [37]—if they feel that they gain less than what they give away. An important factor here is management of relationships [33], that is, establishing and developing shared goals and rules for the collaborations as well as understanding the differences between the parties.

6 RESULTS

In this section the main results of the survey is presented, providing a view of how the companies in this study view knowledge sharing in their contexts and which challenges and problems they see in this.

6.1 Definitions of knowledge sharing

Out of the responding organizations in the study, two have formal definitions for knowledge sharing in place, which is confirmed by both respondent groups (i.e., product development and IT representatives) at these companies. For the first company, knowledge sharing is defined in the following way:

“Knowledge sharing is a system for increasing the competitiveness of all organization and improving the efficiency by means of the sharing and capitalization of the intellectual capital.”

For the second of the companies with formalized definitions, knowledge sharing is defined as:

“The interaction and exchange of information, experiences, best practices between groups with common interest and objectives finalized to the process improvements in the achievement of the results.”

The third organization that also answered the survey confirmed that they do not have a formal definition of knowledge sharing. However, one of the respondents describes instead, in detail, how they are working with knowledge sharing and knowledge exchanges, indicating that there is a matured implicit understanding of the concept and its importance:

“Knowledge is a valuable but intangible asset and sharing it among employees is important for any business. We have a knowledge management group that facilitates knowledge sharing and capturing. Any activity that facilitates knowledge exchange between employees and/or organizations can be referred to as knowledge sharing. Knowledge sharing just doesn’t involve technical aspects but also social aspects and makes it all more challenging as people are not always ready to exchange knowledge.”

6.2 Tools for knowledge sharing

When looking at the knowledge sharing tools that the organizations are using for collaboration, the results are indicating that there is no major difference in views between the two respondent groups within each organization.

Further, companies use similar tools for sharing knowledge both within the organization and with other organizations.

6.3 Problems with knowledge sharing

All of the studied organizations are reporting three major problem areas when it comes to sharing knowledge in the context of collaborating with other companies:

- Lack of trust and fear of losing competitive advantage
- Deployment and implementation challenges
- Technical challenges

Among the issues related to trust, challenges relating to intellectual property rights and evaluations regarding what knowledge to share with the partners and what not to share is brought forward as the main challenges.

In terms of implementations of knowledge sharing, having a knowledge sharing culture—such as common processes, methods and rules—to go hand-in-hand with the deployed technical solutions is a major challenge.

From a technical perspective, synchronizing interfaces between organizations, automating data exchange and communications as well as packaging, searching for and retrieving knowledge across organizational borders is seen as a challenge.

7 DISCUSSION

Looking at the challenges with knowledge sharing in an enterprise collaboration context, between different organizations in the extended enterprise, it is evident that the issue of co-competition [15] is something that companies are struggling with. What and how much should you share with your partners? Since one first tier supplier might go with your direct competitor on the next project, there is always a question of trusting them with enough knowledge, and how much knowledge that actually is? Still, to bring out good results, you need to collaborate and you need to share knowledge.

Information and communication technology (ICT) is seen as an important enabler of knowledge sharing within a collaborative context. There is no major difference between the two respondent groups within each organization when looking at the knowledge sharing tools the organizations are using for collaboration, and in addition, there is also no major difference between the tools used for internal collaboration and external collaboration. This can, in a wider interpretation, point at a situation where the studied organizations are quite mature to initiate a wider implementation of knowledge sharing tools for usage in external collaboration. Such an implementation is usually based on strategies, pointing out directions for the respective companies to take. However, there is always a risk that a single company's ICT strategy will not fully support the need of knowledge sharing within a collaborative context, *"Although we were able to find positive effects of IT we argue in favor of developing an information and a knowledge strategy prior to developing an IT strategy"* [38].

One of the identified problem areas point towards challenges with deployment and implementation of tools for knowledge sharing while collaborating with other organizations. Therefore, what is needed before installing yet another tool is to move stakeholders into discussions regarding how they should organize knowledge sharing and how they should organize ICT development and deployment strategies and initiatives. Here it would be of interest to move towards facilitating a strategic workshop between some of these roles (e.g., project leaders, engineers and other users of ICT solutions as well as the ICT architects, etc.) spanning over several companies in the extended enterprise. In addition, it might be of interest to invite people with appropriate roles in solution provider organizations (i.e., PLM providers, web conferencing system providers, etc.) to these forums to have all parties concerned present around the same table voicing their concerns, wishes and needs to one another and thus increasing the general understanding of both the barriers and the opportunities and benefits with increased knowledge sharing in the extended enterprise.

8 CONCLUDING REMARKS

The purpose of this work was to investigate how knowledge is managed and shared within product development in an enterprise collaboration context in the aerospace manufacturing industry. The paper has presented three aerospace manufacturing companies' view on knowledge sharing and on challenges with knowledge sharing.

When managing implementations of tools for sharing knowledge when collaborating with other organizations it is important to identify the 'strategy owner' and make sure that all the listed problems are taken into consideration when developing this strategy. Even though ICT is seen as an important enabler of knowledge sharing within a collaborative context, it is not necessarily the ICT strategy that should cover these alone.

Lack of trust and fear of losing competitive advantage is a problem area identified by all three organizations. This is not related to technical implications, but instead pointing towards business values, rules and expectations. However, part of the solution lies with ICT. To solve these problems, it is recommended to involve the business developers early in the process, as these issues are to be handled within a formal contractual work – and solved, partly or in total, by ICT.

8.1 Future Work

The main intention with this study was to initiate a dialogue with the concerned parties in the research project, to identify the individuals that are responsible for developing and coordinating the information sharing strategies, knowledge sharing strategies and collaboration strategies within each organization. This study has identified the need of comparing data from adjacent industries, to more closely identify which aspects that are specific for aerospace (given the competition context), and which are generic for supply chain collaboration.

In future studies, we will map how collaborative aspects are taken into consideration while developing strategies for connecting companies in the aerospace supply chain.

As a concrete action, we will move towards facilitating a workshop within the CRESCENDO project, to further collect data and insights on these issues and gain a deeper understanding on how the needs of the different stakeholders in terms of strategies for information sharing, knowledge sharing and collaboration.

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