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STUDY OF THE EFFICIENCY OF PRODUCT DEVELOPMENT TEAMS THROUGH COMBINED VIRTUAL COMMUNITIES OF PRACTICE, PLM AND SOCIAL MEDIA TECHNOLOGIES

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Abstract

With globalization and increasing product complexity, manufacturing industries are experiencing increased user demands to incorporate informal exchange mechanisms especially when it comes to international groups and multifunctional products where collaboration is much more difficult.
The article looks at industrial case studies within a global manufacturing company involving established communities of practices and Enterprise Social Media (ESM) technologies to see how these could possibly be combined eventually with PLM tools to improve the productivity of large product development teams. The results of surveys based on geodistant product development teams are presented. Then, a Social Network Analysis (SNA) tool is evaluated to represent the product development team dynamics and a brief overview of Social PLM functionalities is presented.
The study indicates that the role of communities of practice and their moderators supported by ESM technologies can effectively complement the formal product development process commonly supported by PLM systems based on 3D mock-ups and other Data Management Systems.

Keywords: Organisation of product development, Communities of Practice, Enterprise Social Media Tools, Product lifecycle management (PLM)

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1 INTRODUCTION

Collaboration is an essential activity during product development where people receive and send information using different media. With globalization and increasing product complexity, manufacturing industries are experiencing increased demands from stakeholders to incorporate informal exchange mechanisms especially when it comes to international groups and multifunctional products where collaboration is much more difficult.

This paper presents an industrial case study within a global manufacturing company involving established communities of practice. The purpose of this study is to see how virtual communities of practice could be supported by Enterprise Social Media (ESM) technologies in order to improve the efficiency of large geodistant product development teams. Essentially, the chief engineer is looking for ways to better use the intellectual potential of his large technical teams to solve crucial problems that are becoming more and more complex.

ESM technologies offer an array of opportunities for enhanced collaboration with mechanisms such as crowd sourcing which are now used effectively in the open market. Companies are interested in using such approaches to pull the best ideas coming from their employees when they are facing difficult technical issues; a process that is not supported at all by current PLM (Product Lifecycle Management) technologies or social media technologies when one considers data security issues. The underlying question is the following: How far can those be adapted to the complex product development organizations that must efficiently manage formal and informal information?

Communities of Practice (CoP) and Virtual Communities of Practice (VCoP) have been put in place in industry to support informal technical networks. They may represent a viable method of supporting informal internal collaborations and even the “Enterprise Crowd Dynamics” concept that chief engineers would like to implement.

In this study, we first present the results of a survey based on geodistant product development teams. Then, a Social Network Analysis (SNA) tool is evaluated to represent the product development team dynamics, and finally, we briefly look at possible Social PLM approaches to support these communities.

2 VIRTUAL COMMUNITIES OF PRATICE AS A ROUTE TO EFFICENT PRODUT DEVELOPMENT

VCoPs are used extensively in a number of manufacturing companies; these bring the human side into the knowledge management world enabled by online technologies (Ardichvili, Page, & Wentling, 2003). This approach is particularly beneficial for people who work more often remotely than on-site and those located on distant sites. This allows the working teams to focus on designated areas of technical expertise instead of receiving and sending suggestions or questions not related to the targeted expertise. As Enterprise Social Media (ESM) promotes the information transfer within CoPs, the reverse path where existing CoPs extract the maximum benefits from ESM is also valid as pointed out by Annabi et al. (Annabi, McGann, Pels, Arnold, & Rivinus, 2012).

In order to conduct a well-oriented analysis and provide effective conclusions, this study takes into consideration practical constraints and requirements of information management for product development teams. For the aerospace industry, three general constraints have to be considered:

1. **Export Control (EC):** Export Control became more important with globalisation and the corresponding increased exchange between countries. The rules are used to manage controlled and restricted data that should not be disclosed to certain third parties. The country where the activities of this industry are conducted, as well as extra territorial laws regulates these rules. Every user has access rights and limits. Based on these facts, it becomes evident that ESM exchanges should be controlled. Controlling information while promoting open ESM is a real challenge.

2. **Intellectual Property (IP):** Intellectual property could be violated by the utilisation of non-authorized content or artefacts belonging to a third party. Nowadays, different persons or teams modify content, and the IP should follow the cycle and be labeled.
3. **Records Management (RM):** Records management is used to hold and archive documents for a certain period of time in accordance to internal and external regulations. Within this discipline, many rules are applied to classify, archive, secure and destroy information. Data should be managed independently of its format and means used to communicate. The challenge resides in the act of recording informal information shared or deleted on ESM. Not all the exchanges are mature enough to be considered as managed information, therefore the overall content could be treated as non-managed information which could thus lead to loss of information.

These requirements strongly influence the type of technical solution and process that can be successfully implemented in a manufacturing environment for both formal and informal information content. These constraints appear to be major impediments for the concrete implementation of Enterprise Crowd Dynamics in product development.

This study aims to understand how social tool can support Virtual Communities of Practice during product definition. Where VCoPs are communities of practice that are supported by internet technologies as their participants cannot physically meet on a regular basis.

Through human interactions in a VCoP, for instance, information can be leveraged, reused and shared throughout the enterprise. When information reaches an “acceptable” maturity level, it should be captured and managed by a controlled platform such as a PLM system or a more general document management system. Yet, as highlighted by Ameri and Dutta (Ameri & Dutta, 2005), only a mere 4% of companies knowledge is currently available for re-use while the other 96% remains in people’s minds. CoPs properly supported by ESM technologies and eventually PLM technologies might be a way forward to solve this problem.

Moreover, sometimes within the development teams the capturing and follow-up of information tend not be done on a regular basis, thus leading to confusion, rework and loss of productivity. Companies have complex processes, often evolved over many years that can hardly be supported by a single system answering all user needs. Especially in the early stages of the research and development process, controlled sharing of information is not possible due to its high degree of informality. This fact currently prohibits the traceability of the information in the early stages of the product development decision-making, documentation and product content.

Considering the following requirements and technical issues, the authors conducted semi structured interviews and surveys to identify potential ways to overcome these barriers during product development and see how these combined approaches could improve the productivity of product development teams.

3 CASE STUDIES

In order to obtain, solid data on the product development teams behaviour as proposed by Blessing et al (Blessing & Chakrabarti, 2009), two separate case studies were conducted in 2 different departments of a global aerospace company. The Design Research Manual (DRM) guidelines (Blessing & Chakrabarti, 2009) where used. This section summarises the two case studies, the purpose of each, the criteria they respect, how the data was collected and finally the analysis method.

Case study 1

The purpose of the first study was to explore generic user requests for individual ESM functionalities, potentially to be combined with PLM functionalities. Therefore, the following criteria for the choice of users were defined: team members had to be working in geographically distant sites, no usage of a PLM platform was required and a willingness to explore ESM functionalities and management support for the introduction of both PLM and ESM was also essential. Data were collected through an online survey with answers from 20 out of 34 users as well as semi-structured on-site interviews with 10 participants.

Case study 2

The purpose of the second case study was to investigate first, to which extent a CoP can support information exchange between users and second how to eventually combine traditional PLM and ESM technologies to support the complete process. The following criteria for the selection of the participants were set: a multi-disciplinary team working on the same topic, the geographical distance of CoP members had to be substantial, the active use of a PLM platform, and membership in CoPs established by management decision. Finally, technical specialists and designers of mechanical systems from three different countries were chosen and ten preliminary semi-structured interviews were conducted on-site or via web conference. Based on these results, an online survey was conducted which was answered by 63 out of the 67 selected participants.

4 KEY FINDINGS FROM THE SURVEY

4.1 Geographical situation

Globalisation is nowadays a normal fact in manufacturing industries. Case study 1 includes 2 geodistant teams having different hours of work. Users ranked their frequent contacts in 5 user categories: internal colleagues, colleagues in another country, manager, external partner and supplier. The outcome matched well-known results in the literature, indicating that the frequency of communication decreases as the distance increases between individuals. However, the results also showed some exception to this finding. This is due to the fact that a new project was delegated to the second team while the expertise and know-how resided in the first team. In this case, a clear purpose for ESM would be to ensure synchronicity with geodistant teams and then the CoP would support the process to reach equilibrium by distributing the expertise within both teams. Both teams have the same manager; his regular office is located with the first team, explaining why members in the first team send him more information than the geodistant team.

4.2 Demographic influence

Due to the general adoption of social media in the day-to-day life particularly by young people, one would expect from this survey to have corresponding buy-in from this group of people. However, as shown in Figure 1 below, Case 1 results suggest that young employees 20 – 30 years old (mostly new employees), have less confidence in sharing information on ESM or are split about this issue. This is the opposite case for most of individuals between 30-50 years old. These results cannot be considered as statistical evidence but indicate a tendency that is worth noting. As research published by Chui et al from McKinsey indicates, there is a link between trust and information sharing (Chui et al., 2012). Hence, experienced people have confidence to share openly; new comers need time to adapt themselves to the new environment and are cautious about sharing information. This could maybe be explained by their reluctance to share their lack of knowledge; it could rather be a case of lack of self-confidence combined with a lack of confidence in colleagues. This hypothesis should be checked in a further study. This behaviour could also be helped to a certain extent by an ESM that would favour some unidentified exchanges between participants. However, a CoP moderator who promotes that mistakes are allowed and even openly supported with the understanding that they are learning experiences, can foster this behaviour. One can clearly see the importance of a thoughtful moderator in those circumstances and potentially see his role as a potential bridge between a chief engineer and the deep technical knowledge within an expertise domain of a global company.

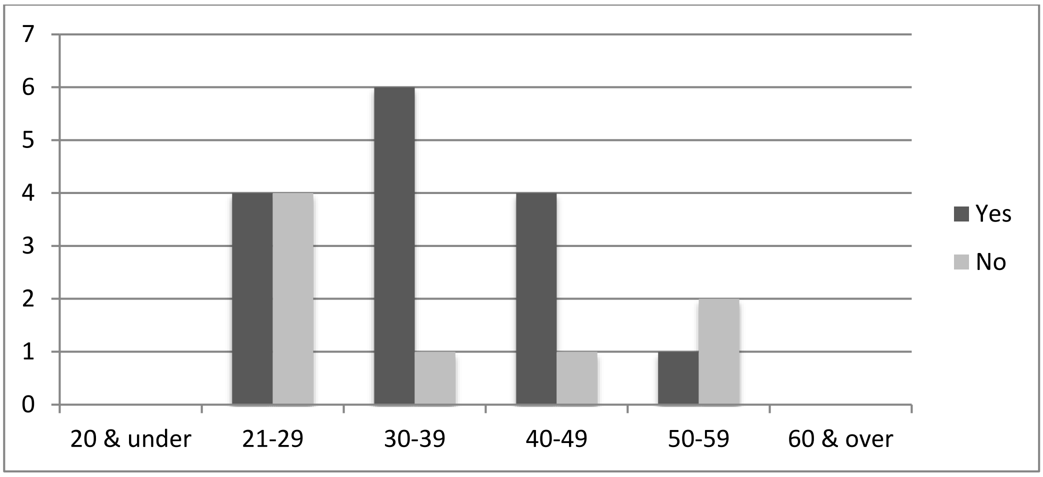

Figure 1 Trust of information shared on ESM with respect to age groups

Generally, a CoP and VCoP moderator can actively enhance confidence between colleagues to share their knowledge. In fact, CoP moderators can ensure information integrity with the knowledge owner's intervention. In the absence of external intervention from the team, implementing an ESM alone will not contribute to the rise of confidence between colleagues. Besides virtual communication, a VCoP can organise face-to-face video meetings or conferences to establish a trust relationship between members and benefit from the input of senior members. Then their contribution on ESM could possibly go beyond information sharing to reach real knowledge sharing.

4.3 Sequential approbation cycle

Points of view regarding the necessity of having a hierarchical approbation cycle are divided when considering the various levels of information maturity and thus formality. On one side, employees would like to have a record of decisions, especially when a new employee is having trouble finding existing information in these multiple systems. In fact, senior employees tend to neglect the importance of their knowledge, and decide to keep the working process too informal. The question is rather to determine: what to keep in the informal information category and, when and how to formalise that information. A proper balance must be found, as a too formal decision-making process will hinder efficiency and creativity of a product development team, but the inverse in also true, as the decision-making becomes too informal, the productivity will also suffer.

In the end, it comes down to determining the maturity of the content. Content should be improved, released or discarded when it reaches a certain maturity level. As the authors have previously suggested (Doumit, Huet, & Fortin, 2013) an improved way to develop best practices would be to use a VCoP to decide how information is treated. The VCoP moderator of that community could take care of the information maturity and avoid non-useful formalisation or loss of important content. They could then play an important role by supporting information towards the appropriate platforms for formal and informal information management, namely PLM and ESM. In fact, one could say that moderators exercise an informal authority within the product development teams that could, when properly exercised, significantly improve the team cohesiveness and thus its efficiency, creativity and reactiveness to change.

4.4 Loss of productivity in day to day activities

Ameri and Dutta (Ameri & Dutta, 2005) state that searching information, working with wrong information and recreating existing information are the principal factors impacting productivity during product development. Some factors were surveyed in order to identify the root of the problems. It is important to note that country A is not supported by a CoP unlike country B.

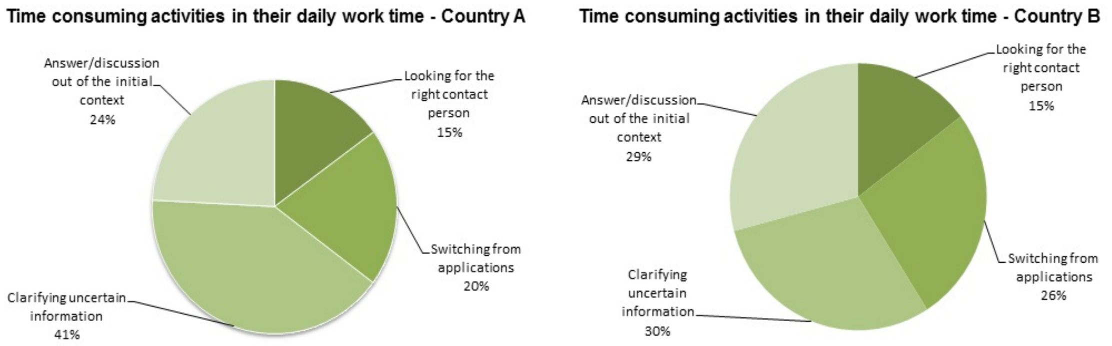

Figure 2. Comparison of the percentage of time spent in various daily activities

The following findings were obtained from these surveys:

- **Need to clarify uncertain information:** Information is gathered from different databases, presenting certain inconsistencies. Users struggle to find the latest version, which requires considerable time. In addition, some users do not have access to the product structure. The systems appear to be over-secured, and people cannot even see if the information exists to initiate a request. Most of the time, they recreate existing information, which generates duplicates as well. The VCoP has helped to grow the networks across the company. Since Country B already has a CoP, this could explain a lower need to clarify uncertain information when compared to country A.

  However this factor still needs to be optimised: Country B meets only once every 2 weeks which is not sufficient; also a platform that can support discussions, questions and answers, instead of a static PDM (Product Data Management) system, can better support them. This input from users indicates that a combination of formal and informal information management is required in this type of work environment.

- **Need to answer questions of their working context:** It is normal, even encouraged, to ask for explanations to experienced employees. Nevertheless, experts beeing asked the same questions several times is an indicator that information does not circulate well between employees. Nothing can totally replace a discussion between peers, but an organised documentation with a common VCoP for the two countries would allow experts to be more productive in their own tasks. Knowledge can then be available outside official meeting times.

- **Need to look for the right contact:** It was found that the CoP did not have proper support. Users are still spending the same amount of time looking for the right contact. ESM could leverage profiles that match their work, by creating profiles with people's expertise, and even suggest joining a new CoP.

According to these surveyed categories, the need for social collaboration strongly exists for the reasons stated above.

5 SOCIAL NETWORK ANALYSIS TO ENHANCE A VIRTUAL COP

By using existing organization explicit or implicit groups, such as CoPs, one can enhance the use of a social collaboration tool. Communities of Practice can be found in many manufacturing companies, they are used for different purposes and known under different names. Through discussion with engineers all around the company, existing CoPs can be identified. CoPs operate under various conditions depending on their own maturity and status, but in all cases, social collaboration tools must help them to function more efficiently. On the other hand, if there is no such existing group, it is preferable to start a systematic method to analyse the relationship between workers. In order to understand the CoPs and the user's behaviour, the authors have chosen to use in this study the Social Network Analysis.

The Social Network Analysis (SNA) is a tool used by researchers that focuses on group interactions. It was introduced by Moreno in 1934 (Chinowsky, Deikmann, & Galotti, 2008). It aims to illustrate graphically the relations between individuals in a group or community, where nodes represent individuals, and relations are represented by a link between the nodes. In order to analyse the graph, one should consider the following key concepts(Chinowsky et al., 2008):

- **Network density:** represents the quantity of existing links between the nodes, thus the link between individuals in the studied group, in comparison with the quantity of possible nodes when all nodes are interconnected;
- **Centrality:** reflects the node distribution. When the relations are equitably distributed through the network, there is a low centrality;
- **Distance:** measures the number of nodes that the communication has to pass through on its way from sender to receiver.

Thus, this tool is used to characterise the relations between multi-countries product development teams and their interactions. It is also used to identify champions and understand the “As Is” state of information transfer within the global product development teams.

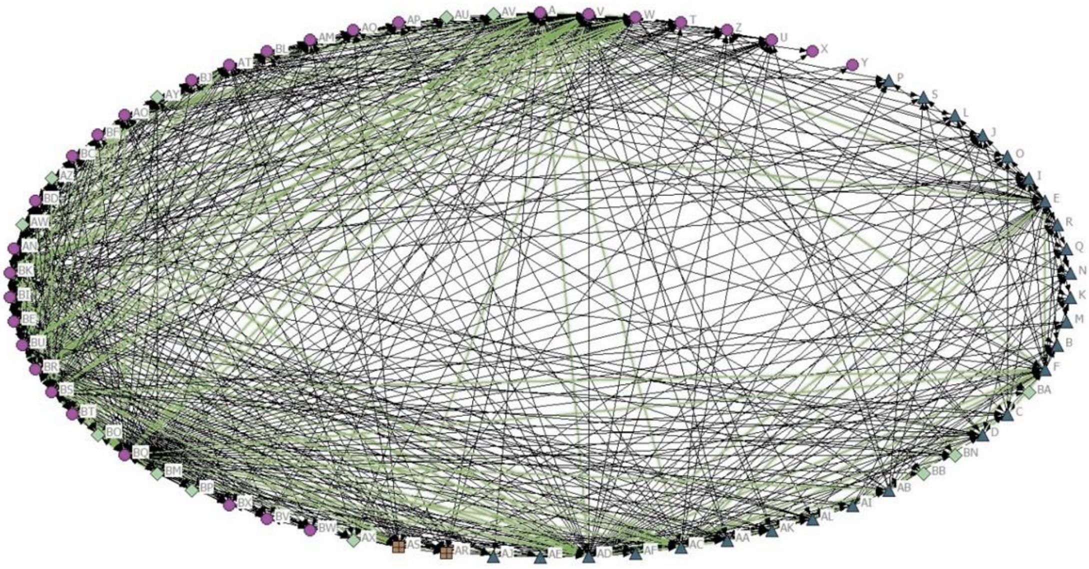

Figure 3. SNA between a geodistant CoP’s members, where participants are the nodes

In case study 2 presented above, four product development teams located respectively in four countries are identified with various symbols. Country A is shown by blue triangles, Country B by light green diamonds, Country C by purple circles and Country D by orange squares. The green lines identify the reciprocity within the product development teams, whereas black lines indicate one-way information flows. It is interesting to note that many relations are reciprocate, which indicates that there is close collaboration between some teams. Country A and Country C manage most of the information flow, even though the principal site is located in Country C. This is due to the seniority of the teams in these two countries. Thus they are essentially autonomous and in a good position to help a new team such as the one in Country B.

The relationships of Country B, both with other countries and internally, were analysed in order to find ways to strengthen the team know-how. In fact, interviews revealed that Country B exchanges with geodistant teams more than within their own team, hence creating bottlenecks especially in Country A. One could therefore suggest to shift the communication exchange into a VCoP where it becomes public to everyone concerned. This would remove this bottleneck and enhance multilateral information exchange, such that, in term of expertise, more homogenous geodistant teams could be developed.

The above SNA observations guided the authors to derive an appropriate structure of collaboration using existing communities. This includes the introduction of moderators who both maintain the CoPs and increase their efficiency as discussed in section 4.2 on demographical influence. Proper maintenance is even more important when it comes down do virtual groups. A moderator, also known as champion, can foster topics of interest. By continuously controlling follow-up and updates of recurrent problems, a champion plays a crucial role for the success of the community (Dubé, Bourhis, & Jacob, 2005) . As a consequence, the number of lasting and engaged members will increase to meet the needs of the evolving team. However, success depends on the choice of the CoP leader: the champion should be a leader. Discrepancies between current group leaders and CoP champions can be identified through the SNA.

On a large scale, ESM tools could provide input for the SNA by determining the number of exchanges between the various participants, rather than the few data points of the generic methodology used in this case study. By using virtual tools, participants could even be evaluated based on their behavior, quality of participation and ratings given by their peers (Parameswaran & Whinston, 2007). As expected, a knowledge owner is frequently chosen as champion since he masters a particular topic within the community. This system of merit approach stimulates the members engagement; Michaelides et al. have observed that users are encouraged to open their own discussion boards and wikis to manage their topics of interest (Michaelides, Tickle, & Morton, 2010). Once a community has identified its champion, other key persons could be designated in order to respect specific industry constraints.

On the long run, one could think of an approach called “Enterprise Crowd Dynamics” that would host any kind of information exchange within a company, moderated by the various champions including the chief engineer, while protecting confidentiality of the information.

Furthermore, a regular recruitment has to be guaranteed to ensure a constant flow of CoP members. Even though preliminary research suggests a voluntary participation to CoPs (Wenger, 1998), others propose that CoPs could be intentionally created (Dubé et al., 2005; Soekijad & Bet, 2004) .When intentionally created, the group should be oriented in a way to homogenously distribute the information flow (cf. the SNA illustration fig. 3). To reach a normally distributed network of knowledge, the authors suggest to adopt a mixture of both recruitment methods. Industries should be open to freely create communities aligned with specific subjects, managed by champions, while accepting voluntary membership.

Finally, the brief analysis above clearly demonstrates the effectiveness of the SNA tool to improve the efficiency of product development teams by visualizing information flows. Furthermore, the SNA tool could be improved by classifying the types of information exchanges into formal and informal categories. A degree of information formality could also be attached to each link. This would certainly enrich the information content and capability of analysis of the CoPs based on approved data.

6 SOCIAL PLM TO SUPPORT COMMUNITES OF PRACTICE

Besides the facilities that bring CoPs based on people behaviour, they could also ensure information fluidity between different technological support tools. When it comes to social media, for example, information shared informally cannot reach a desired maturity level without human intervention. At this level, existing CoPs could be used to leverage information and bring it, when needed, to a formalized platform such as a PLM tool. This approach could be used in industries that are looking to increase productivity using on their existing technological platforms. Well running CoPs supported by technological tools allow synchronous exchange, decrease repetition and increase reuse of existing knowledge.

In this logic, the authors have studied the detailed functionalities of both PLM and ESM systems to understand their potential complementarities using CoP. In summary, to properly describe the global required functionalities of these systems, Doumit (Doumit, 2014) has categorised their functionalities following the "4Cs" categories introduced by Cook (Cook, 2008): communication, cooperation, collaboration, and connection.

- Communication: participate in a communication while exchanging artefacts;
- Cooperation: people exchange artefacts without a specific objective;
- Collaboration: refers to formal exchanges where individuals work together for a common, definite target, e.g. follow-up existing problems, documentation of best practices;
- Connexion: social links trough geographical distance and time zones.

As an example to this concept, the authors have first taken the known topic of "lesson learned" under the cooperation category. Lessons learned are not elaborated by one person but rather by a collection of individuals sharing their experience through a period of time. When they are collected as formal best practices, it is rare to initiate a change to these, due to the related internal process complexity (Doumit et al., 2013). Therefore a platform able to manage the suggestions informally could appropriately host the exchange required to modify best practices. The champion who moderates the changes could then formalise the content to be used depending on its evolution. Best practices should be approved before anyone uses it in order to verify the content compliance in forehand.

As second frequent topic "how to resolve problems using existing resources" is covered under the same category. In engineering departments, previous problems resolution are often linked to the component itself; one must search all the existing bill of materials to find the targeted content. It would be then recommended to categorise problems by type of components. CoPs supported by a social media tool, where individuals can exchange their experiences informally, would manage these groups of components. Users can search for previous problems using a global search tool for asynchronous resolution, or submit a question to the correspondent community for a synchronous resolution. At a large scale, this practice is called "Enterprise Crowd Dynamics", where the crowd participate –wherever they are- in solving a problem.

Other subjects such as "update knowledge", "access expertise" and "collaboration with geodistant teams" could be analysed in the same way.

7 CONCLUSION

The case studies and their analysis carried out within a global aerospace enterprise comprising geodistant teams in a number of countries and geographical locations clearly indicate the potential of Enterprise Social Media technologies to support product development teams. However, the limits imposed nowadays by stringent data security constraints, intellectual property, export control requirements, and disciplined data management policies limit the openness of social media approaches within most manufacturing environments.

In this context, the study indicates that the simple Social Network Analysis tool tested on a fairly large and geographically dispersed product team, can be useful to illustrate and analyse the group dynamics and help to define the proper technological tool functionalities to manage both formal and informal information content efficiently. It is through these types of case studies and tools that the efficiency of product development teams can be improved. Furthermore, the CoPs and VCoPs represent very valuable mechanisms to manage the informal to formal information content, while respecting the constraints mentioned above. Moreover they can support the information transition as it becomes more mature, which is valuable to enhance the efficiency and creativity of product development teams.

It appears that the role of communities of practice and their moderators supported by ESM technologies can effectively complement the formal product development process commonly supported by PLM systems based on 3D mock-ups and other Data Management Systems. Communities can be interconnected virtually in order to freely exchange experiences "without border" but within given data security constraints. It is most likely through these well-developed communities of practice that chief engineers can implement customized "Enterprise Crowd Dynamics" processes and solutions that can be foreseen for the near future.

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