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An Investigation into Collaboration and Knowledge Management during Product Development in the Aerospace and Defence Industry

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Abstract: Organisations need to overcome a number of challenges, including improving knowledge management, to ensure competitiveness in today's global business environment. Product development and engineering design decisions are typically based on the knowledge available within enterprises. An ability to quickly discover and capture this knowledge and communicate with colleagues is required to enable effective outputs. An in-depth industry investigation, conducted within a leading manufacturing organisation in the Aerospace and Defence Industry (ADI), confirmed that knowledge management is only *average*. Employees would welcome the introduction of new technology to improve knowledge sharing and feel competent to use Web 2.0 and social media technologies. Based on the investigation, an interactive groupware prototype employing collaborative Web 2.0 technologies has been proposed. The prototype will be introduced as a case study to engineers within the collaborating company during product development projects with benefits in productivity and collaborative practices being assessed.

1 INTRODUCTION

The last two decades have been characterised by major developments in enterprise globalisation and technological advancement. This has resulted in many opportunities being created for businesses, but also many problems.

In an increasingly competitive global marketplace, organisations in the 21st century have to overcome challenges presented on a number of fronts which include:

- Meeting the complex requirements of customers who demand lower cost, higher quality solutions and;
- Establishing effective communication channels between employees and external partners anywhere in the world (Shehab, Bouin-Portet, Hole and Fowler, 2009).

The Aerospace and Defence Industry (ADI) is an industrial sector, which has a record of product innovation and where the UK enjoys a global reputation as a world leader (Harrington and

Blagden, 1999). The sector employs highly skilled and competent work forces and is committed to promoting high performance work practices (Richardson, Danford, Stewart and Pulignano, 2010). The ADI is also an industrial environment where significant development of collaborative work practices has already taken place, but where further major opportunities exist for improved Knowledge Management (KM) and the utilisation of technology.

2 PRODUCT DEVELOPMENT AND COLLABORATION

In today's global business environment, manufacturing companies are becoming increasingly aware of the need for on-going product innovations and efficient product development (PD) in order to ensure their commercial survival (Rebolledo and Nollet, 2011). Managers recognise that the traditional process of New Product Development (NPD) is no longer sufficient and that successful PD

now relies upon a far greater corporate team effort than in the past.

A significant challenge facing companies is to facilitate the collaboration of all employees within geographically dispersed teams in order to meet common goals while sharing, developing and retaining knowledge and ideas during on-going PD processes. The use of collaborative web-based technologies is seen as providing the potential to address this challenge by allowing project review teams to access data, records of knowledge contributions and social interactions, all of which would benefit subsequent PD activities (McAdam, O'Hare and Moffett, 2008).

It has also been suggested that companies must "create initiatives to dismantle organisational silos and foster collaboration" (McAdam, O'Hare and Moffett, 2008). Such initiatives are necessary because collaboration is dependent upon the voluntary exercise of discretionary time by employees (CSC, 2006). Effective enterprise collaboration may again be facilitated by the integration of people, processes, information and knowledge through technologies.

In the past, collaboration would often have taken place by phone, fax or in face to face meetings, at significant financial and time costs to organisations. With the rapid growth in the popularity and use of the internet today, however, members of PD teams can now be located thousands of miles apart and still retain the ability to share and address issues with minimal loss of time and cost. The World Wide Web (WWW) can provide an interoperable means for collaboration, utilising software applications on a variety of platforms and frameworks.

3 KNOWLEDGE MANAGEMENT AND WEB 2.0

Businesses recognise 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 making more effective use of their knowledge assets, organisations can benefit from product development breakthroughs and improved processes and practices.

Information and Communication Technology (ICT) tools and, in particular, the internet have a key role to play in supporting KM as they can facilitate "efficient transfer, storage and integration of

knowledge" (Rebolledo and Nollet, 2011, Carlsson, 2003). Their role cannot be ignored as they impact directly on the quantity, speed and efficiency of data flow across both geographical and organisational boundaries (Scott, 2000).

While it is recognised that businesses often cannot identify what is known within their organisations and as a result, best practices, expertise and knowledge and skills cannot easily be applied and transferred (Lockwood, 2008), digital technologies offer the prospect of transferring both tacit as well as explicit knowledge (Rebolledo and Nollet, 2011); (Carlsson, 2003).

Web 2.0 technologies and the relatively new phenomenon of social media with its emphasis on user-generated content, can help eradicate such barriers encouraging open communication and information sharing. Expertise and solutions to problems need no longer remain "hidden" as they can be actively sought out and exploited within a Web 2.0 collaborative environment. Web 2.0 tools, which commonly incorporate semantic web techniques such as meta-tagging, allow for more meaningful information sharing and improved searchability and encourage greater interaction with content by employees during the collaborative process.

4 INDUSTRIAL INVESTIGATION

BAE Systems is a multi-national organisation employing approximately 100,000 people worldwide across its range of businesses. The organisation is the second largest aerospace, defence and security company in the world, and, in 2010, reported sales of over £22bn (\$34.6bn). The organisation is involved in the design, manufacture and provision of advanced products and services for worldwide military forces (BAE Systems, 2011).

An independent bench marking study, commissioned by BAE Systems in 2008, showed that practices in relation to learning and knowledge management were judged to be "average" when compared to similar types of organisations (Milton, 2008). The study concluded that BAE Systems' KM performance, as a world-leading development and manufacturing enterprise, could be raised to "best in class" by following forty-nine recommended actions. The actions identified included the creation of a common collaborative platform for engineering and product development across the company and the embedding of KM activities into various corporate processes including Performance and

Development Review (PDR) and Product Lifecycle Management (PLM).

The last ten years has seen significant growth in the volume of information being generated within the organisation and document management has proven to be an issue for the company (Jackson, et al., 2008). At the end of the last decade, the volume of data being generated was growing at an estimated rate of 41% per annum and the scale of the problem was doubling in size every two years. In the UK business alone, over 1000 different file types were being managed, as illustrated in Figure 1 (Jackson et al., 2008).

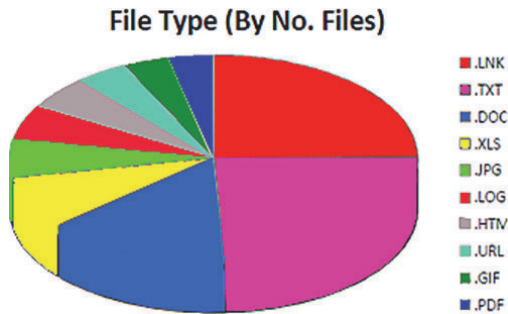


Figure 1: BAE Systems – File Types (adapted from Jackson et al., 2008).

Electronic communications and increased global requirements for compliance with information and knowledge legislation have impacted on the quantity of data in existence and the company recognises that the problem must be addressed. The problem is exacerbated by the number of dispersed teams found within the organisation who find it difficult to arrange face to face meetings. Furthermore, the various business units within the company have different approaches to information management and this has created isolated solutions, a range of different tool sets and a lack of interoperability between business units.

Technological improvements in terms of information search and retrieval, knowledge sharing, document storage and team collaboration are seen to offer significant benefits, including increased agility when reacting to business change, improved collaboration and increased availability of good information to aid decision making.

In late 2011, an in-depth survey of over 100 senior managers and engineers was conducted within the collaborating company. The survey, which was hosted on surveymonkey.com, produced an encouraging 46% response rate and provided a very good insight into knowledge management and the process of collaboration within the organisation.

In commenting below on the results of the survey, the qualitative categories found on the x-axes are based on: 1 - Poor; 2 - Below Average; 3 - Average; 4 - Good; 5 - Very Good; and 6 – Excellent, while the figures given on the y-axes show the number of responses per category.

With regard to how effectively knowledge is managed within BAE Systems during product development processes, the previously drawn conclusion of “average” was confirmed. A third of all responses expressed this view, while 26.7% of respondents thought the effectiveness was *good*, although 23.3% stated that it was *below average*. Only two respondents believed that the organisation was *very good*, while the same number viewed KM as *poor* (see Figure 2).

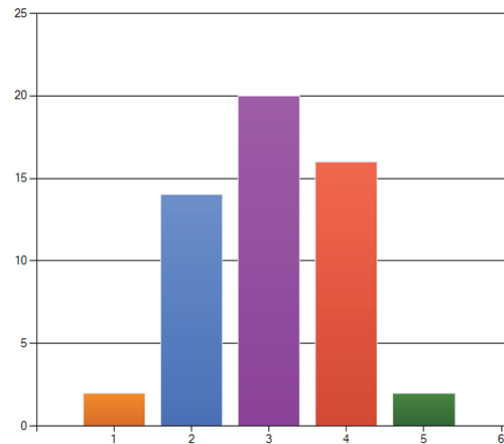


Figure 2: Effectiveness of knowledge management during product development.

On the other hand, as might be anticipated given the security consciousness of the industrial field in which BAE Systems operates, the security of corporate knowledge was seen to be *good* or *better* by nearly 72% of respondents. Indeed, the most common view expressed was that security is *very good* (38.3%) and only 5% believed it to be *below average* or *poor* (See Figure 3).

When asked what concerns may exist in relation to security of corporate knowledge, if online knowledge sharing were to become a standard collaborative practice, there was clear evidence of employees recognising that the commercial success of BAE Systems was founded upon its Intellectual Property (IP); furthermore that the company is bound to comply with a range of national and international laws and regulations.

It was apparent that the requirement to operate within national security and export control

guidelines often resulted in information and knowledge only being shared on a *need-to-know* basis; it was suggested, furthermore, that technological innovations in relation to KM should be introduced only behind the corporate firewall.

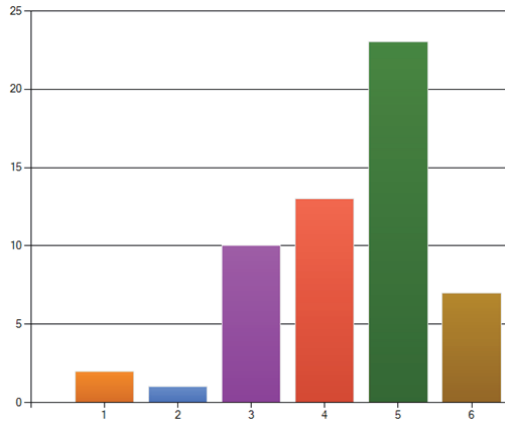


Figure 3: Security of corporate knowledge.

When the investigation focussed upon the specific process of collaboration and how employees interacted and shared knowledge and ideas within project teams, there was clear evidence that traditional methods of communication were still being used routinely, with little reference being made to more recently introduced Web 2.0 tools.

Over 50% of all respondents stated that face to face meetings were the main method of communication, while 47.2% confirmed the significant role played by e-mails in communication; this reinforced the findings of Jackson, et al., (2008) who reported that in July of that year 15 million e-mails had been sent internally.

Video or teleconferencing is seen to play an important role within the organisation and shared document servers are seen as important by 32%.

In terms of more technology-based solutions, Microsoft Sharepoint sites are seen as important by 22.6% of respondents and these rank more highly than the telephone, which accounted for only 20.8% of responses.

Instant messaging and Web 2.0 tools, such as wiki's, blogs and social networking sites including Yammer and LinkedIn, were identified as being important by only 13.2% or less of respondents.

A detailed breakdown of the different methods of communication of knowledge is given in Table 1.

When the effectiveness of collaboration during PD processes was considered (see Figure 4), the most common view expressed was *good* in 37.3% of cases. A further 20.3% thought that they were *very*

good or *excellent*, although 32% suggested that the effectiveness of collaboration was only *average* or lower. This divergence of opinion is again illustrated in Figure 4.

Table 1: Knowledge sharing methods within project teams.

Method	% of Responses
Face to Face Meetings	54.7
E-mails	47.2
Video/Tele/Web Conferencing	45.3
Shared Document Servers	32.0
Microsoft Sharepoint Sites	22.6
Telephone	20.8
Instant Messaging	13.2
Other Web 2.0 tools inc. Wikis and Blogs	13.2
Social Networking Sites, inc. Yammer and LinkedIn	11.3
Informal communication	7.5
Workshops	5.7

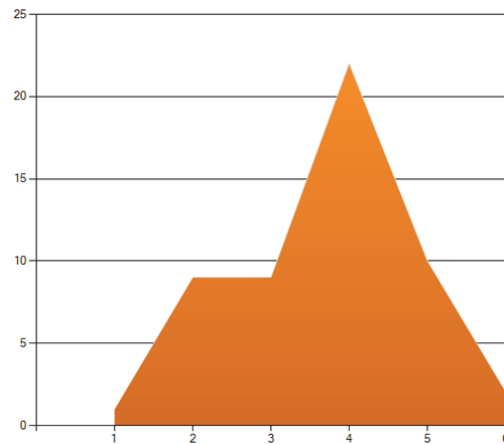


Figure 4: Effectiveness of collaboration during product development.

When asked what barriers may prevent more effective collaboration within the organisation, a limited number of factors were given, although these could be significant. Firstly, the need for security and the legislative background to operations within the aerospace and defence industry could represent a major inhibitor of collaboration and knowledge sharing. Secondly, while operating very much in a technology-driven and innovative environment, there is claimed to be a lack of tools employed to facilitate the collaborative process. Furthermore, geographical dispersment of employees is perceived as a real constraint on collaboration, which impacts negatively on a collaborative ethos.

When asked to identify how collaborative practices could be improved within the organisation, it was interesting to note that repeated references

were made to barriers which hinder collaboration and it was suggested that cultural change is required in order to make a real difference. A number of specific ideas were nevertheless suggested to realise improvements and these included:

- Development of a bespoke project collaboration tool;
- Creation of a centralised information repository;
- Company-wide adoption of Web 2.0 and social media tools.

Finally, the importance of the need for improved collaboration tools within the organisation's global operations was confirmed when it was revealed that *all* respondents have a need to contact colleagues at other locations during PD activities. Over one-third of these contacts take place on a daily basis, while over 60% take place weekly or more frequently. Similarly, nearly 95% of respondents confirmed that they have regular contact with colleagues overseas. Although this contact takes place less frequently than the figures reported for *other sites*, 20% still have daily contact while a further 25% report either weekly or monthly contact.

5 THE PROPOSED INTERACTIVE GROUPWARE PROTOTYPE

Based on the results of the industrial investigation, it is proposed to develop an interactive collaborative groupware solution, which will incorporate a bespoke user interface (see Figure 5).

The groupware will be made accessible using a variety of devices, which will include, but are not limited to:

- An interactive capacitive touch screen all-in-one unit with integrated web camera;
- Personal computers;
- Handheld portable devices, including smart phones and internet tablets.

It is proposed to design a high impact user friendly and accessible front end with easy-to-use navigation and functionality, which complies with the W3C's Web Content Accessibility Guidelines (WCAG). The groupware will be designed using HTML5, CSS3 and JavaScript programming languages to maintain accessibility and usability on a variety of devices. The associated database will be coded in PHP and content will reside on a MySQL database. The collaborative prototype will include:

- Fast and easy access to uploaded user-generated content;
- Instant messaging;
- Project discussion board;
- Timeline file management tool.

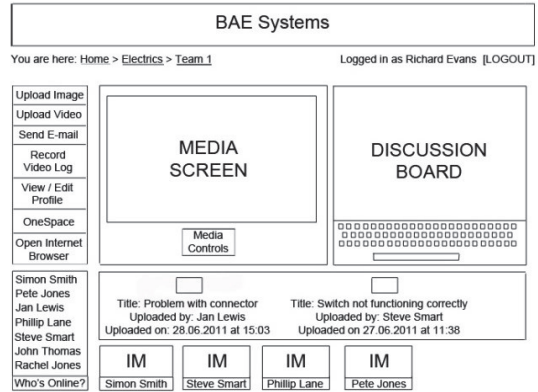


Figure 5: Wireframe of the Front End of the proposed Interactive Groupware Prototype.

During PD activities new concepts and lessons learned will be recorded and uploaded to the groupware site from a variety of file types including video, images, documents and presentations. These will be immediately available to view by project team members anywhere in the world who will then be able to add further comments and ideas to enhance the collaborative new product development process in real-time. Additionally, users will be able to collaborate one-to-one using the embedded instant messaging facility or one-to-many using the on-screen discussion board.

6 CONCLUSIONS

The investigation showed that an increased usage of online collaboration and data exchange methods would be welcomed by respondents.

It was recognised that Microsoft Sharepoint, which has been introduced at various business units over the past few years, had impacted positively on practices within the organisation and there was recognition that the internet could provide employees with more dynamic interactivity, rather than them having to merely rely on more passive methods of communication, such as e-mails.

It was suggested that interactive functionality could allow for formal record keeping, logging of decisions, sharing of information and discussion of ideas. It was proposed that increased use could be

made of Web 2.0 tools, such as wiki's and blogs to improve collaboration and inform work practices.

Social media applications, such as chat rooms and forums could be utilised in order to seek out information and answers to problems, while a central repository of corporate files could be established to improve access to data.

A corporate groupware designed to enhance the sharing of information, beyond simple exchange of data, would be received positively by respondents and, ultimately, knowledge management and collaboration could be enhanced within the organisation. It was recognised that social media tools, which are growing in use significantly in personal lives, have potential for use in corporate KM and provide "even technically illiterate people (with) an accessible way of sharing knowledge" (Anon., 2011).

The investigation confirmed that the internet is seen as allowing BAE Systems the opportunity to overcome barriers to collaboration and KM, which exist within the organisation. It offers the whole of industry the prospect of revealing concealed expertise and exposing employee knowledge and skills; ultimately, it allows dispersed teams to collaborate effectively and more efficiently on a global scale.

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