Crowdsourcing User-Contributed Solutions to Aerospace Product Development Issues through Micro-Blogging

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Abstract: Revenue and production output of the United Kingdom's Aerospace Industry (AI) is growing year on year and the need to develop new products and innovative enhancements to existing ranges is creating a critical need for the increased utilisation and sharing of employee knowledge. The capture of employee knowledge within the UK's AI is vital if it is to retain its pre-eminent position in the global marketplace. Crowdsourcing, as a collaborative problem solving activity, allows employees to capture explicit knowledge from colleagues and teams and also offers the potential to extract previously unknown tacit knowledge in a less formal virtual environment. By using micro-blogging as a mechanism, a conceptual framework is proposed to illustrate how companies operating in the AI may improve the capture of employee knowledge to address production-related problems through the use of crowdsourcing. Subsequently, the framework has been set against the background of the product development process proposed by Maylor in 1996 and illustrates how micro-blogging may be used to crowdsource ideas and solutions during product development. Initial validation of the proposed framework is reported, using a focus group of 10 key actors from the collaborating organisation, identifying the perceived advantages, disadvantages and concerns of the framework; results indicate that the activity of micro-blogging for crowdsourcing knowledge relating to product development issues would be most beneficial during product conceptualisation due to the requirement for successful innovation.

Keywords: Aerospace Manufacturing; Crowdsourcing Knowledge; Employee Collaboration; Knowledge Management; Micro-Blogging

1. Introduction

The Government of the United Kingdom (UK) considers its aerospace industry a "phenomenal success story" (Hough, 2014), employing a technology-driven workforce of approximately 100,000 direct employees, which represents 1.9% of total UK employment. The UK's AI is the largest in Europe, with over 2600 companies operating within the sector (ADS, 2014), and is the second largest in the world, after the USA, enjoying a global market share of 17%. The revenue generated by the global AI is increasing at an annualised rate of 5% and in 2015 it is expected that a new record will be set in terms of production output; this is mainly due to the replacement of obsolete aircrafts by next-generation, more fuel-efficient machines together with the ongoing increase in air travel, particularly in the Middle East and Asia Pacific regions (Captain, 2014).

In today's AI marketplace, manufacturing companies are increasingly becoming alert to the need for on-going product innovation and the development of flexible and responsive work processes to ensure their commercial survival by meeting or exceeding customer expectations. Organisations are now having to develop improved solutions in less time with reduced costs (Carbone et al., 2012); this means that the traditional process of Product Development (PD) is no longer sufficient. Previous practices concentrating upon product cost, quality and time to market are no longer enough to maintain competitive advantage. The focus is progressively turning towards innovation with clearly differentiated product offerings being the anticipated outcome. Against this background, effective employee knowledge sharing is seen as paramount and remains a significant challenge for both small to medium sized enterprises and large Original Equipment Manufacturers (OEMs).

The AI is typified as employing highly skilled and competent workforces, which allow companies to operate effectively worldwide (Richardson et al., 2010). Employee skillsets are now being strained, however, with design and

manufacturing engineers no longer being required to simply have the knowledge to deliver products, such as commercial aircrafts, but additionally they now have to augment their knowledge and skills to be proficient in the use of Computer Aided Design/ Manufacturing/ Engineering (CAD, CAM, CAE), Product Data Management (PDM) and Product Lifecycle Management (PLM) software and other knowledge-based systems (Bertoni and Chirumalla, 2011). Furthermore, research (McAdam et al., 2008) has shown that engineers in PD teams are increasingly expected to work more collaboratively together across geographical boundaries and between multi-functional business units; additionally, they are expected to be conscious of aerospace regulations, such as the International Traffic in Arms Regulations (ITAR), to which companies such as Airbus, BAE Systems and Lockheed Martin must adhere. On top of this, engineering practices and standards in the AI are traditionally based upon high quality components, highly technical data and extended development and production lead times (Johnstone et al., 2009, Niosi and Zhegu, 2005).

Current challenges facing the AI include: 1) The increasing cost of fuel, which as a percentage of operating costs for airlines, has risen to approximately 30% currently compared with only 13.6% in 2001 (International Air Transport Association, 2014); 2) The dramatic rise in air travel by consumers, which has grown by some 8-10% year-on-year (Bouvet et al., 2011) and which is predicted to continue at 4.7% per annum until 2030 (Hough, 2014); and 3) The need for user-contributed social technologies to be introduced to airlines to meet rising customer expectations in terms of communication and entertainment while airborne. These challenges all contribute to global aerospace companies striving to design and manufacture more innovative products which are fuel efficient and provide consumers with cutting edge technology.

In order to meet these identified challenges, the global AI industry has been tasked with creating new or innovative enhancements to existing product lines. The development and production of new, highly-innovative products, however, can often involve extended timescales, high costs and significant risk, relying heavily on employee knowledge to generate new ideas. Consequently, the sector relies heavily on Research and Development (R&D) departments and the use of innovative collaboration technologies, such as micro-blogging, is core to competitiveness. The challenge is further extended as AI employees are often co-located or geographically dispersed around their home countries, typically conducting business and collaborating with colleagues based overseas as they are often part of large multi-national organisations. This has created the requirement of aerospace OEMs to seek novel methods to take advantage of the global knowledge base which their workforces already possess.

This paper aims to explore one such method, micro-blogging, through the development of a conceptual framework introduced in section 4. The proposed framework aims to illustrate how AI manufacturers may use micro-blogging as a social collaboration mechanism to crowdsource user-contributed solutions from dispersed groups for production purposes, thus creating the potential for more open and innovative R&D in PD teams, which have traditionally suffered from a knowledge-silo culture (Evans et al., 2014a).

2. Related Work

2.1 Keyword Analysis

In order to fully appreciate currently-published research relating to the topic of crowdsourcing using micro-blogging as a mechanism for product development activities, a keyword literature analysis was conducted using Elsevier's academic search engine, Scopus. Numerous keyword strings were searched for using Boolean queries to identify research outputs which were most relevant to the topic of this paper; the first column of table 1 identifies the keyword strings which were identified in published articles together with the year of publication, number of papers published per year and number of publications per type.

Firstly, it is interesting to note that zero research was identified which used all three keywords of "Crowdsourcing" / "Crowd-sourcing" and "Product Development" and "Microblogging" / "Micro-Blogging"; n.b. searches producing a value of '0' have been omitted from Table 1. When the search parameters were expanded, as can be seen in table 1, to interchange "product development" for "manufacturing" *or* "product design", research showed a total of 30 papers relating to crowdsourcing in product development and manufacturing. Through analysis of this data, it was identified that three of those 30 papers were duplicates i.e. the authors used two similar keyword terms in one research paper e.g. "manufacturing" and "product development". Of those identified 27 papers, 14 were published between 2013-2014, 8 papers were written in Universities in the United States, with Germany and the United Kingdom each publishing 5 papers. 15 papers were presented as conference papers and 8 as journal articles.

When analysis concentrated on those papers found using the Boolean search terms: 1) "Crowdsourcing" *and* "Microblogging"; 2) "Crowdsourcing" *and* "Micro-Blogging"; 3) "Crowd-sourcing" *and* "Microblogging"; and 4) "Crowd-sourcing" *and* "Micro-Blogging", 11 unique papers were identified. These papers were all written in the time period of 2011-2014. Interestingly, when the review concentrated on the activity of micro-blogging in a product development *or* manufacturing setting, research was extremely limited, displaying only 1 article, which in fact, was that of the authors of this paper (Evans et al., 2014a).

Table 1: Analysis of Published Literature relating to Crowdsourcing in Product Development *or* Manufacturing

Search Terms	No. of Papers	Year	No. of Papers	No. of Papers per Publication Type	Publication Type
"Crowdsourcing" and "Product Development"	**14**	2014	4	2	Journal Articles
				2	Review Papers
		2013	4	2	Journal Articles
				2	Conference Papers
		2012	4	1	Journal Article
				2	Conference Papers
				1	Research Note
		2011	1	1	Journal Article
		2008	1	1	Conference Paper
"Crowdsourcing" and "Product Design"	**10**	2014	3	1	Journal Article
				2	Conference Papers
		2013	4	4	Conference Papers
		2012	1	1	Conference Paper
		2011	1	1	Conference Paper
		2008	1	1	Conference Paper
"Crowdsourcing" and "Manufacturing"	**3**	2013	1	1	Journal Article
		2012	1	1	Conference Paper
		2009	1	1	Journal Article
"Crowd-sourcing" and "Product Development"	**2**	2011	2	1	Conference Paper
				1	Research Note
"Crowd-sourcing" and "Product Design"	**1**	2011	1	1	Conference Paper

Conclusions drawn from this analysis exercise include:

▪ The spelling of crowdsourcing and micro-blogging is not always consistent – micro-blogging is not hyphenated 10 out of 12 times and crowdsourcing is not hyphenated 3 out of 38 times;
▪ All research papers identified were published from 2008 onwards, even though the term crowdsourcing was first introduced in 2006;
▪ The majority of research into this topic was conducted between 2013-2014 (57.8%) and were predominantly published as conference papers (63.1%) or journal articles (23.6%);
▪ Researchers in the USA accounted for 13 (34.2%) published papers, with the United Kingdom (15.7%) and Germany (13.1%) closely behind; and
▪ The majority of research published was in the Information Systems, Communications or Human Factors subject areas. Those publications with more than 1 paper published were: ACM's Computer Communication Review and ACM's Conference on Human Factors in Computing Systems.

2.2 Review of Published Literature

The authors of this paper have published several exploratory studies (Evans et al., 2012a, Evans et al., 2012b, Evans et al., 2014c, Evans et al., 2014b) detailing the use of Web 2.0 technologies, including micro-blogging, within the aerospace industry; their investigations concluded that:

▪ AI employees are increasingly using online collaboration and information exchange methods;
▪ AI organisations lack a standardised process for capturing and sharing explicit employee knowledge;
▪ The use of more interactive Web 2.0 functionality, such as micro-blogging sites, would encourage more formal record keeping, logging of decisions, sharing of knowledge and discussion of ideas; and
▪ Increased use of social media applications offers the potential for improved knowledge capture and sharing, problem sharing and, ultimately, innovation.

This paper extends this previous work by exploring how micro-blogging, as a mechanism for crowdsourcing, could capture user-contributed solutions to aerospace product development issues.

2.2.1 Using Micro-Blogging to Crowdsource

The concept of crowdsourcing has been a developing research topic in the field of Information Systems and Design Science since the early noughties (Pedersen et al., 2013), but has received little attention in publicised aerospace literature and, indeed, in the manufacturing industry, in general. In the July/August 2014 edition of IEEE's Software Journal, Wang et al. (2014) concluded that "micro-blogging as a crowdsourcing mechanism hasn't received much attention in previous studies", but that there is "clear potential for it". Ehrlich and Shami (2010) added that micro-blogging has generated a lot of research interest in the public domain, but very little is known yet of how employees may make better use of it.

At present, the most widely-known application of crowdsourcing is within the recruitment industry, where sites such as Amazon's Mechanical Turk (https://www.mturk.com/) and microWorkers (https://microworkers.com/) have allowed organisations to crowd source ad-hoc members of staff to complete one-off tasks in return for financial reward. As illustrated in Figure 1, the generic business model is one of companies posting an advert detailing a specific job and potential 'employees' then bidding for the opportunity to do the job i.e. the organisation selects who to do the job, based on peer-reviews for previous work carried out and a quoted price. For the organisation, it allows them to tap into a global knowledge base and have the work completed for a fee which they judge to be reasonable and competitive. Further applications of crowdsourcing exist in industry and these include, for instance in the field of astronomy, Galaxy Zoo (http://www.galaxyzoo.org/), which aims to crowd source participants to help understand how galaxies are formed and how they may be classified by shape.
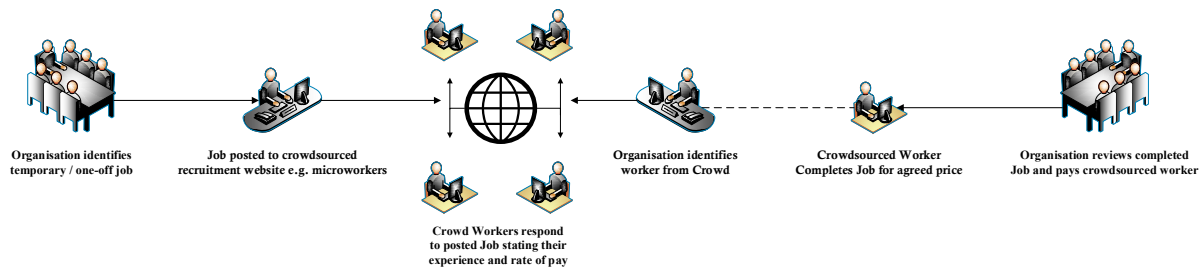

Figure 1: Generic Crowdsourcing Business Model

The most commonly agreed definition of crowdsourcing was provided by Jeff Howe (2006) in an article written for Wired.com in 2006, where he coined the term 'crowdsourcing' by stating that it is "the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call". Other researchers (Brabham, 2009, Surowiecki, 2004) have offered their own definitions of the term and these include Pedersen et al. (2013) stated that "Crowdsourcing is a collaboration model enabled by people-centric web technologies to solve individual, organisational and societal problems using a dynamically formed crowd of people who respond to an open call for participation". Tarrell et al. (2013) offered a more concise definition, concluding that it is the act of "using the collective intelligence of a large group of people to help solve problems". Researchers (Tarrell et al., 2013) have also used different inter-changeable terms to describe Crowdsourcing, including 'Peer Production', 'User Generated Content' and 'Smart Mobs'.

Increasing corporate usage of Web 2.0 technologies has driven the development of bespoke applications which employ crowdsourcing principles, although the use of such tools to crowd source is still in its infancy. In the academic world, little research has been conducted into the use of crowdsourcing within a manufacturing environment, especially within the AI, as may be concluded from Table 1. Multi-national OEMs have now started to adopt crowdsourcing as a method for problem solving, but current academic research mainly focuses on the activity from the point of view of companies seeking input from external sources i.e. using crowdsourcing as a mechanism to engage with potential customers or suppliers.

Closely aligned to this paper, Yu and Nickerson (2011), in the field of product design, proposed a sketch combination system which was tested by 1047 participants. Each member of the crowd submitted sketched designs of chairs for children whilst other crowd members evaluated the contributions; this allowed the problem owner to develop a complete product through iterative crowd design. Also in the field of product design, Müller, Thoring and Oostinga (2010) developed an online crowdsourcing game, which allowed designers to collect empirical data to understand what meanings users associate with certain shapes; they aimed to develop a crowdsourcing-based method to establish common meaning for shapes/forms.

Academics and industrialists have expressed several concerns in relation to the activity of crowdsourcing. Both Pedersen et al. (2013) and Sonnleitner et al. (2013) commented on intellectual property rights and copyright ownership of the solutions submitted and stated that this could be a crucial barrier impeding the success of crowdsourcing within enterprises. Pedersen et al. (2013) continued by stating that the success of a crowdsourcing campaign may depend on attracting and retaining knowledgeable participants. Organisations must optimise their crowdsourcing retention policies to motivate solution providers to continue contributing ideas to solve identified problems. Trust between problem owners, solution providers and the crowd is a key factor underpinning successful crowdsourcing. The crowdsourcing instigator/problem owner should generally seek to provide constructive feedback to a solution provider to develop motivation; this should help to develop future ties and encourage further contributions from existing crowd sourced participants. Moon and Sproull (2008) concur with this need for positive feedback, stating that users are more likely to return to a problem owner's issues when feedback has previously been provided.

Researchers (Müller et al., 2010, Kaufmann et al., 2011) tend to agree that the most notable challenge found in crowdsourcing is to keep the solution providers motivated. They separate the reasons for solution providers contributing to crowdsourcing into two distinct categories: extrinsic and intrinsic. Extrinsic motivation refers to tangible payoffs, whereas intrinsic refers to a solution provider achieving some form of personal fulfilment from contributing solutions. Müller et al. (2010) divided the reasons into four motivational categories: money, altruism, usefulness and fun. Other researchers (Arakji and Lang, 2007, Yu and Nickerson, 2011) conclude that by offering extrinsic motivation to solution providers, it may create social barriers in the workplace and discourage cooperation on the part of some. Furthermore, some potential solution providers may wish to sabotage PD projects by submitting solutions which they know will not succeed.

Finally, some academics and industrialists may question the need for crowdsourcing activities when internet search facilities are readily available at each employees desk, but as Savage (2012) stated, humans bring added benefits to crowd sourced problem solving, including their ability to notice unusual things and to ask questions which were not mentioned in the original problem identification. The World Wide Web *per se* is not able to highlight anomalies or suggest suitable changes, whereas motivated individuals forming part of a large crowdsourcing initiative are likely to suggest and develop novel and more innovative solutions.

2.3 The Identified Potential

Today, huge amounts of explicit knowledge exist in various formats including documents, images, videos and audio files. By employing Web 2.0 technologies, such as micro-blogging, enterprises are able to connect people to people and people to information more effectively; they can facilitate connectivity, sharing and collaboration across boundaries, capture a wide range of views and information that is typically informal or highly dispersed and, indeed, help colleagues locate previously unknown experts (Lee, 2013). More specifically, employees are able to identify and share organisational resources more easily via a less formal communication channel; this in turn encourages greater interactivity and collaboration in the workplace.

Crowdsourcing offers individuals seeking solutions to specific problems the ability to elicit collective knowledge using an informal communication channel, such as micro-blogging. It enables users to reach out to a wider virtual community and extract knowledge which previously remained hidden. The potential on offer in terms of outward facing contact with customers is recognised and being pursued by organisations, such as Lockheed Martin, Northrop Grumman and GE, but the use of Web 2.0-based tools in aerospace manufacturing still appears limited (Aerospace Industries Association, 2010).

Research (Harden, 2012) shows that the use of web 2.0 tools within organisations can impact both positively and negatively on corporate practices. They can increase employees' knowledge and allow them to find potential solutions far more quickly than typical internet browsing. On the other hand, the use of external web 2.0 tools, may be seen as a distraction to workers and could lead to leakage of confidential information.

In terms of the PD process, Web 2.0 platforms and micro-blogging, in particular, offers the prospect of generating and encouraging innovation. Organisational behaviour research (Paroutis and Al Saleh, 2009, Razmerita et al., 2009) has shown that collaborative Web 2.0 tools are especially effective where a high value is placed on technical knowledge. In global enterprises, it is often difficult to identify and locate individuals who possess highly specific expertise as it can remain hidden – and consequently unexploited – within complex organisational structures. Indeed, in hierarchical

organisations, in particular, where a 'knowledge silo' culture is recognised to often exist, there is frequently no incentive for employees to look beyond their familiar workplace setting of nearby colleagues as sources of information. Web 2.0 technologies, however, can help overcome such barriers by encouraging more open communication and knowledge sharing. Expertise and solutions to problems need no longer remain concealed as they may be actively sought out and elicited in a more informal manner. Web 2.0 tools allow for visible communication and the positive input of any employee to collaborative problem solving; consequently, this can be recognised and, indeed, rewarded by management.

3. Methodology

In order to create the proposed framework, an exploratory investigation was conducted within a collaborating aerospace OEM between October-December 2014. The investigation produced an as-is process model which was created to identify the key processes employed by PD teams when searching for ideas and solutions to identified problems relating to design and production. The captured process model was then embedded into the created framework, shown in Figure 2, which identifies 4 key actors for the successful identification of solutions to identified problems by product development teams.

In order to validate the proposed framework, a one-hour focus group meeting was held with 10 employees from the collaborating organisation in June 2015. This allowed for the identification of the perceived advantages and disadvantages of the framework, detailed in section 6.

4. The Proposed Framework

This paper contributes to the general fields of Product Development and Manufacturing Informatics and also extends into the research fields of Information Systems and Design Science. Specifically, we aim to extend published research relating to the use of micro-blogging in product development activities.

In order to improve the crowdsourcing of knowledge to address issues and better inform product development processes, a methodological framework has been developed to illustrate how aerospace organisations may employ micro-blogging to generate user-contributed solutions to PD problems.

As can be seen in Figure 2, the framework is presented against a background of 5 key stages to generate preferred solutions. The stages are broadly based on those found in generic PD processes generally employed within the AI. Essentially, the scope of the activity covers Problem Identification through to Evaluation and Implementation, with a further Post-Implementation stage to address motivational issues to encourage further participation in crowdsourcing activities.

The framework is presented for adoption when problems arise during PD processes or any other situation where organisations need to encourage the contribution of employees and partners to address operational issues. Specifically, it is believed that the framework would prove particularly beneficial during the concept creation and solution development stages of problem solving, where innovation and blue sky thinking is vital and where demanding challenges are most likely to be encountered.

The activities involved when adopting the framework are covered in detail in Table 2, which explains in a step-by-step format, with step numbers marked in Figure 2, the potential actions taken by participants in the framework. The key actors in the process are introduced below and it is suggested that the knowledge captured via the framework will constitute a knowledge base which is accessible to both the problem owner and anyone who is a member of the Crowd. Participants in the process will be able to contribute to the improved sharing of ideas and solutions to manufacturing problems through the more informal mechanism of micro-blogging.

4.1 Key Actors

The **Product Development Team (PDT)** is the key stakeholder group responsible for delivering new products and product enhancements.

The **Problem Owner (PO)** is the employee within an organisation who has been delegated the task of solving a specific problem relating to the design or development of a product or modification. The PO has control over the selection of

Crowd participants who are targeted to receive notification of the problem by assigning targeted @UserAccount or by using specified keyword-rich #Hashtags. He/She also has the final decision on which solutions are selected for presentation to the PDT.

The **Crowd (C)** is the group of individuals within the organisation, and possibly beyond, who participate in the crowdsourcing activity. Employees within the 'Crowd' may not necessarily contribute final solutions, but may identify concerns or suggest comments to inform the evaluation process undertaken by the PO.

The **Solution Provider (SP)** is an individual or group that proposes a possible solution to the identified problem. The SP may at some stage become involved in implementation activities relating to the proposed solution, when adopted. The SP volunteers their own tacit knowledge or acquired explicit knowledge to the PO, dependent on their motivation and potentially the reward on offer, if the solution is adopted by the organisation.

Within the micro-blogging environment, employees in the 'Crowd' may choose to collaborate between each other before and while contributing ideas or solutions to the PO; this communication is visible to others and participation in the discussion by either the PO or other Crowd members may lead to even more informed or innovative solutions being developed.
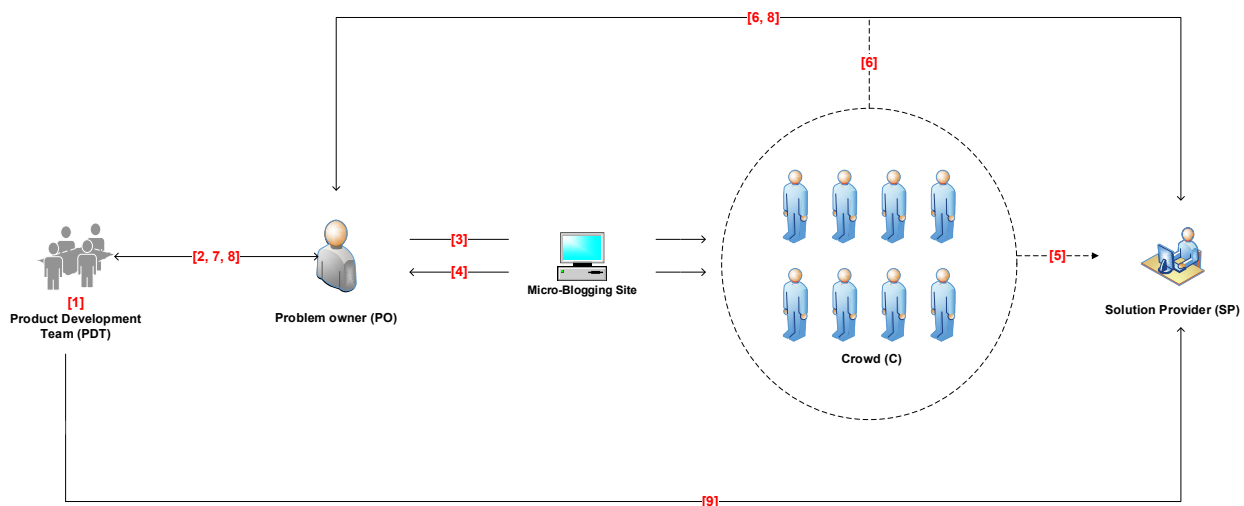

Figure 2: Proposed Crowdsourcing Framework Using Micro-Blogging

Table 2: Steps to Implement Proposed Framework

Key Stages	Step	Activity
Problem Identification	1	**Product Development Team (PDT)** details problems and issues relating to design and production.
Concept Creation	2	**PDT** delegates problems to designated **Problem Owner (PO)** to elicit potential solutions from others (**Crowd**).
	3	**PO** shares problems with online micro-blogging community using specific keyword-rich #Hashtags and targeted @UserAccount; invites input relating to potential solutions – contributions also encouraged from the wider crowd through re-posting.
	4	Specific problems/issues refined informally through further messaging between **Crowd** members and **PO**.
Solution Development	5	Members of the **Crowd** suggest ideas and propose potential solutions with one or more emerging to become **Solution Providers (SP's)**.
	6	**PO** communicates specifically with **SP's** to evaluate, develop and refine potential solutions, although communication remains visible to members of the **Crowd** to allow for further input.
Evaluation and Implementation	7	**PO** presents potential solutions to **PDT** for discussion and feedback; further development/ refinement of ideas may be requested from the **Crowd**, on an iterative basis.
	8	When preferred solutions agreed, **PDT** authorises implementation with the possibility of **SP's** being involved in the deployment.
Post-Implementation	9	Constructive feedback given to **SP's** by **PDT**, with potential financial reward.

5. Analysis of Proposed Framework

Howe's (2006) coining of the term "Crowdsourcing" in 2006 highlighted three key actions to harness the full benefits of using crowdsourcing. Firstly, the specified task must be solvable by a large group of people, whether co-located or dispersed. Secondly, the problem owner must have access to a large group of people that are able to work collaboratively or independently towards a solution, and thirdly, but possibly firstly, the problem owner must be able attract people to join the large group (crowd) via an open call.

The proposed framework meets all three characteristics identified by Howe by 1) allowing the problem owner to send out a company-wide message either via an open call to all or via targeted messages using specified @UserAccount's or #Hashtags; 2) if the problem is unsolvable within the organisation, the problem owner can make the problem transparent outside of the organisation by posting on an external micro-blogging site, although this is not always encouraged, especially in security-conscious industries, such as the AI; and 3) crowd members are able to work collaboratively by using specified project #Hashtags or are able to work independently and setup a private dialogue directly with the problem owner, if preferred.

When consideration is given to how micro-blogging could be integrated into the traditional product development approach to assist with the crowdsourcing and solving of problems, it can be illustrated against the process proposed by Maylor (1996), shown in Figure 3. During the identification of customer needs, the marketing department of a company may use micro-blogging to communicate with current or potential customers to identify their needs and record any problems previously experienced with current products. During the product design stage, designers could use micro-blogging for project team collaboration and to confirm the marketing brief. During manufacture, micro-blogging could be used by engineers to discuss and solve any issues which arise during production. Finally, once the product is manufactured, marketing can again use micro-blogging to sell the product, via a social media campaign, but can also utilise it for recording initial problems/faults experienced by customers.
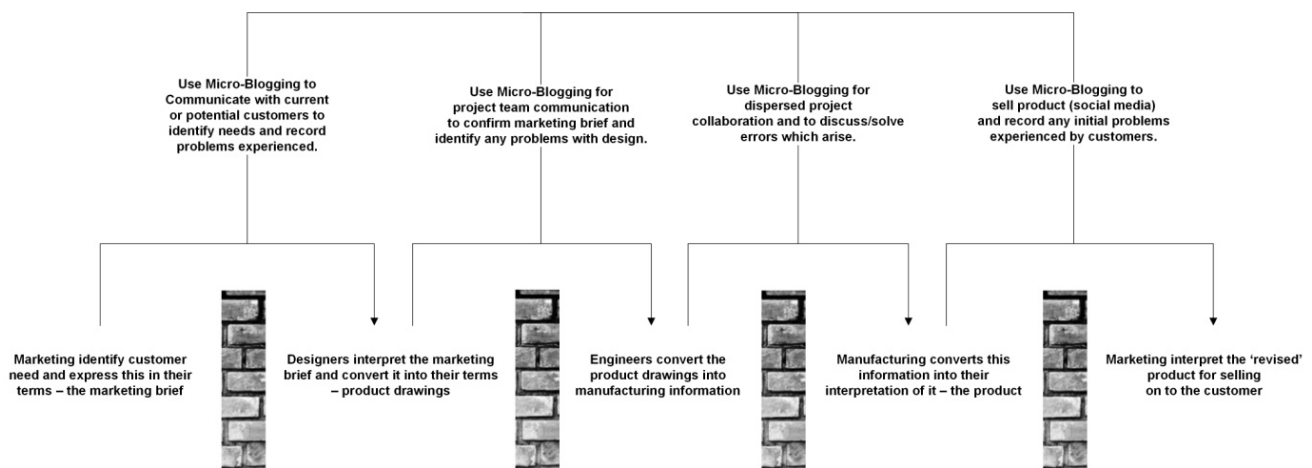

Figure 3: Micro-Blogging Activities involved in Maylor's (Maylor, 1996) Traditional Approach to PD

6. Validation Exercise to determine Advantages and Disadvantages of the Proposed Framework

For initial validation of the proposed framework, a one-hour long focus group with 10 employees from the collaborating AI OEM was conducted in June 2015. The meeting allowed for the identification of perceived advantages and disadvantages of the framework by employees of the organisation who would play a 'key actor' role within the crowdsourcing process. Results of this meeting are now provided.

6.1 Perceived Advantages

The focus group revealed that the proposed micro-blogging framework would be welcomed within the product development environment of the collaborating company, with interviewees agreeing that "right now, knowledge is stored in very few places. Knowledge dispersal can only be a positive thing". However, numerous concerns do exist, as recognised in section 6.2.

With regard to perceived advantages, interviewees believed it would be most beneficial during product conceptualisation; this is due to "most of our ideas and problems arise during initial project meetings". One respondent stated that the "advantages would be endless. Across the different company sites there are people dealing with the same or similar problems. At present, there is a lack in communication or collaboration between these people and micro-blogging or something similar could help solve this issue". A further comment was made stating "collaboration is generally driven at senior level and often in response to a programme specific requirement. A developed tool, based on the framework, would allow us to effectively make decisions at production level".

With respect to security, all interviewees concurred that "if relevant knowledge is shared with people at the correct security level, there should be no issues…the benefits will greatly outweigh any security concerns".

Interviewees recognised that micro-blogging would allow PD engineers to "contribute information towards a collective project resource", but that it will depend on "peoples' willingness to create and share ideas". One respondent acknowledge that it would allow his team to "find each other and get more personally involved", allowing employees to "identify experts on any given subject".

Finally, a major advantage was acknowledged by all – "it would facilitate discovery by removing silo walls".

6.2 Perceived Disadvantages and Concerns

The meeting raised a number of disadvantages and concerns relating to the proposed use of micro-blogging within an AI organisation product development environment. Firstly, security was seen as a major inhibitor to successful implementation. Interviewees reported that safeguards would need to be put in place, but they were confident that they could be. Documentation which was shared via the micro-blogging tool would need to meet required security levels and must be "assured as free from ITAR and UK security classifications"; interviewees were concerned with how this could be done effectively.

User training was raised as a major concern for the framework and any developed tool based upon it. Interviewees reported time constraints with regard to training could be an issue and that policies would need to be put in place which taught employees what they may and may not share outside of the PD environment; interviewees concurred that "people could inadvertently make something public to the general crowd". One interviewee added "I think it will be difficult to encourage people to share", while another added that "access control, particularly across countries, is an area for concern". A further disadvantage relating to employee knowledge was that interviewees felt that their intellectual capital or product knowledge may be leaked outside of the organisation through sharing or "re-tweeting".

One respondent identified a potential issue with regards to the user interface of any developed tool, stating that "a key aspect is the user interface. Make it simple to use and people will use it. Make it difficult to use and people won't use it".

A final conclusion by all key actors was that the developed micro-blogging tool, based on the proposed framework, must be embedded into current systems which the PD teams are using, such as PTC Windchill, and not developed into "yet another tool" which becomes redundant over a period of time.

7. Conclusions and Future Work

Crowdsourcing within enterprises offers AI organisations and those operating in other industries the ability to capture problem solving knowledge from network-connected contributors via the use of Web 2.0 technologies. This paper proposes a methodological crowdsourcing framework which enables users to elicit solutions to PD problems through the mechanism of micro-blogging. It empowers problem owners to reach out to targeted or unfamiliar colleagues who may be either co-located or dispersed within the business environment.

As with the majority of Web 2.0 technologies which facilitate user-contributed content, crowdsourcing is susceptible to possible interference during usage, including the submission of inaccurate or incomplete knowledge being from colleagues. By including the 'moderator' role, it enables trusted users within the organisation are enabled to edit submitted content and delete inappropriate contributions. Motivational factors also come into play when user-contributions are concerned; companies may wish to put in place reward or recognition mechanisms to promote the contribution of solutions to recognised problems.

Large multi-national organisations may face problems with regard to language barriers and may wish to incorporate a multi-lingual translation service into the micro-blogging tool to enable automatic translation of content for colleagues from overseas locations to be able to read problems being faced. A 'monetary' award for contributions is also recognised in the literature and could be employed within the framework to improve the sharing of solutions to identified problems.

Of course, it should be acknowledged that certain barriers may exist if organisations wish to use the proposed framework with external micro-blogging tools, such as Twitter.com. These could include unwanted hijacking of discussions by other Internet users who simply 'guess' #Hashtags which project groups are using. Indeed, as the aerospace industry is one which is highly security conscious, organisations must also make sure that documents which include sensitive material are not shared on these sites and, for that reason, the authors of this paper recommend that an internal solution based on the framework proposed is developed, rather that incorporating the framework using an external micro-blogging website. In large organisations, future work may include the incorporation of a user-tagging mechanism, which allows users to target specific groups of employees within the organisation, rather than sending out their 'issues' to the whole Crowd; this should assist in the minimisation of problem-overload. Finally, from the analysis of the validation study, it can be concluded that employees of the collaborating company believe that the usage of micro-blogging for crowdsourcing ideas and solutions to identified production problems would be beneficial. Further research exploring how the framework may be embedded into bespoke product development activities would be seen as beneficial.

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