TOWARDS OPEN INNOVATION PRACTICES IN AEROSPACE INDUSTRY

Vinit Parida[1,a], **Tobias C. Larsson**[1,b], **Ola Isaksson**[2,d] **and Pejvak Oghazi**[1,c]

[1]*Division of Entrepreneurship and Industrial Management, Luleå University of Technology, Luleå, Sweden.*
Email: [a]*vinit.parida@ltu.se,* [b]*tobias.c.larsson@ltu.se,* [c]*pejvak.oghazi@ltu.se*
[2]*PD Process Management, Volvo Aero Corporation, Trollhättan, Sweden.*
Email: [d]*ola.isaksson@volvo.com*

Across industrial settings and environmental conditions, innovation is viewed as a source of advancing firms' competitive position. Recently, a shift has been witnessed from the traditional innovation model, which mainly focused on internal research and development (R&D) towards open innovation. In this study, we have attempted to study if this approach is suitable for the regular, more mature industry by focusing the context of aerospace industry. The study involves a single case company that is a developer and manufacturer of components for both civil and military aero engines as well as for rocket engines. In addition to previous findings we would like to propose three key areas, which need special attention by any company aiming to successfully realize open innovation. These areas are people, process and technology, put into a framework. The PPT framework was found to be particularly helpful regarding the organizational changes needed for open innovation.

Keywords: Open innovation, challenges, opportunities, framework, aerospace industry.

1. INTRODUCTION

Across industrial settings and environmental conditions, innovation is viewed as a source of advancing firms' competitive position. Recently, a shift has been witnessed from the traditional innovation model, which mainly focused on internal research and development (R&D) towards *open innovation*. The term "open innovation" was coined by Henry Chesbrough [1] and he proposed that companies can and should use external ideas as well as internal ideas, and internal and external paths to market, as the companies look to advance their technology. There are two rational for companies to open their product development process. First, as not all competent people work for a single company being able to tap into the knowledge and expertise of bright individuals or highly specialized companies can allows firms to rapidly develop commercially viable technological products and second, as companies usually possess technologies which are not necessarily targeted towards their current market needs, it can be beneficial to leverage from these technologies through licensing-out or venturing them for increasing companies' monetary performance [2, 3].

Despite the expected positive effects, limited number for companies have been successful in practicing open innovation. Most industrial examples are related to software industry, where "open source" development has become a popular phenomena or business to consumer (B2C) setting such as use of "connect & develop" by Procter and Gamble or pharmaceutical industry [4]. Thus, the question remains, if open innovation is applicable or valuable for companies from more traditional or mature industries? And if, so what are the potential opportunities and challenges with adoption of open innovation in these industries?

In this study, we have attempted to shed light on these questions by focusing on issues surrounding open innovation in the context of aerospace industry. Since, the development of the first powered flight

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by *Wright brothers* in 1903, Aerospace industry has become an integral part of modern transportation. This industry is widely diverse with a multitude of commercial, industrial and military applications. Regardless of the application, the products manufactured in the aerospace industry are classified as *complex products* [5], because they are characterized by continuous technology development and high cost intensity. The requirements on the industrial companies is also high is respect to *safety and regulations*. Many would regard that the industry has zero tolerance to product failure compared to other industrial settings. This means, there is a *long product development process*, which can take anywhere between 10 to 15 years from idea to final delivery of the product. Moreover, the *life cycle of a product is more than 40 years* and during this time, the companies should be able to provide *complete product support*. These characteristics make the aerospace industry particularly interesting for investigation and similar to companies from "high tech" manufacturing industry or nuclear energy industry.

Although, open innovation could ease the pressure of most companies in aerospace industry as they would be able to addressing high innovation requirements by opening their product development process, integrating external technologies, and forming risk and revenue sharing agreements. It can also increase the risks as the collaborations would need to be sustained over a long period of time and companies would lose control over the product development process. Thus, based on this background the purpose of this *explorative study is to gain detailed understanding of open innovation applicability in a mature and complex industrial setting, like aerospace*. This purpose would be achieved through two steps. First, by identifying potential opportunities and challenges with open innovation for aerospace industry and second, by presenting a generic framework which can guide companies intending to adopt open innovation. Thus, the contribution of this study will be towards practitioners and academia as we will be able to provide theoretical contribution to open innovation literature and practical insights to the managers.

2. RESEARCH APPROACH

In order to achieve the stated purpose, a qualitative research approach was adopted as the focus of this study is to gain deeper understanding of a complex real-life situation [6]. The study involves a single case company that is a developer and manufacturer of components for both civil and military aero engines as well as for rocket engines used for space applications and gas turbine engines. The company work as a first-tier supplier to the major aero engine manufactures (OEMs), see Figure 1. These companies are increasingly expected to take large responsibilities while simultaneously reaming depended on OEM due to the strong system dependency that exits for subsystem and components provider companies in aerospace industry. This leads to an insecure and complicated industrial position of first-tier companies.

Moreover, as the authors are involved in a research project at their university, it provides a unique opportunity to gain access to rich data from the case company. The mode of data collection was semi-structured interviews and focused group discussion. This method was chosen because it provides the respondents with the freedom to speak from their experiences [6]. The respondents' stories and examples from their experiences were important to capture in this study. The interviews were mainly performed personally. Moreover, all interviews were recorded so that they could be replayed later for increasing the reliability of data.

The respondents were selected based on having long experience (i.e. more than 5 years) of working in different development projects within areas product development. In total, 12 detailed interviews and a group discussion involving 7 respondents was undertaken. The atmosphere during the interviews and discussion was sensed to be quite honest as the respondents stated clearly when they felt that they could not answer the question. Therefore, the risk that they would be guessing or making up answers to any questions can be assumed to be low.

The content analysis was made by first transcribing the recordings of the interviews. These transcripts were sent to the interviewees so that they could agree, correct, and/or comment on the answers. At this point they also responded to further questions that the researchers developed during

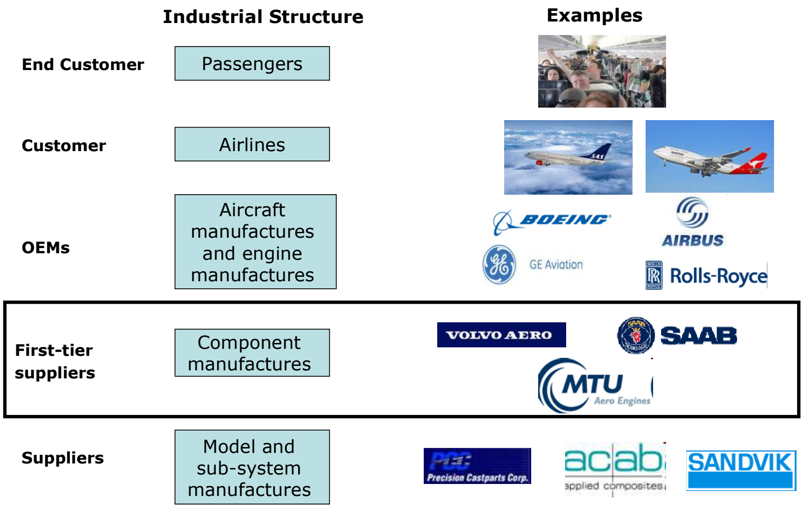

Figure 1. Industrial structure of aerospace industry.

the initial screening and analysis of the interviewed material. Thereafter themes, originating from the purpose of the study, were used to classify the data. The data was later reduced, where relevant information which acts as the bases for the upcoming sections.

3. OPEN INNOVATION OPPORTUNITIES

Aerospace has primarily been driven by product performance and safety. However, in recent decade the environmental impact has increased the importance of cost advantage. This is status is further intensified as new competitors from emerging markers are entering the industry, such as Brazil and China. In this respect, an open innovation approach could provide several strategic advantages to the companies in aerospace industry.

During data collection, we explained the respondents about main principles behind open innovation and how it differed from the traditional or closed innovation approach. Based on this new insight, they were asked them to visualize potential opportunities or provide examples of existing activities which could be related to open innovation. In the following section, some of the prominent opportunities with open innovation for aerospace companies will be presented.

1) *Cost and risk sharing:* The product development of Boeing 787 Dreamliner involved more than 50 first-tier suppliers. This clearly depicts the complexity related with development of the products in Aerospace industry. Thus, to manage product development most companies could gain from opening their boundaries for collaboration and creating extended enterprise or/and virtual enterprise. This open innovation approach would then lead to spreading the costs and reducing the risks with product development.

2) *Access to external competence*: Open innovation approach suggests that not all competent people work in a single company, therefore depending only on internal research and development (R&D) may lead to higher cost and loss of opportunities. This is the reality for many companies, in the world of mobile workers and widely distributed knowledge companies are required to access external competence [1]. In the Aerospace industry, after the predevelopment phase, most companies have a short window to get involved in a project. Once they agreed on a contract, they are expected to deliver otherwise breach of contract can be lead to heavy loss of money and reputation. Therefore, companies can substantially gain from having access to pool of experts which could compensate for lack of internal knowledge and compliment the existing knowledge during product development.

3) *Licensing-in technologies:* This point builds on the previous argument, but takes it a step further. As the products that are sold in aerospace industry are already sold before they are build (i.e. contract-driven), and the companies have limited time span to build the complex product. Many companies can foresee the strategic value in accelerating their product development by licensing-in external technologies [7]. This approach is particularly suitable for aerospace industry as rather than "reinventing the wheel", the company can build on tested technologies and acquire it at lower costs, thus reducing the odds of breaching the contract.

4) *Employees involvement:* Employees in the aerospace industry are required to have complimentary competence as the end product on one company would function in conjunction with another company's end product. This can have positive effect on employees working with R&D as over time they formed "T-shaped competence", meaning that they possessed deep skill in their area of expertise as well as board horizontal knowledge in other areas. In this respect, adapting open innovation approach could facilitate a company to capitalize on its employees' knowledge and experience through developing products that address new market needs. Moreover, if the product idea falls far outside the company's' scope, they could also patent it and licensing-out the technologies to other companies in return for monetary gains.

5) *Product-service system:* Several aerospace companies, particularly in the engine manufactures are attempting to integrate product and service in one value added offer. Traditionally, companies have sold products but there is a shift towards selling functionality. This would mean that the manufacturing company will own the product, while customer would pay based on the utilization of the function, such as the "power by the hour" approach of Roll-Royce Corporation. To reach this purpose companies have to collaborate with up-stream and down-steam partners and develop a product-service system. In this respect, an open innovation approach would serve companies to open their development process and facilitate companies to develop new business model which is based on the win-win ideology.

4. OPEN INNOVATION CHALLENGES

Although, the above discussed opportunities can be a driver for the implementation of open innovation, it only represents one side of the coin. This discussion is incomplete without a thoroughly considered risk and challenges that may prohibit companies from successful implementation open innovation in aerospace industry.

1) *Loss of competitiveness in long-term:* Most companies fear that opening their boundaries to other companies in the value chain could lead to loss of core competitiveness. This loss of control over its own technology as it leaks out to partners is a prominent concern which hampers the transformation towards open innovation. Moreover, companies also need to consider that partners (e.g. suppliers) that collaborate presently may become direct competitors in future, such as in the case of software industry. This may be one reason why companies prefer not to license-out their internally developed technologies and prefer to keep them on the "shelf". However, as recently Boeing has sub-contracted large development work to third parties for the 787 Dreamliner project. This can be seen as a positive trend which may catch on in future.

2) *Intellectual property rights*: When discussing open innovation, intellectual property (IP) rights are always considered as a critical issue. The development of an agreement with fair ownership rights of IP is a challenging task. Additionally, if the collaboration involved uneven balance of power, then the larger companies may dictate the terms and conditions, which adds to complexity and likelihood for dissolution of collaboration. However, the main challenge is not IP agreement *per se*, but rather how to foster a collaborative environment where partners feel safe and secure to share ideas and co-develop new products. Reaching such an open collaboration can be challenging for most of the large companies' with bureaucratic structure and processes.

3) *Changing the culture:* The cultural of a company represents the values, norms, attitude shared by individual employee and the group. This can facilitate or prohibit organizational change. A traditional and risk aversive culture could pose challenge for adoption of open innovation as it represents higher level of ambiguity. The present mind-set in the company depended on fixed processes (e.g. stage-gate

process) and due to this the employees may not feel motivated or willing to adopt an open approach to product development. For example, we found that most employees lacked the trust in externally acquired technologies. This could be related to the issues of "not invented here" syndrome [8]. Moreover, it was a common consensus that employees were also not trained or skilled in developing products in collaboration with new partners. Most employees were analytical in their attitude and behavior compared to being entrepreneurial and open to change.

4) *Complexity in developing win-win collaboration:* Although, developing win-win collaboration represents a corner stone of open innovation, it also accounts for several challenges. First of all, a company has to identify appropriate partner for collaboration and later managing several interfaces with large companies (e.g. suppliers, competitors and customers), small specialist companies and individual experts. The main issue here is to determine each partner's perceptions for collaboration and strive for developing mutually beneficial collaboration. Otherwise, the collaboration would result in *opportunistic behavior* from certain partners. The notion of "learning race" explains this behavior, where one company aggressively gains knowledge of others without sharing their own. In addition, some companies may not even involve their experts in the joint R&D efforts due to threat of losing core knowledge. These behaviors work counter to open innovation principles and most likely result in unproductive collaboration [9, 10].

5) *Collaborating with Small companies:* In the open innovation context, small companies can be seen as strategic partners as they know for generate technological innovation due to their specialized and deep knowledge [11]. Moreover, due to lack of internal resources, small companies are motivated to collaborate with large aerospace companies, leading to win-win collaboration. However, the reality was different as the case company perceived collaboration with small firms externally challenging and risks as most joint development requires at least 5–10 years of collaborative working, which seems to be unsure in relation to new small companies. Moreover, the company could also incur high transaction cost, such as cost of searching for appropriate small company partner, cost of establishing, monitoring and enforcing the implementation of the contract [12]. Therefore, in past when the case company had found a specialized small company, they opted for acquiring them instead of establishing collaboration.

5. THE KEY AREAS FOR REALIZATION OF OPEN INNOVATION

Henry Chesbrough in his seminal book makes a black/white distinction between closed and open innovation [1]. However, the reality is that most companies operate in a grey zone, where due to specific reasons they choose to adopt certain open innovation activities over another. For example, the case company preferred collaborating with university compared to new companies because they could easily foresee a long-term relationship and it was easy to develop a win-win situation.

The path to realization of open innovation largely depends on a company's ability to consider potential opportunities and challenges. Based on these calculations most companies make a judgment regarding implementation of open innovation. There is no guide-book to success with open innovation. Each company needs to find the processes and activities which suites their specific innovation management needs and requirements. Hopefully, if the company can foresee more benefits compared to risks with open innovation, a smart strategy would be to make small changes during initially stages rather than drastic changes. The initial changes may focus on taking advantage of "low hanging fruits" that is, activities requiring minimum changes and considerable benefits. So that once a company is able to realize benefits from open innovation, they would have a strong case for motivating employees across the company to adapt similar practice in a large scale.

In addition, we would like to propose three key areas which need special attention by any company aiming to successfully realize open innovation. These areas are represented by the *acronym PPT, i.e. people, process and technology*. The PPT framework was found to be particularly helpful when holding discussions with respondents regarding the organizational changes for open innovation. Although, each component of PPT framework is different, they are also interrelated and together contribute towards the overall successful adoption of open innovation. For example, people are able to perform coordinated activities due to specified processes, but for effectively performing processes people depend on use of

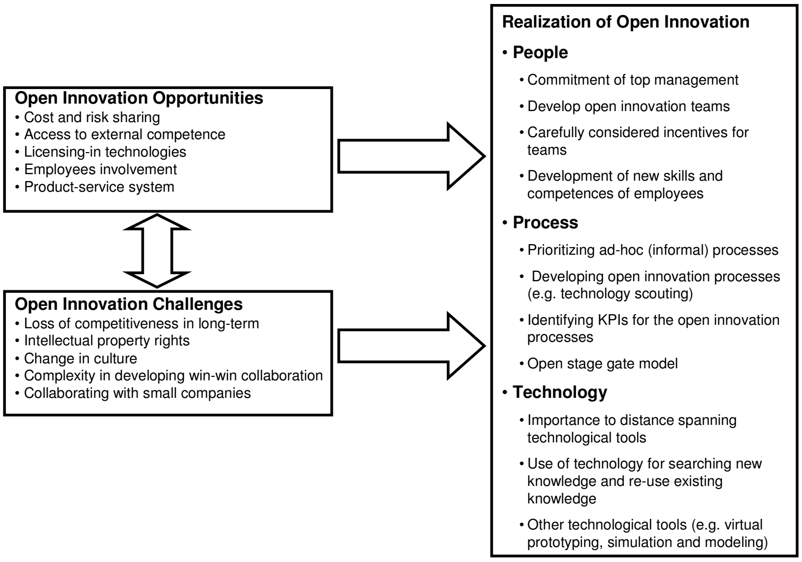

Figure 2. Striving towards realization of open innovation.

technology. The above discussion is summarized in the Table 1, showing the key issues related with open innovation challenges, opportunities and PPT framework.

5.1. People issues

People are central to any company and the most difficult organizational component when it come to change. The first step towards open innovation is to have a clear support and encouragement of the top management. Full managerial commitment in-terms of resources and time, ensures that open innovation initiatives will be priorities and accepted. Although, the transformation should start at the top, but the effect can only be measured at operational level. Thus, the focus should be to develop a culture within the company which supports cooperative and communicative working rather than restrictive and control working.

Another initial step could be to create specific teams or projects which are allowed to work outside the traditional norms and rules. They should be encouraged to take risks and move towards higher degree of externally oriented collaboration for innovative development. If failure occurs, it should be acceptable and seen as learning lesson. As one manager put it "failure needs to be celebrated, so that we can learn from it". However, when the project is successful their story could form the base for motivating the other employees to adopt similar open innovation approach. The project teams should include individuals with multi-disciplinary background, open attitude, adaptive attitude, and having the ability to foresee future treads across functions and industries.

An important issue to consider here is what could effectively enable or motivates individual innovation behavior. The learning from open-source software industry could be useful in this respect. Monterey benefits are not the most optimal choice as individuals are usually more likely to be motivated by personal rewards, such as recognition. This is an important issue which needs attention by other researches in the field.

Finally, open innovation requires employees to develop new set of skills and competence. Thus, most of them would need to be trained to effectively identify and utilize external knowledge. This would mean that they would move from being reactive searchers to more pro-active searchers for potential external technology. In additional, they should also develop the ability to manage several relations with external actors and strive for long-lasting relationships. This could be related to the notion of developing relational capability.

5.2. Process issues

Processes are needed because supports in managing and guiding peoples' to perform work and when we are discussing open innovation, several processes can be seen as being crucial, such as technology scouting or out-sourcing R&D. Therefore, there is not one specific open innovation process, but rather a combination of different processes. Processes can be ad-hoc (e.g. informal) or systemic in nature. In the initial stages, utilization of ad-hoc processes can be beneficial as it leads to limited change within the company and acts as a pilot test for the applicability of the process in question. Moreover, another advantage of ad-hoc processes is the possibility to make modifications based on learning as they are not fully integrated like systematic processes.

Technology scouting process can be particularly strategic in the context of any industry as it could provide the possibility to identify relevant external technologies. An important issue to consider here is not to regard technology scouting only based on current project needs but rather having it as an on-going process which could also aims to support future projects. Companies can also consider using services of external scouting organizations (e.g. intermediate organizations) for compliment internal process. Recently, several companies have reported gained from using services of InnoCentive, NineSigma, and Yet2.com [13]. The external scouting organizations have access to a huge network of professionals, experts and competent companies, who can provide services to companies' requests at reasonable charge. Additionally, several other processes can also be crucial, such as IP management process, strategic technology planning process, employee driven innovation process, out-sourcing process and customer involvement process.

The measurement of open innovation processes is necessary for determining their value, but this is a challenging task. Companies have to identify new key performance indicators (KPI) of the open innovation processes. Moreover, the new KPIs needed to be integrated to the existing indicators which added to the complexity. Several respondents also feared that being unable to measure the processes could hamper the companies' open innovation efforts.

Recent study by Cooper (2008) [14], suggest the possibility to integrate open innovation principles to the stage gate model process, which is currently used by most companies for product development. This notation was further developed by Grönlund *et al*. (2010) [15], where they attempted to integrate several open innovation activities within the framework of stage gate model and called it "open stage gate model". They propose that developing an open stage gate model could be the missing link which can allow companies to fully integrate the open innovation activities across different stages of product development. Although, this idea is intriguing it represents drastic change which would be challenging for most companies to successfully manage.

5.3. Technology issues

The importance of technology as an enabler for making people work according to process for realization of open innovation is reasonable. The technological advancement of last decade has facilitated companies to effectively collaborate with geographically dispersed partners and in doing so it has helped to support the shift towards more open and collaborative and network centric innovation [16]. According to several respondents' web portals, audio/video communication tools and project rooms have become even more important. It has evolved as a safe and secure system for connecting employees from different locations to perform internal processes. Although, internal communication has become effortless, integration of third parties can still be problematic due to differences in the technological system standards and concurs regarding security.

In addition, to acting as a main mode for communication and collaboration, technological platforms are increasingly used for other open innovation processes, such as searching for new knowledge and re-using existing knowledge. Technological shouts depend on technological tools for connecting to different data sources and their peers. Moreover, through the use data mining techniques they attempt to identify patterns in the data about future market trends or competitors up-coming products. In addition, there is an increasing interest towards re-using existing knowledge with in the companies. As most employees are becoming mobile and are changing jobs regularly, being able to store their tacit knowledge is a priority. Being able to do so can facilitate the open innovation process of tapping into internal employees' knowledge and uses it for the development of new products for current and potential market. In this respect, several technological tools are used by companies, such as Wiki's and forums. Finally, companies are also using design support tools such as virtual prototyping, simulation and modeling for product development. Although, these technologies have been in the use in past, their effective use as a standard part of product development has happened recently.

6. CONCLUSION AND FUTURE OUTLOOK

The study was initiated with the purpose to gain detailed understanding regarding the applicability of OI in a mature and complex industrial setting, like aerospace. We find that the case firm is in a transformation phase, where they identify open innovation as an important strategy for competitiveness. Even when certain opportunities with OI have been identified, they need to be considered in relation to potential challenges which may also arise due to the opening of the product development process. We also found that the dimensions of PPT framework comprehensively captures three critical issues which need to be understood and reflected upon before venturing into open innovation. Maybe some of these issues are much more curial to the context of certain firms compared to others.

We believe that the present study has offered several interesting points of discussion that needs to be addressed in future studies. Firstly, we acknowledge that the applicability of current findings may be limited to the context of Aerospace industry. Future studies are encouraged to investigate other mature industries (e.g. manufacturing industry) and examine the applicability of OI. Secondly, the PPT framework is not exclusive and may be needs to be modified or revised based on further investigation of other aspects that me be found important for the realization of OI. Thirdly, our case company did not fully utilize OI principles and for improving the current framework, it could be productive to benchmark certain companies from mature industrial context that are in the forefront of using and gaining from OI. This could provide possibility to include additional sub-aspects to the framework which are currently absent. Thus, we encourage other researches from the field of innovation management to validate and build on the present study.

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