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# MEASURING INNOVATION CAPABILITY IN TECHNOLOGY-FOCUSED DEVELOPMENT

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## ABSTRACT

Product development in the aerospace industry is associated with relatively long lead times and product lifecycles, which means that it takes years and even decades to find out if a novel product or technology concept fully realizes its potential and becomes an innovation on the market. How can a company in such an industry context know, preferably already in the conceptual stages, that they are on the path to innovation? How do they know how innovative they are? How can they increase their innovation capability? A project together with Volvo Aero, an aero engine manufacturer, was initiated to explore potential answers to these questions. The paper reports on an ongoing study of the company's current state-of-practice with regard to measuring innovation capability, starting from a range of innovation indicators provided within a previous research project, which Volvo Aero contributed to. Based on interviews with project managers of advanced engineering projects within the company, six areas were found to be of importance in order to more effectively measure the innovation capability at Volvo Aero: *Project selection*, *Customer involvement*, *Interaction between functions*, *Team climate*, *Innovation methodology* and *Innovation rewards*. Within these areas a selection of preliminary metrics was established, which will be presented in this article along with a discussion on the advantages and drawbacks of combining activity and effect measures to better relate particular activities to particular outcomes.

## INTRODUCTION

There is an apparent need in industrial companies today to increase the innovation capability in order to be competitive on the market, and a crucial question is how such an increase in innovation capability can be brought about? First, how can the current state of innovation capability be known, and, secondly, what need to be undertaken to increase innovative performance? These were the guiding questions behind this research project being conducted at Volvo Aero, a Swedish engine component manufacturer in the aerospace industry. The rationale behind the company's heightened interest in assessing and promoting innovation capability is that the concept of innovation has recently been put into a new light.

The company has a strong history of technology development, manufacturing and in-service support, but has recently positioned themselves as a provider of solutions, including products (of sub systems and components), technology and services. The new situation of increasingly providing solutions rather than products based on specifications requires technology and product ownership for the full lifecycle of a solution. Such move implies that companies need to improve their capability to develop and offer product-service system solutions (Baines et al, 2007). Many, if not all, of the solutions imply close business collaboration with other companies and

organizations throughout the value-chain and throughout the product lifecycle. Innovation is essential – but the changing conditions for innovation need to be better understood in light of the emerging business logic.

The primary purpose of the research activities described in this paper is to investigate the factors that influence the company's innovation capability, in order to establish an empirical reference basis for a framework to measure innovation performance in the organization. This includes the design of a set of preliminary indicators and metrics that seem to be particularly appropriate for improving the innovative capability of technology-focused firms facing similar challenges due to the changing industry context.

PIEp (Product Innovation Engineering program), a Swedish national research initiative aiming to increase innovation capability in people and organizations, has identified four major areas (Olsson et al 2008, p.17) that need to be explored to better understand what innovation capability is about: organizational and leadership-related factors, customer involvement, interaction between sub-processes in the overall innovation process, and innovation capability metrics. This work focuses on the fourth aspect, the metrics, and is based on a range of innovation indicators provided within a PIEp sub-project (Olsson et al 2008, pp.78-105) where five companies were studied, including Volvo Aero.

**Literature Review**

According to the OECD (OECD Oslo Manual, 2005, p.46) an innovation is the *"implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations."* Thus, innovation is more than a great idea, it needs to be realized and add value for both customers and firms to be an innovation (Schramm et al 2008, Olsson et al 2008). Further, innovation can be seen as the determinant of productivity growth (Schramm et al 2008, Chan et al 2008). Schramm (2008) describes innovations as the only opportunity to grow without increasing inputs – innovations enable output growth to exceed the growth of inputs.

How the concept of innovation is used also affects the way to measure it, and Olsson et al (2008) note that the companies in their study focuses primarily on minimizing risk, thus making high-risk/high-return projects rare. The importance of metrics for organizations to successfully capitalize on innovation is frequently stated (Chan et al 2008, Schramm et al 2008), and could be seen as a way for companies to measure and thus better understand if their so-called high-risk projects are worth pursuing. Measurement of innovative capability is important both from a change management perspective and to ensure that high-impact ideas can be identified and selected for product development.

There are several views on innovation measurements. Schramm (2008) signifies the importance of measuring not only the input to innovation but also the output. Andrew et al (2007) group the innovation metrics in three categories: *Inputs* (or resources such as people and money), *Processes* (which act on and transform the inputs) and *Outputs* (or results such as cash returns, benefits, stronger brand and knowledge). Muller et al (2005) use the same three categories, but also suggest that metrics are tailored from three views – *Capability view*, *Resource view* and *Leadership view*. Olsson et al (2008) divide the innovation capability metrics into four areas: *Project selection*, *Innovation identification*, *Innovation projects & methodology* and *Effects & influences*, with different factors for each area. However, they also highlight the importance and need of every organization to figure out what is important to measure

in view of their specific circumstances.

Chiesa et al (1996, p.106) note that focusing on indicators of input and output, whether on a macro or micro level, indicate rather than explain performance, and that understanding innovation performance must include looking more closely at innovation capability and the processes involved in developing and exploiting innovations. One of the problems with focusing too heavily on financial metrics, for instance, is that past performance is often a poor indicator of future successes. Rosenzweig (2007, p.18) notes, for instance, that just because *"...a given choice didn't turn out well doesn't mean it had been a mistake. It is therefore necessary to examine the decision process itself and not just the outcome."* Poor innovation practices can lead to good outcomes, and good innovation practices can lead to poor outcomes – thus knowing more about the processes and practices of innovation, not just the inputs and outputs, is crucial.

A summary of measures of innovation performance in firms provided by Cordero (1990) highlights that performance evaluation in many organizations focuses mainly on resources and outputs, such as R&D expenditure, speed to market, market share, and the number of new products, thus tending to ignore the processes in-between.

Adams et al (2006) propose a framework for innovation management measurement that consists of seven categories: *inputs*, *knowledge management*, *strategy*, *organization and culture*, *portfolio management*, *project management* and *commercialization*. In their conclusions, they point out several omission gaps, where measures are currently lacking, noting that financial measures of portfolio optimization are often used, but that portfolio capability measures are lacking, and that there is a reliance on codified knowledge such as patents, excluding more intangible measures, such as tacit knowledge. Cooper et al (1999) highlight the importance of portfolio management practices that can, among other things, help companies create a better balance of projects in consideration of long-term versus short-term, and high-risk versus low-risk perspectives.

Szakonyi (1994, p.30) states that measuring patents, publications and citations, for instance, cannot be thought of as legitimate indicators of R&D output, because output and effectiveness are not the same thing. The author argues that more emphasis should be put on managing R&D effectively, which is not the same as focusing on R&D efficiency (e.g. errors generated or assignments completed on time). Szakonyi notes that an effective R&D department "…*measures its output not to get a certain score but to learn where it stands and how it might improve.*" (Szakonyi, 1994, p.31), and proposes to focus on 10 activities involving R&D effectiveness, including the selection of R&D projects, establishing cross-disciplinary teams, and coordinating R&D and marketing.

Loch et al (1996, p.17) also point to the importance of measuring the quality of the processes used at project level, and their process performance aspects include, but are not limited to, the involvement of suppliers in design, the use of team rewards, and listening to customers and to marketing.

Haffey & Duffy (2001) note that a substantial lack of support exists for bringing organizational objectives down to a process level, aiding the identification of measures to support the focus of effort toward their satisfaction.

Dodgson & Hinze (2000) provide an overview of a wide set of indicators used to measure the innovation process, highlighting that combining and integrating various indicators, and assessing which indicators to use in what circumstances are relevant issues for future research in the field.

## The Case Situation

A clear understanding of the contextual situation is a pre-requisite for understanding how relevant metrics can be established. (Chiesa et al, 2009). The aerospace industry is characterized by a high degree of technical complexity, high development costs, and long product life-cycles. Today's solutions on system level (jet engines) are typically a combination of the physical product and accompanying service offers (e.g. TotalCare® by Rolls-Royce, 2010). It is a highly regulated industry, primarily with respect to safety and airworthiness criteria. Product development in the aerospace domain is largely contract-driven, which means that binding contracts are normally signed before development work starts and risk minimization is thus given higher priority than finding innovative new solutions during product development. Reduction of risks is an absolute requirement for a new product in the aerospace industry, which is rather counter-intuitive in the search for innovations and new thinking. As a consequence the innovative capability within pre-development activities is crucial. *The central research question is how a suite of metrics can be designed to improve innovative capability within a manufacturing company with these organizational prerequisites?* In a previous study at Volvo Aero, Larsson et al (2007) note that the aerospace business provides an industry context where creativity is risky, yet a precondition for success, and where there is a need for creativity inside-the-box. In that study, one of the Volvo Aero engineers commented that *"innovation disappears when the contract is written. After that, it's only about bringing the stuff out"*, whereas one of his colleagues noted that *"we have very little time for innovation…we have to go for safe solutions. We have to know that what we're doing works to ninety-five percent. You glance a lot at how earlier generations look…we go for the things that give us a competitive advantage…and with low risk. No customer wants us to take big risks*."(Larsson et al, 2007)

Due to the highly technical nature of Volvo Aero's current product portfolio, the company has a tradition of focusing closely on technology development, which implies a set of different objectives and approaches compared to an organization with a broader perspective on innovation. To more carefully understand these differences, the present study uses the measurement of capabilities related to technology development as a reference.

The development projects within the company, i.e. product development as well as technology development, are performed by cross-functional teams. The teams can change in the different phases of the project since the development process has the duration of several years. The company uses a Technology Readiness Level (TRL) scale (Mankins, 1995) in order to specify the maturity of evolving technologies.

The customer of the product development project is the Original Equipment Manufacturer (OEM) of the engine (i.e. General Electric, Rolls-Royce or Pratt & Whitney, ESA). The problems to be solved are usually related to keeping product cost and product weight down while making the product easy to produce. The technology development projects often have an internal customer. The problems consist of keeping costs down and timing the technology to the product development.

## DATA COLLECTION

The paper reports on an ongoing study of the company's current state-of-practice in terms of performance measurement related to innovation capability, in general, and technology development, in particular. First, a literature study was performed to explore, from a research perspective, what areas have been found to affect innovation capability. Second, six project managers from advanced engineering at the company,

all responsible for various next generation products and technologies, were chosen as a focus group to investigate current practices related to innovation capability measurement within the company. The rationale for selecting this particular group is that the culture and work methods represented by these individuals, and their teams, should provide a representative example of the current practices, and thus provide insight into this group's perceptions of what affects the innovation capability at the company, and how it can be more effectively measured and increased.

The methodology used to capture empirical data is based on semi-formal interviews with each member of the focus group and three other key individuals (responsible for patent application, idea proposals and technology innovation research) followed by a questionnaire study with the focus group and second level project leaders within their respective project teams, in total 22 respondents. The interview and questionnaire study were focusing on the factors identified by Olsson et al (2008), which are perceived to impact the organization's innovative capability, including cooperation between product/technology/business development, customer involvement, interactions between functions, team climate, open innovation and innovation rewards. The findings from the interviews are discussed in reference to the findings from the literature review.

## MEASURING INNOVATION CAPABILITY

The project has initially highlighted the strengths and weaknesses of the company's innovation capability, from the perspective of the leaders and members of advanced engineering project teams. Preliminary findings show that the company has a strong base in technology development and also uses a relatively stable framework for assessing maturity of technologies, whereas innovative capability has shown to be a contested concept that is interpreted differently between individuals and their position in the organization.

The factors identified by Olsson et al (2008) were initially used as a foundation to set the direction for the interviews and the questionnaire, but were in the course of analysis modified to suit the current innovation process at Volvo Aero. Since *Innovation identification* is part of the *Innovation methodology* at the company, these two factors have instead been divided into: *Innovation methodology*, *Team climate*, *Interaction between functions*, *Customer involvement* and *Innovation rewards*, because these factors were considered important in order to measure innovation capability at the company. Another addition, in relation to Olsson et al's factors, is the division of metrics into 'Activity' and 'Effect' categories, instead of an 'Effect and Influences' factor. The activity measure is fulfillment of the activities and actions identified and planned for improving innovation capability and the effect measure is about assessing whether or not the activities actually contribute to innovation performance.

As a result, the areas found to affect the innovation capability at Volvo Aero are the following:

- Project selection
- Customer involvement
- Interaction between functions
- Team climate
- Innovation methodology
- Innovation rewards

**Project Selection**

One area of measures includes balancing the degree of radicalism of the targeted innovations. Dewar and Dutton (1986) states that incremental innovation could be seen as containing a low degree of new knowledge, i.e. minor improvements or adjustments in current technology, whereas radical innovation could be seen as revolutionary changes in technology, with clear departures from existing practice and a high degree of new knowledge. Radical innovations create fundamental changes in human behavior or usage, whereas incremental innovation creates small changes, or improvements to existing products/services.

The other area of measure includes the balancing between existing customers and new customers. "*Exploitation occurs when firms rely on existing competencies or operational capabilities to sell to existing customers*" (O'Reilly et al, 2008, p.195) By addressing new customer segments or through innovations that enable companies to charge customers a higher price or reap higher margins, the companies can move into adjacent markets (O'Reilly et al, 2007).

There needs to be a careful selection between incremental, architectural and discontinuous innovation projects to enable the company to explore new markets and opportunities for growth, while continuing the exploitation of existing markets and capabilities for profit (March 1991; O'Reilly et al, 2004; O'Reilly et al, 2008).

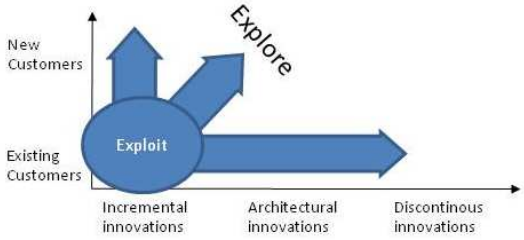


**Figure 1: Exploit/ Explore**

The company's aero-component business is characterized by being a "supplier" and the company is finding it hard to develop in the vertical axis (Figure 1). Vertical climbing requires an interaction in business development in a way that a horizontal move does not. With business development at the company concerns the establishment of contracts and ensures meaningful business rather than finding new customers. The current customers help the company to move horizontally, since the customer gets part of the innovation profit.

To meet the competition on today's market requires a long-term balance between risk taking and safety measures, a good understanding of where the emerging technologies and products aim and continuous work for improvement.

In the study at Volvo Aero, the project managers were asked what the main purpose with their project was. Based on their answers an attempt to map the project portfolio to the exploit/explore dimensions was made. It was found that the most common purpose with a project at was to '*meet the requirements defined by customer*' and to '*develop a new product with in a known product specialization*'. Few projects had the purpose of '*developing a new product outside specialization*' or to '*reach a new market*'. Therefore the projects were mapped closer to the exploit rather than the explore dimension.

This exploit/explore perspective can be used to balance the project portfolio and spreading the risks when initiating projects. It can also be used as a metric of the

innovation capability, since a balanced project portfolio ensures that future innovation opportunities are not missed and ensures that neither short-term profits nor long-term innovation opportunities are missed.

However, risk taking at Volvo Aero is more complicated than the exploit/explore perspective conveys, because a project can take large risks even though it is making small changes to a known product for a known customer. One project manager describes the difficulties in keeping the creative spirit alive in a big company such as Volvo Aero, given the aerospace industrial context: *"We have constraints because of the industry [the character of the Aerospace industry], but are innovative in other ways. We are innovative when it comes to lightweight, composites and fabrication"*. In general, the scale of exploit/explore is still perceived to be a useful tool to map the project portfolio, even though other criteria need to be taken into consideration, too.

To explore new markets for existing products and services in order to create innovations, a close cooperation between the Product development and Business development domains is found to be preferable and the projects need strong support from both organizations. At the company the support usually comes from the promoter of the projects, which more often is the product development department rather than the business development department. Therefore, the company could benefit from a closer cooperation between Product development and Business development in order to explore new markets and new customers.

**Customer Involvement**

Since a great idea cannot be realized nor create value without a customer, the customer involvement in the product development teams contributes to innovations. Olsson et al (2008) describes it as a key success criterion that everyone involved has a clear picture of the reality of the customer.

Volvo Aero's partnership in the engine programs implies a close contact with the customer, where the customer is the Original Equipment Manufacturer (OEM) of the engine. All projects have a continuous contact with the customers throughout the process, although this can be described as both positive and negative. One manager describes the customer both as a hindrance and an influence to innovations. Some of the project managers describe the customer as *"part of the team"*; the customer involvement makes the project *"sharper"*, *"balances the demands"*, *"clarifies the requirements"* and *"supports the idea generating"*. But it was also expressed in interviews and in the questionnaire that the customer involvement can create conflicts between project directives from the company and the external customer goals. It is a fact that the system level product (the jet engine) is jointly co-developed by the company together with the customer from a technical point of view, whereas the means of collaboration may be different between different product development projects.

However, when it comes to customer involvement there is a significant difference between technology development and product development at the company. Product development always has an apparent external customer, which technology development rarely has. The external customer creates, within the product development team, a stronger driving force for an expected result. But consequently it creates boundaries for the innovation capability for the product development teams, whereas technology development projects can develop in the direction that is most profitable for the company alone.

This points to the importance of keeping customers, internal or external, close and to the importance of paying attention to expectations on results. It also points out the

importance of a methodology and a process, which makes the most out of the relationship between the team and the customer, making it as profitable as possible for both company and customer. Further, there is a need for a methodology that can handle ideas that do not fit within the boundaries of the customer needs and expectations, but which possibly could be of interest to the company, for future considerations or as embryos for new development projects.

**Interactions between functions**

*"Innovative breakthroughs frequently come at the estuary region where different fields, not necessarily related, intersect."* (Schramm et al, 2008, p. xii). In a manufacturing company there are many processes and functions. Innovation integrates several of them, if not all. The better these functions are synchronized the better for the innovation process (Olsson et al 2008). The interaction and communication with other departments in the organization is important for several reasons:

- *Knowledge transfer*. It increases the success of transferring the team's results, for example from design to production, resulting in the realization of the good ideas leading to innovations. This is particularly important in a company where the team changes during the development process. Standards and best practices can also be of importance for this integration between functions.
- *Solution exploration*. Creativity arises in the cross-section between different areas, which can lead them to explore a larger solution space and ultimately end up with better solutions, which take into account many different perspectives inside and outside of the firm.
- *Streamlining work processes*. A close collaboration between functions can improve the flow of the development process, avoiding long decision loops, and helping to keep deliverable deadlines.
- *Supporting exploration*. As mentioned in the previous section on project selection, a closer collaboration between Business development and Product development would support the exploration of new markets, by avoiding a too narrow focus on either existing customers or existing technologies.

At the company, the teams consist of people from different organizations and this is mainly viewed as something positive. It gives the team a wider network with further qualifications and experience, but is sometimes negative due to vague target with respect to the specific product needs. Many team members also highlight the importance of working geographically close to each other. However, there seems to be a general belief that the placement of the physical workspace should neither have an impact on the communication within the company, nor on the communication outside the company.

**Team Climate**

It is within the teams of the development projects that many great ideas are born and the development of the innovations is started. According to many informants within the advanced engineering teams at Volvo Aero, the climate of the team has a great influence of the innovation capability, but in both positive and negative ways. A good team climate with openness, committed debates and collaborative problem solving approach affects the innovation capability in a positive way, whereas a team plagued by work overload and lack of time can feel that their innovation capability is affected in a negative way.

The methodology used within the team and the way of working affects the team

climate as well as the leadership. The team leader is usually not the same person as the boss of the team participants, which ensures that the two roles are not confused. One of the most important team leader qualities is to make sure there is a good, creative environment within the team to support the emergence of innovative ideas.

According to Olsson et al (2008) the risk-taking environment within the team needs to be supported and mistakes accepted in order to increase the innovation capability of an organization. One project manager expressed in an interview the need for courage in order to admit to mistakes. The teams consist of people with different backgrounds, competencies, experiences, ages and genders, which is a foundation for a positive team climate since it can allow a mixture of ideas to arise.

**Innovation Methodology**

Innovation requires creativity and creativity requires time. In order to create innovations, time to work on the ideas is needed. In product development, the focus is on delivering products that meet a technical specification. Under these conditions, the majority of co-workers have no, or quite limited time (less than one hour per week) to explore new ideas not directly connected to the project. One of the project managers also said in an interview that there was not time to take care of all the ideas that erupt in the project. This could affect the innovation capability of the company in the long run, when it is missing out on ideas getting realized.

Innovation needs a balance between creativity and structure (Olsson et al, 2008). Too much structure restrains the creativity. A project manager thought that *"the will to control hinders innovation"*. However, with too little structure the good ideas will most likely not be realized in time. As noted by an aero engine project leader in a previous study by Larsson et al (2007), the immense time pressures could actually prove to be a driver of creativity and innovation: *"He who suffers conquers"*. However, to better balance the pressures and to use the available time more effectively a good innovation methodology that suits the team is essential.

Part of the innovation process is the generation of ideas (which can be performed internally and/or externally) as well as the search for and recollection of existing ideas that might be found in, for example, ongoing or finished projects that current team members have little or no knowledge about. Methods for reflecting on previous projects are important to make sure the learning is not lost. At the company there are established methods for making sure the learning from the project is not lost. There is also an established method for collecting various improvement ideas within the company. Mainly the ideas come from and regard the production domain. The engineers at the product development departments rarely use it; they see the improvement work as part of their everyday work.

The concept of Open Innovation (Chesbrough, 2003) suggests that companies should make better use of external, in addition to internal, ideas in order to grow on the market. Within Volvo Aero there are established methods within most teams on how to generate ideas within the team and making sure the customer needs are taken into account, which is important in the innovation process. However, there are few, if any, established methods for collecting ideas outside the team (neither within the company nor outside of it). Some project managers describe a resistance to even go outside the own department, others see a big opportunity to go outside the company, for example to universities to solve problems, and are currently doing so. Although many informants were positive to the idea of going outside the company to gather or generate ideas, many found it difficult for reasons such as secrecy, time, economy and business structure.

**Innovation rewards**

Because of the high technology content in the products, innovations at Volvo Aero are, according to the informants, considered to be something that is '*unique*'. Therefore patents play an important part for the innovation capability; it is one of the first things that are associated with innovations at the company.

The aerospace industry has very long lifecycles of their products; it takes decades before the idea in the development projects is known as an innovation on the market. Since many of the products and technologies that are under development at Volvo Aero do not reach the market until up to ten years, innovations at the company are not about what is on the market today, but about what will be on the market in the future.

One part per thousand of the company's sales is used for patents, and patent applications are part of the systematic work at the company. Compensation for the patent application is a way to reward innovation; compensations are also given to idea proposals. Patenting is also a way to validate that the product or technology, that has not yet reached the market, is in fact an innovation.

The number of patents and patents applications are counted every year, but this measurement alone does not give the overall picture of the innovation capability of the company. In some cases patents are avoided in order to keep the innovation secret and the number of applications corresponds to the amount of effort that is made collecting the applications. There are other ways than patents to reward innovations at Volvo Aero, such as a technology prize, and giving team members the opportunity to participate in conferences and team celebrations.

If not managed properly, rewarding innovation can lead to "not-invented-here" attitudes, making people overly interested in the success of their own project at the expense of other innovation projects elsewhere in the company (Muller et al 2005).

**INNOVATION METRICS**

Measurements proposed within this research project are preliminary examples of metrics for measuring innovation capability. These are divided into 'Activity' and 'Effect' categories, where the former measurement provide the means to manage progression and development following the scheduled plan, whereas the latter measurement gives the possibility to measure the effect of performed activities. One of the perceived drawbacks is that effects are given 'downstream' in the innovation process, so the response is obtained in retrospect. The combination of activity and effect measurements enables the organization to deepen the understanding of both the real-time performance indicators related to ongoing activities, and the after-the-fact performance measures, allowing a more careful analysis of how particular activities relate to particular outcomes.

Measuring activities related metrics gives more or less "instant" feedback and allows management and control, but does not reveal if the activities did their job. Effect measures should be designed to measure the effect of innovation performance. Typically - these measures measure *if* the activities do their job, with the drawback that the response may take years. Effect measures may, although not always, have a significant time delay omitting these to be used directly for management of improvement programs.

Following the analysis of the interview and questionnaire material, taking its basis in the indicators provided by Olsson et al (2008), a first proposal of innovation metrics particularly targeted to the Volvo Aero context was designed (Table 1). Activity and effect measures were proposed for each of the six areas that were found to impact the innovation capability at Volvo Aero, and they are both qualitative and quantitative in

nature.

**Table 1: Innovation capability measurements**

| | Activity | Effect |
|---|---|---|
| Balancing the project portfolio | **Number of customer meetings regarding future needs**<br><br>**Subjective assessment of the effort when dividing resources (team members, money) per project** | **Number of projects based on radical future scenarios**<br><br>**Number of projects challenging the current business model**<br><br>**Number of projects focusing on improvements on existing products** |
| Customer involvement | **Number of customer meetings** | **Customer satisfaction** |
| Team climate | **Number of activities for teambuilding**<br><br>**Number of activities to solve team conflicts** | **Subjective assessment of the team climate** |
| Interactions between functions | **Number of cross-project meetings**<br><br>**Number of activities for networking** | **Number of proposals received from various sources**<br><br>**Subjective assessment of project handovers or the knowledge of other function in the organization**<br><br>**Assessment of the project finishing on time** |
| Innovation Methodology | **Number of activities for systematic idea generating**<br><br>**The distribution of time in each co-workers calendar (time to work on own ideas)** | **Estimated Return on Investment** |
| Innovation Rewards | **Number of activities for patent proposals, applications** | **Number of patent applications**<br><br>**Number of granted patents** |

## CONCLUSIONS AND MANAGERIAL IMPLICATIONS

This paper reports intermediate results from an ongoing study, and the final analysis of the results is not completed. The main difference between measuring innovation and measuring innovation capability is that the former measures the effect and the latter measures both activity and effect. Dividing the metrics into activity and effect categories implies that managers must take into account the measures of innovation capability, not only inputs and outputs, when they assess the performance of their teams.

Though the aim is to achieve an improved innovative capability, the effect of innovation in a business such as the aero engine business comes several years after the actual "start" of the innovation activities. Effect measures consequently are of little value for monitoring and steering the work related to improving innovation performance. The value of effect measures is that they are visual goals for the organization, whereas the activity metrics measure the progress and likeliness to reach the goals.

There were six areas that were found to be of importance at Volvo Aero, which were proposed in this article: *Project selection*, *Customer involvement*, *Interaction between functions*, *Team climate*, *Innovation methodology* and *Innovation rewards*. These areas would be suitable in similar business as Volvo Aero with high technology

content and long product lifecycles.

Measurements proposed within this research project are preliminary examples of metrics for measuring innovation capability and further research on integrating these into the company needs to be conducted. Measuring innovation capability can also be used to give feedback to the innovative teams, especially in companies such as Volvo Aero where the innovation result might take several years; a quicker feedback to the teams might be of importance.

Measurements for innovation capability need to be customized for each company, since each company is different, and the areas of importance might differ. Improving innovation capability must take its start from a current state – raising the company's awareness of which areas to leverage further (i.e. strengths) and which areas to improve upon (i.e. weaknesses). The study results reveal several areas that must be used as the basis for gaining acceptance and trust amongst the employees and leaders. Based on the interviews the informants perceive that the company has several strong areas that impact innovation, namely:

- Continuous customer involvement
- Cross functional teams
- Established methods for generating ideas within the team
- Established methods for making sure the customer needs are taken into account
- Established methods for making sure the learning from the project is not lost
- Established method for collecting idea proposals
- Systematic work with patents
- The Technology Price

The informants' perceptions of strengths are crucial from a change management point of view, whereas identifying the true strengths requires a careful analysis. One observation that can be raised based on the findings is the view of the customer. The company has a supplier dependency to the jet engine OEM, and how this influences the innovation work and capabilities needed, will be retained for further work.

The areas identified that require special attention for successful improvement of innovation capability, i.e. implications for managers, were:

- Increased integration and co-creation between Business- and Product development
- Facilitation of cross functional disciplines
- Enable space, time and priority to work on ideas – outside formal projects
- Establish methods for identifying and bringing in outside ideas into the teams
- Facilitate the generation of ideas for individuals and in small teams

When informants refer to customer involvement, this most often refers to the involvement of the jet engine OEM. From an innovation perspective this is a limited view, in particular from a product service system perspective, as new customer and markets may need to be addressed.

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