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# *Towards new challenges for Innovative management practices*

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# Table of contents

# Preface

The global objective of ERIMA (European Research on Innovation and Management) is to constitute a “Network of European Excellence” in the field of the creativity and innovation management. ERIMA is currently formed by highly qualified Europeans Universities and Research Centres from different countries in Europe. The aim of this network is to promote new theories, methods, and techniques in order to improve good practices for the innovation management.

The third edition of this book “Towards new challenges for innovative management practices” is resulting from the scientific and industrial contributions of the ERIMA 2010 Symposium. This conference was held in June 2010 in Wiesbaden, Germany.

After the two previous conferences of the ERIMA network in Biarritz (France) and Porto (Portugal), the ERIMA 2010 conference has gathered together researchers, business leaders of both SMEs and large companies, public sector representatives, and practitioners focused on innovation management. The objective of the conference is to provide an inspiring background and stimulus for a focused, target-oriented discussion concerning new concepts in the field of creativity and innovation including topics such as collaborative working environment, management, tools and technologies…

The topics of ERIMA 2010 were:

- Models, tools and methods for Innovation Management and learning
- Fieldwork, case studies and storytelling of Innovative Management Practices
- Creativity/Innovation culture and people
- Open innovation
- Innovative services
- Creative routines, cultures and behaviors
- Education, learning and knowledge flows in practice
- Professional virtual and informal communities
- Collaborative environment

Reference to the papers of this book should be made as follows: Initiale(s), Name(s), “Title of the paper”, in the book “Towards new challenges for innovative management practices”, Vol.3, n°1, pp. xx-xx, Editors: J. Legardeur, K. North, ER IMA Publication, 2010. ISSN 2100-0778

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# An Empirical Study on Integration of the Innovation Management System (MS) with other MSs within Organizations

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**Abstract:** This article reports on a questionnaire study aimed at empirically validating a set of hypotheses pertaining to management systems (MSs) in organizations, developed from previous studies, with emphasis on the innovation MS and its relation with other MSs. The article elaborates upon previous research on MSs integration and their evolving nature from being order winners to become market qualifiers. The innovation MS may well represent a means of systematically promoting innovation across the organization, improving how the organization deals with the ever running cycle leading to commoditization of what once were innovative products, and transforming what once were competitive advantages into market entry requirements. A questionnaire study was carried out to submit the hypotheses to the scrutiny of academics, consultants and practitioners from industry. The paper exposes the theoretical grounds that led to the hypotheses and presents the results obtained with the questionnaire study. Improved resource management, cost cutting, added performance, improved communication and increased competitiveness were hypothesized as benefits resulting from integration of MSs in organizations. Hypothetical advantages of implementing innovation MSs in organizations and valid reasons to place them at the core of the integrated group of MSs in organizations were also subjected to the questionnaire respondents' scrutiny.

**Keywords:** Questionnaire study; management systems; competitive advantages; market entry requirements; innovation

## I. Introduction

In the last couple of decades, the implementation of management systems has been massive, and it is taking place through certification, based on normative documents which are internationally accepted. The most disseminated are Quality Management Systems – QMS – (ISO 9000), since 1987, and Environmental Management Systems – EMS – (ISO 14000), more recently, since 1996. Although there is yet no International Standards Organisation (ISO) standard in the area of Occupational Health and Safety Management Systems (OHSMS), the OHSAS 18001 standard, created in 1999 by an international group of organisations, is starting to show universal acceptance. The Management System of Social Responsibility, SA 8000, developed by Social Accountability International (SAI), was first published in 1997.

These management systems (quality, environment, occupational health and safety, as well as social responsibility) are important for the competitiveness and positive outwards image of organisations. In this context, four different systems and the standards supporting each management system are focused upon in this paper. Growing global adherence to the standards reinforces their importance for effective company management. Other systems are also mentioned, such as maintenance and energy management systems, contributing to the success of the implementation of other management systems. Various factors contribute to the success of implementation of one or several management systems, e.g. leadership, motivation, widespread collaboration, and the design of a system that fits the organization's characteristics and dimension. Other systems may contribute to this success and are included in this analysis, including the maintenance management system (related to the quality and/or OHS management systems) and the energy management system which articulates with the environmental management system.

Equipment reliability is assured by the complementarity of maintenance with continuous improvement. Thus, it is hence possible to increase equipment availability while reducing operational costs. Concerning the role of the maintenance function to third party assessment, the maintenance activities of a manufacturing organisation are vital for successful certification. A good maintenance management system that aims to satisfy the maintenance requirements of certifiable management systems includes the maintenance activities of planning, control and improvement. In addition, operational maintenance activities are contributing to control and improvement of the organisation's quality, environmental and, or, health and safety performance (Bamber, Sharp & Hides, 2002; Bamber, Sharp & Castka, 2004). To this regard, standard NP 4483:2008 "Sistemas de Gestão da Manutenção" (in Portuguese, Maintenance Management Systems), published in Portugal, follows a P-D-C-A approach and is aligned with the ISO 9001, ISO 14001 and OHSAS 18001 standards, as well as with other management standards and with some particular maintenance specific standards. Analogously to what is the case in other systems, this standard may result either in an independently implemented system or in a joint and integrated systems implementation in the organization, within a set of other standard based management systems.

Concerning energy management, European standard EN 16001:2009 'Energy Management Systems - Requirements with guidance for use' was formally issued in July 2009. The purpose of this energy management standard is to provide industrial facilities with guidance on how to integrate energy efficiency into their management practices. The adoption of EN 16001:2009 is expected to contribute to the setting up of a continuous improvement process that will lead to cost reductions, thereby strengthening competitiveness and continual improvement of energy use and business performance. Such as the previous ones, this standard can be applied to all types and sizes of organizations, and may be used independently or while integrated with any other management system. It fits in the continuous improvement philosophy, and is compatible with other standards, such as ISO 9001 and ISO 14001, aiming at enabling systems integration. Previously existing national energy management standards (e.g. Danish, Swedish, Irish and Dutch standards) have many features in common with this supra-national edition and have been developed by individuals well-versed in the ISO management model for continuous improvement.

Additionally, Human resources management performs an important role in assuring organizations' success, and it is hence fundamental that a systematic approach is followed therein. This can be achieved by way of the implementation of a Human Resources Management System (HRMS). In the Portuguese context, standard NP 4427:2004 "Sistemas de Gestão de Recursos Humanos" (Human Resources Management System), specifies the requirements for this system, encompassing the full scope of hierarchical levels and activity domains in an organization, aiming at the latter's continual improvement and its increased efficiency and effectiveness. Additionally, this standard sets guidelines enabling the assessment and certification of the HRMS and it is compatible with other MS standards, including ISO 9001, ISO 14001 and OHSAS 18001. On the other hand, the management system for security of information (ISO 27001:2005 - Information technology - Security techniques - Specification for an Information Security Management System) enables assuring that the management of information security in the company is framed by a continuous improvement process. Supply chain security management systems share a common approach with the latter (ISO 28001:2007, Security management systems for the supply chain – Best practices for implementing supply chain security – Assessments and plans – Requirements and guidance).

## II. Innovation Management System

For a long time, innovation has been perceived as a competitive vector by companies in many countries with a successful track, and it is deeply rooted in company culture (Rossetto, 1995; Tuominen, Piippo & Ichimura, 1999). In some countries, such as the Iberian countries, innovation is only being considered in recent years as a means for improved competitiveness. In order to systematize the practice of innovation, the innovation management system (IMS) needs to be included in the latter cases in the management systems integration pool. Additionally, it is emphasized that the modern competitive market scenario insists on satisfying customers by integrating innovations with quality (Vinodh, Devadasan & Rajanayagam, 2008). Zero defects, zero emissions, zero accidents and occupational diseases and zero faults are the ultimate aims of the quality, environment, OHS and maintenance MSs respectively. In what concerns the energy MS, it aims at energy efficiency, with zero energy waste as its ultimate aim. The social responsibility MS, however, has broader aims. The environmental and safety aspect of collaborators and social issues are viewed as an aim of day to day management of the company. The innovation MS aims at improving the competitiveness of the organization through planned and systematic management of the company's innovation process, whether it is concerned with products, production processes or organizational or marketing processes.

The act of innovating is also concerned with the manner innovation is understood. Innovation should be looked upon from the broadest of perspectives. The Oslo Manual defines four types of innovations that encompass a wide range of changes in firms' activities: product innovations, process innovations, organisational innovations and marketing innovations (OECD & Eurostat, 2005). From such a stance, innovation includes the manner in which people, organisations, companies, entrepreneurs, and even society in itself, create value by exploring change. Change springs from a number of settings and events, including not only technological advances, but also changes of a distinct nature and level of importance. Innovation is as much an individual as a collective process (Lam, 2005). Thus, support mechanisms should be devised in order to improve the competitive placement of companies.

## III. Compatibility

Throughout the process of revision of the several standards discussed a growing affinity has been created among them. ISO 9001:2008 reinforces continuous improvement and compatibility with ISO 14001:2004. ISO 14001:2004 stresses compliance and compatibility with ISO 9000:2000 and also continuous improvement. Concerning OHSAS 18001:2007, this standard highlights the alignment not only with ISO 14001:2004 but also with ISO 9001:2000. Additionally, ISO 19001:2002 (Guidelines for quality and, or, environmental management systems auditing) was developed, providing guidance on the principles of auditing, managing audit programmes, conducting quality management system audits and environmental management system audits, as well as guidance on the competence of quality and environmental management system auditors. The revision of SA 8000:2008 strengthens the management system's continuous improvement and maintenance methodologies, in the same way that RCM, TPM and the standard for a Maintenance Management System emphasise continuous improvement. The new European standard for an energy management system fits into the continuous improvement philosophy, in order to be compatible with ISO 9001 and ISO 14001, aiming at systems integration.

There is a growing correspondence among some of the standards frameworks (including a structural correspondence) as well as common orientations in what concerns continuous improvement. This aims at reducing documentation, bureaucracy, simplifying audits and cutting costs. Given the impossibility of having a single unique document for every management system, the alternative solution concerns the integration of the systems within the organization, following a P-D-C-A approach.

## IV. Integration

Given the competitive advantages that can potentially be reaped from systems integration, and despite the effort to develop successful methodologies, achieving compatibility goes back to the way organizations define aims and prepare the process. The process is limited by the characteristics and size of the organization. In a study about 12 SMEs and 7 large companies, Hines (2002), found that SMEs are less interested in integration than the greater companies, which stands in line with their defensive strategy against change. Moreover, SMEs are typically endowed with less human and financial resources than companies with a greater dimension (Coelho & Matias, 2007, 2010). The innovation MS may well represent a means of systematically promoting innovation across the organization, improving how the organization deals with the ever running cycle leading to commoditization of what once were innovative products, and transforming what once were competitive advantages into market entry requirements (evolving from being order winners to become market qualifiers – Hill, 1993). On the other hand, the culture of organizational learning is very important when trying to improve organizational performance by business process change (Škerlavaj, Štemberger, Škrinjar & Dimovski, 2007). Additionally, models of an integrated management system should also emphasize the need for no significant differences in the scope of the integrated systems, and a strong culture which supports the main requirements of TQM (Wilkinson & Dale, 2002). In summary, companies ought to base their decision process on fitting MSs to their characteristics, culture, scope, capacities and strategies for development.

## V. Competitive advantages from innovation and the contribution of the implementation of RDI management systems

There are many different kinds of innovation, but, in general terms, within the attainment of all these types, one of the most important innovation goals of a company is to produce competitive advantages in order to make its survival possible in the future (Sumii, 1986). Competitiveness derives from the creation of the locally differentiated capabilities needed to sustain growth in an internationally competitive advantage. Moreover, the competitive race between firms stimulates innovation (Fagerberg, Mowery & Nelson, 2005). The impacts of innovation on firm performance range from effects on sales and market share to changes in productivity and efficiency, encompassing more effective operations management, but in general improvement of their competitiveness is verified. The relationship between TQM and innovation is complex; literature suggests that the role of TQM varies according to the type of innovation (see Sá & Abrunhosa, 2007). However, there is a positive relationship between a high technological level and the firm's advance towards TQM (Escanciano, Férnandez & Vásquez, 2002). If innovation plays a central role in policy making, then the effects on productivity and on the entire economy in the long-term are remarkable. While innovation allows the opening of new areas, new scenarios and new opportunities to exploit, the competitiveness of one country is strongly influenced by the rate of innovativeness it entails (Chini, 2008).

Innovation contributes to the improved competitiveness of companies (Fagerberg et al., 2005; Chini, 2008) and therefore, of countries themselves. There are countries where the culture of innovation has been rooted in companies for a long time (e.g. Japan, Sweden, and the USA) (Fagerberg et al., 2005). In these countries, the need to resort to management system implementation as a way to systematically improve the innovation activities is not significant, since most companies already do that inherently. In other countries, e.g. Portugal and Spain, the turn to innovation as a strategic competitiveness vector is fairly recent. In these cases, the impact of an RDI MS in companies is likely to be greater. Practical results of the implementation of innovation management systems are not yet expressive, given the recent formal implementation of these systems in Portugal and in Spain. Some companies are showing visible results, in what concerns the effectiveness of the process of innovation, as well as improved communication, responsibility and definition and monitoring of objectives (Brandão, 2009; Portela, 2007; Yepe, Pellicer & Correa, 2006). The attainment of these objectives stands in line with what is expected from older and more mature management systems (MSs), including quality and environmental MSs.

An example of how innovation has become the basis for creating and sustaining competitiveness and constitutes an important aspect of business strategy, can be appreciated from Japan’s manufacturing based success, which was based on the binomial quality and innovation (Rossetto, 1995). In this sense, Kanji (1996) presented various suitable types of innovation and their linkage with the TQM process towards a proper understanding of innovation and the TQM process. On the other hand, Bossink (2002) concluded that quality management can be used to strategically support the management of innovation. More recently, Martínez-Costa and Martínez-Lorente (2008) verified that TQM promotes innovation within companies and there is also evidence that companies that apply TQM and develop organizational innovation get more benefits than companies that do not. Another verification made was that companies that operate in sectors where continuous innovation is a necessity should not only see TQM as a good way of improving quality but also as a way to facilitate the innovation process. In summary, TQM promotes quality performance as a primary effect and innovation performance as a secondary effect (Hung, 2007).

In as much as quality management facilitates innovation management, the implementation of RDI MSs is easier when there is another MS in place, such as the QMS (ISO 9001). Moreover, if integrated management systems are already in place, RDI MS implementation is even simpler (Brandão, 2009). Benefits of implementation of an RDI MS will only show through if they translate as competitive advantages. The results attained in terms of added effectiveness of the process of innovation, as well as improved communication, responsibility and definition and monitoring of objectives, as well as the use of innovation as a managerial tool, are unquestionably contributing towards added competitiveness. This not withstanding, the innovation management system must be tailored in every case to the current level of innovation strategy, policies, organization breakdown and sector of activity. Touminen et al. (1999) emphasize the compatibility of a company's innovation management system with the cultural, economic and social context where it stands.

Figure 1 schematically illustrates the integrative rationale proposed for MSs integration. Given the advantages of integrating MSs, an innovation MS should be implemented in an integrated manner with existing MSs, and lie at the centre of the pool of MSs, as a means of fostering the establishment of competitive advantages, contributing to the achievement of the company's corporate, marketing, operational and production goals.


Figure 1. A rationale for management systems integration, with the innovation management system at the core of the integrated pool, in order to promote widespread company innovation and foster competitive advantages, that translates into an integrated total quality view.

Table 1 presents the correspondence between the benefits of systems integration, envisaged advantages of innovation Ms and some envisaged supporting reasons to place innovation MSs at the core of the integrated pool. This Table shows the hypotheses that formed the basis for the design of the questionnaire study presented in the following section.

| Some Benefits of Systems Integration | Envisaged Advantages of Innovation MS | Reasons for placing the Innovation MS at the core of the integrated pool of MSs |
|---|---|---|
| - improved resource management;<br>- cost cutting;<br>- added performance;<br>- improved communication;<br>- supporting increased competitiveness ; | - use of innovation as a managerial tool;<br>- effectiveness of the process of innovation;<br>- improved communication;<br>- added competitiveness;<br>- responsibility, definition and monitoring of objectives; | - innovation encompasses product innovations, process innovations, organisational innovations and marketing innovations;<br>- innovation has been perceived as a competitive vector by companies in many countries with a successful track;<br>- innovation is the central element in the information flows between the company and the outside (watching for threats and opportunities);<br>- innovation, plays a strategic role in the convergence of several concepts pertaining to different kinds of vigilance (competitive, commercial, economic, technological, environmental and social) and their relation with competitive advantages |

Table 1. Correspondence between benefits of MSs integration, envisaged advantages of the innovation MS and reasons for placing it at the core of the integrated pool of MSs.

## VI. Questionnaire Study

The questionnaire was sent by invitation to email addresses resulting form a Google search for “management of innovation”. This included academics, practitioners and consultants. Respondents accounted to 20, from North America (3), Europe (15) and Asia (2). These were distributed across organizations in the sectors of Manufacturing (2), Services (5) and Education and Research (13). 20% of the respondents described themselves as managers, while 60% were self-reportedly researchers. 55% of the respondents considered they had practical experience on innovation as well as theoretical knowledge. 20% of the respondents declared that the subject of innovation was new to them. 40% of respondents reported that their organizations had a system of management of innovation in place, while 55% of them reported that there was no formal mechanism or system in lace to manage innovation in their organization. 60% of respondents reported on the existence of a Quality Management system in their organization. In most cases, existing management systems were not integrated (60%).

Table 2 presents the overall level of agreement with envisaged advantages of MSs integration. In what concerns agreement with the perceived advantages of implementing an innovation management system in the respondent’s organization, aggregate results are shown in Table 3. The existence of valid reasons to integrate the Innovation management system with all other management systems in the organization, and place it at the core of the integrated group of management systems was subjected to the questionnaire respondents’ scrutiny. The results are shown in Table 4, concerning percentage of agreement with the validity of the reasons presented in the questionnaire.

| Perceived advantage of management system integration | Improved resource management | Cost cutting | Added performance | Improved communication | Increased competitiveness |
|---|---|---|---|---|---|
| Percentage of agreement | 75% | 60% | 75% | 70% | 65% |

Table 2. Rating of perceived advantages of management systems integration obtained from the questionnaire study.

| Perceived advantages of implementing an innovation management system | Agreement |
|---|---|
| Innovation used as a managerial tool, to attain company objectives and performance goals | 40% |
| Increased effectiveness of the processes of innovation within my organization | 60% |
| Improved communication across the organization's departments and vertically within its hierarchical levels | 60% |
| Added overall competitiveness or efficiency (for non-competitive sectors) of the organization | 45% |
| Clearer responsibility assignment for organization and department directors, given better defined objectives and increased monitoring ability | 40% |

Table 3. Aggregate results of respondents' scrutiny to perceived advantages of implementing an innovation management system in their organization.

| Reasons presented | Innovation encompasses product innovations, process innovations, organisational innovations and marketing innovations | Innovation has been perceived as a competitive vector by companies in many countries with a successful track | Innovation is the central element in the information flows between the organization and the outside (watching for threats and opportunities) | Innovation, as a central element in information flows, plays a strategic role in the convergence of several concepts pertaining to different kinds of vigilance (competitive, commercial, economic, technological, environmental and social) and their relation with competitive advantages |
|---|---|---|---|---|
| Percentage of respondents considering reason valid | 65% | 70% | 50% | 65% |

Table 4. Scrutiny by questionnaire respondents of proposed reasons to integrate the Innovation management system with all other management systems in the organization, and place it at the core of the integrated group of management systems.

## VII. Discussion

The questionnaire was formulated based on the main results of literature review on innovation management systems and management systems integration and adding upon the results of previous inquiry (Coelho and Matias, 2010). While experience with innovation management and organizational contexts of the respondents varied widely, the results provide moderate support to the hypotheses summarised in Table 1 concerning the themes focused in this article. In what concerns the hypothesized benefits of system integration, results range from 60% agreement for cost cutting to 75% agreement for added performance.

More moderate percentages of agreement were attained from the questionnaire respondents in relation to the hypothesized advantages of innovation MS implementation (increased effectiveness of the processes of innovation and improved communication across departments were the only reasons with majority of agreement, with 60%). Finally, the hypothesized reasons concerning support for integration of the innovation MS with other MSs in the organization received moderate support from the respondents (ranging from 50 to 70%). Given the reduced empirical basis of this questionnaire study, the results should be viewed with caution. Future research should take a broader view of the issues, and involve a larger number of respondents.

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# Optimisation of an evaluation method for innovative product ideas

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**Keywords:** Evaluation method, innovative product idea, success factors, evaluation criteria, optimisation

## I. Introduction

In times of tough competition, innovations are of central importance for companies (Granig 2007). In this context, an innovation is considered to be a new product that is introduced into the market successfully. Concurrently, the implementation of product ideas is very time-consuming and cost-intensive whereas companies' capacities are quite limited. For developing new and innovative products, a lot of ideas are necessary in a first step because only a small fraction of product ideas can be implemented and introduced into the market successfully (Trommsdorff and Steinhoff, 2007). During the product development process, only the most promising product ideas can be selected for further development. The decision about which product ideas are most promising is very complex. In order to be able to decide as soon as possible which product ideas are the most promising, evaluations have to be done at an early stage of the development process. In such an early stage, it is not easy to predict how successfully a product will be distributed (Granig 2007). Methods that support decision-making are an effective instrument to meet this decision situation adequately. Especially product evaluation methods can be useful for supporting these decisions (Pahl et al. 2007).

The Institute for Engineering Design and Industrial Design (IKTD) of the University of Stuttgart has developed a product evaluation method in 2006. The evaluation method and the results of a wide national and international literature research for factors related to new product success are described in the following chapters. By means of these results, the existing method will be optimised in a second step.

## II. Existing evaluation method

Reichle (Reichle 2006) has developed an evaluation method for innovative product ideas and products at the Institute for Engineering Design and Industrial Design (IKTD). The method can be used for measuring the degree of innovation (grade of novelty) as well as the potential for product success. By means of this method, quantitative values can be defined for these two parameters. The method mainly focuses on the customer requirements and their fulfilment by associated product requirements. To deal with these parameters adequately, the evaluation method is based on the QFD-method (Quality Function Deployment), see figure 1. As the importance of novelty of customer and product requirements is included in the evaluation, the first "House of Quality" of the QFD-method has been modified and expanded. In order to include all relevant aspects of the manufacturer benefit of a new product, several other evaluation parameters are included additionally (see table 1). In a further step, the degree of innovation and the success potential are quantitatively defined by means of a mathematical evaluation algorithm that combines the different input parameters. As a result, the evaluated product can be compared with other ones. Figure 1 summarises the different aspects of the described evaluation method.

The evaluation method has been validated in several pilot projects. The findings show that, in principle, the evaluation method is suitable to analyse product ideas and products in different stages of the product development process. Nevertheless, a potential of improvement was identified. It has been stated that the range of evaluation criteria has to be examined. The proposal was made to integrate further criteria to be able to come to a more substantiated decision (Reichle 2006, Binz and Reichle, 2007). In order to take these results into account, the evaluation criteria have to be optimised. Therefore, a wide national and international literature research for factors related to new product success has been conducted. The results are discussed in the following chapters.

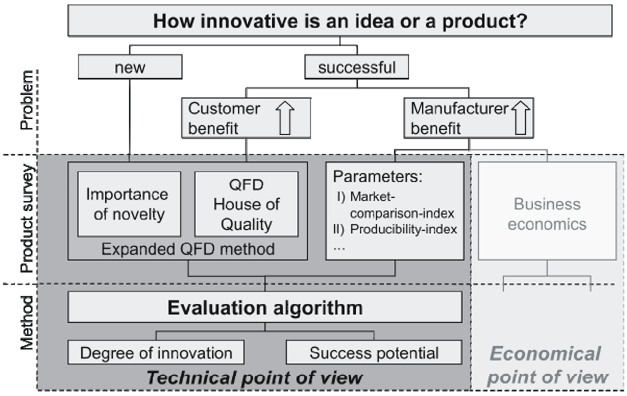


Figure 1. Evaluation method for innovative product ideas based on the QFD-method (Reichle 2006)

| Parameter | Description |
|---|---|
| Market comparison index | The data must be acquired by comparing the objectives of the product with the objectives of competing products. |
| Producibility index | To determine this index, the knowledge of experts is necessary. In general, the risk of failure depends on increasing manufacturing difficulties. |
| Fulfilment index | This index refers to the reliability and the probability of fulfilment of the product requirements. |
| Economic efficiency index | Economical aspects like costs, complexity of manufacturing and assembly, investment costs, etc. are integrated by means of this index. |
| Ideality index | This index examines the need for additional functions in order to be able to fulfil the product requirements. Products with a high degree of ideality are more attractive to customers and cost fewer resources. |

Table1. Additional evaluation parameters in the existing method
(Reichle 2006, Binz and Reichle, 2007)

## III. Factors related to new product success

There is a vast number of empirical studies analysing factors of new product success. Due to this fact and to be able to get a consistent and useful package of evaluation criteria, primarily existing literature researches on such studies were reviewed. Special studies are regarded, too, in order to analyse certain aspects more concretely. Table 2 shows those factors which are strongly linked to new product success. Additionally, the degree of innovation is added because of its central importance in the existing method. Each stated success factor is discussed afterwards (Ernst 2001, Trommsdorff and Steinhoff, 2007, Balachandra and Friar, 1997, van der Panne et al. 2003, Lilien and Yoon, 1989, Montoya-Weiss and Calantone, 1994).

Besides the stated factors, several other impacts on new product success concerning the proficiency of development and marketing activities, the support of the management or other processes during new product development are indicated in the reviewed literature. It is obvious that a well planned and a well conducted development and marketing process improves the later product success. However, with the aim of defining several concrete evaluation criteria for product ideas, factors concerning the process and the organisation of the product development are not taken into consideration in this paper.

| No. | Success factor |
|---|---|
| 1 | Customer orientation |
| 2 | Product advantage |
| 3 | Market-related factors |
| 4 | Synergy |
| 5 | Degree of innovation |

Table 2. Factors related to new product success

**Customer orientation**

In the majority of cases, customer orientation is seen as an important success factor for the development of new products. In this context, customer orientation means that the needs, the structure and the behaviour of customers are analysed. All relevant studies agree that a minimum of customer orientation is absolutely necessary to enhance new product success. In order to be able to satisfy important customer needs, it is essential to deal with the customer's needs and requirements to a certain degree. Several studies support these arguments by indicating that the majority of successful product ideas originate from the market. However, an excessive customer orientation is often seen as harmful for new product success because customers normally only express their current needs and demands. They do not express and know future and implicit needs. This leads to incremental innovations which satisfy only current customer needs and might diminish the innovator's creativity. The companies could loose their ability to shape markets pursuing their own ideas. Especially for products with a long development time, it might be dangerous to consider only current customer needs. For radical innovations, it also seems to be hazardous to concentrate too much on current customer needs (Ernst 2001, Trommsdorff and Steinhoff, 2007, van der Panne et al. 2003, Balachandra and Friar, 1997).

Summarising, neither too less nor too much customer orientation is reasonable. In order to be successful with new products, companies have to find the right balance between market-pull and technology-push (Ernst 2001, Trommsdorff and Steinhoff, 2007, van der Panne et al. 2003, Balachandra and Friar, 1997). As a result, it is necessary to observe customer requirements for an evaluation method for innovative product ideas. However, the conclusion that a product which satisfies all customer needs is at the same time successful is definitively wrong. Instead, two possibilities seem to be reasonable for an integration of the customer's point of view into an evaluation method for innovative product ideas. The first possibility is to respect both current customer needs and future customer needs for an evaluation of a product idea. However, it is very difficult to measure future and implicit requirements and needs of the customers. Observing customers using a product could be one possibility to identify some of these requirements. The second possibility to integrate the customer's point of view into an evaluation method for innovative product ideas is to determine the grade of customer orientation dependent on the degree of innovation of the product idea that has to be evaluated. That means, for example for incremental innovations, that customer requirements have to be integrated into an evaluation method and that the customer needs have to obtain a high impact on the evaluation results. In contrast, for the evaluation of radical innovations, the impact of customer requirements on the evaluation results ought to be reduced.

**Product advantage**

The product advantage is unanimously seen as a very important factor for new product success. In this context, not all relevant studies define the product advantage in the same way. Product advantage often means that a product offers a higher cost-benefit ratio compared with competing products. However, customers may have difficulties in recognising the performance of different products correctly (Balachandra and Friar, 1997). Thus, the definition of product advantage has to be expanded. To be successful, the following conditions have to be fulfilled (Backhaus 2003, Trommsdorff and Steinhoff, 2007, Montoya-Weiss and Calantone, 1994):

1. A product has to offer a superior performance compared with competing products with regard to quality, cost-benefit ratio, function or other properties that fulfil the four following conditions.
2. The (superior) performance has to meet important customer needs. Neither the customer nor the enterprise will have an advantage from an increased performance in an unimportant aspect of the product (Backhaus 2003).
3. The performance has to be easily noticeable for the customers: A superior performance will only be relevant if customers recognise it or rather if it is possible to convince customers that a superior performance is offered by a product. It is important to note that not always the products succeed which offer a superior technical performance. Instead, it is important that the subjective perception of the customer is addressed. Without addressing the customer's perception, a product can offer a superior technical performance. However, a product advantage for the customer as well as for the manufacturer will only be possible if the customer recognises that a product is better than other ones (Backhaus 2003).
4. The competitors may not be able to compensate this advantage: A product advantage will only be a factor related to the later product success if the superior performance offered by a product cannot be compensated by competitors in a short term (Backhaus 2003).
5. The (superior) performance may not be suspended by the environment: Some factors of the environment of a new product can also have a great impact on later product failure or success. For example, social, religious or legal impacts can be the reason for product failures (Trommsdorff and Steinhoff, 2007). Therefore, this aspect of the product advantage has to be examined for an evaluation of product ideas.

The evaluation method has to include each of the five stated aspects of the product advantage because each of them is necessary for later product success.

**Market-related factors**

Principally, the potential of a market is often seen as a strong factor for new product success (e.g. Lilien and Yoon, 1989). However, some aspects of the market potential are discussed controversially. Some references describe that a tough competition is a main factor for product failure. Other studies explain that the expected growth rate of a market is an important factor for the probability of a product success. Still others declare that the competitiveness and the rates of growth of a market neutralise each other because the disadvantages of a high competition are compensated by the advantages of a growing market. Another important impact concerning the market potential is the timing of the product launch. A significant part of the relevant literature agrees that the right launch timing is important for the later product success. Launching the product prior to competing products is principally stated as very positive for the later product success. Nevertheless, in some cases, a premature entry into the market can cause some disadvantages, for example, if an early market introduction is in conflict with the objective of a high quality of the product (van der Panne et al. 2003, Balachandra and Friar, 1997).

Thus, for an evaluation method it has to be examined critically which aspects of market potential should be included. Some of the aspects cited above like market growth or competition cannot be included because the correlation to product success is not obvious. However, the aspect of the right timing of product launch seems to be important. Therefore, it has to be included in an evaluation method for innovative product ideas. Since a premature entry in a market can also cause some disadvantages, an early product launch cannot be simply correlated to the probability of later product success. Thus, it has to be examined if the product and the product advantage come to the market prior to the competitors' products. Additionally, it has to be observed whether the product launch is too early. The other possibility is to examine if it is the right time to offer a certain product. This can be done by linking the timing of product launch to some aspects of the product advantage cited above. For example, the superior performance of a product has to fulfil important customer needs exactly at the time of launching the product. The customer needs have to exist exactly at this moment when the product that fulfils these requirements is launched. In this case, an evaluation from a technical point of view has to consider these aspects as well because they cannot be separated from other important aspects like the product advantage.

**Synergy**

Many studies state synergy to be an important factor for new product success. In this context, synergy means that the resources of an enterprise and the skills of its employees fit to the needs of a conducted development project. Synergy concerns on one hand the technical part of the new product development like research and development, product development, engineering and production. On the other hand, marketing synergy like synergy in sales force, promotion, market research, distribution, advertising or customer service is important (Trommsdorff and Steinhoff, 2007, Lilien and Yoon 1989, Montoya-Weiss and Calantone, 1994). However, Cooper and Kleinschmidt (Cooper and Kleinschmidt, 1993) state that synergy does not influence the later product success in every industry and in every company to the same degree. They explained that in large enterprises with competence in a lot of different fields, synergy generally exists but does not distinguish between successful products and failures.

As synergy is stated to be an important factor related to new product success, it has to be included in the evaluation method. However, the effects and the impact concerning the synergy have to be considered in each particular case.

**Degree of innovation**

The factors related to product success that are discussed in the chapters above are strongly linked to the probability of later product success. In contrast, the degree of innovation is discussed controversially. Many studies examined the correlation between the degree of innovation and the later product success. All these studies can prove their statements by empirical measurement results. However, the results of these studies are quite different and even contradictory. In this context, the degree of innovation is often defined as the degree of novelty of a certain product. In summary, the vast amount of studies examining the correlation between the degree of innovation and the success of products found five different and partially contradictory results (Balachandra and Friar, 1997, van der Panne et al. 2003, Steinhoff 2006):

1. Some studies point out that products with a high degree of innovation are positively correlated to new product success. Concurrently, they stated that products with a low degree of innovation are less successful, see figure 2, curve 1 (Balachandra and Friar, 1997, van der Panne et al. 2003, Steinhoff 2006).
2. Other studies show a negative connection between the innovativeness and the success of a product, see figure 2, curve 2 (Balachandra and Friar, 1997, Steinhoff 2006).
3. Furthermore, rather a U-shaped than a constant connection between these two factors can be found in the relevant literature, see figure 2, curve 3. According to these results, products with a high degree of innovation are positively correlated to the probability of product success. On average, products with a low degree of innovation are also stated to be successful whereas products classified as medium innovative show low success rates. The high success rates of products with a high degree of innovation are explained by a high product advantage that is offered by these products. The high probability of product success of products characterised as low innovative is assigned to technical and marketing synergy effects. Medium innovative products cannot profit from synergy effects and do not offer a great product advantage. This is an explanation for their low probability of success (van der Panne et al. 2003, Kleinschmidt and Cooper, 1991, Balachandra and Friar, 1997, Steinhoff 2006).
4. Still others found a reverse U-shaped correlation, see figure 2, curve 4 (Steinhoff 2006).
5. Finally, other studies affirm that an obvious correlation or any correlation between the degree of innovation and the probability of product success cannot be found (van der Panne et al. 2003, Balachandra and Friar, 1997, Steinhoff 2006).

The bottom line is that the connection between the innovativeness and the success of a product is uncertain. Four different correlations between the degree of innovation and the probability of new product success were found by several different studies (Steinhoff 2006, Balachandra and

Friar, 1997, van der Panne et al. 2003). One reason for these very different and even contradictory results is the inconsistent definition of the degree of innovation in different studies (Steinhoff 2006, Ernst 2001). Furthermore, the definition of the second variable, the product success, is uncertain, too. The success of products is often measured or defined in different ways within the regarded studies. Thus, the integration of the degree of innovation in the evaluation method has to be examined critically. The degree of innovation must not be taken as an evaluation criterion as the correlation to product success is uncertain. Therefore, one possibility is to carry out an evaluation without regarding this factor. The other possibility is to determine the used evaluation criteria or the used evaluation method dependent on the degree of innovation of a certain new product idea. In this case, it is necessary to determine the degree of innovation of a new product idea in a first step. Dependent on the result of this first examination, the suitable evaluation criteria or the suitable evaluation method can be selected in a second step.

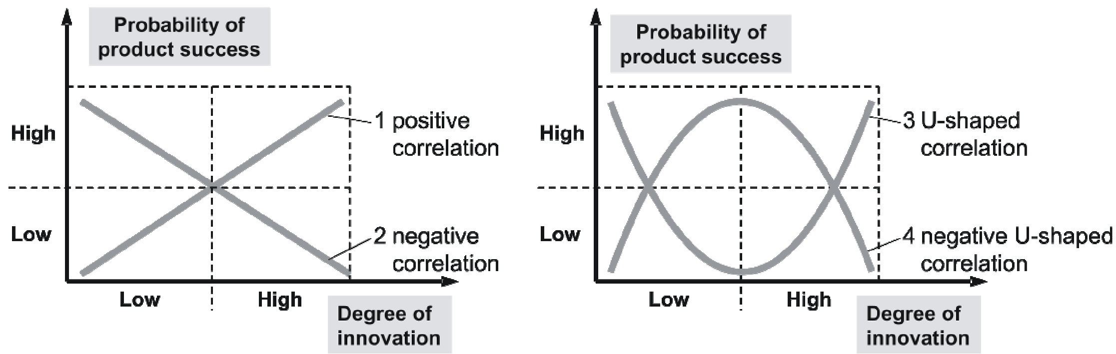


Figure 2. Correlations between the degree of innovation and the probability of new product success

## IV. Conclusion

Summarising, it can be stated that the evaluation criteria of the existing evaluation method have to be optimised in several points. Currently, the customer requirements have a strong impact on the evaluation results. The evaluation is based on the first “House of Quality” of the QFD-method. In this connection, the customer orientation or rather the customer requirements are used as a basic input parameter. It is absolutely right to include the customer needs in the method. However, it has to be examined if they are included too much so that radical innovations would not succeed within this method. Of course, this fact depends on the selected customer requirements. Therefore, there are two possibilities to integrate the customer needs in the evaluation method for innovative product ideas. On the one hand, it seems to be reasonable to integrate both current customer needs and future customer needs in an evaluation of a new product idea. However, in this case the question arises how these future and implicit requirements and needs of the customers can be measured. One possibility could be to observe customers using a product to identify some of these implicit requirements. On the other hand, the customer’s point of view can be integrated into an evaluation method for innovative product ideas by determining the grade of customer orientation dependent on the degree of innovation of the product idea that has to be evaluated. Table 3 provides an overview of the actual and the target state of the factors related to new product success.

The second important success factor discussed in this paper concerns the product advantage. The product advantage was stated to be a decisive factor for product success. So far, it is only included in the method by means of the “market comparison index” (see table 1). It is obvious that this relatively slight involvement is not sufficient and that the impact of the product advantage on the evaluation result has to be increased. Moreover, the definition of the product advantage has been expanded. It consists of the following five aspects: a product has to offer a superior performance compared with competing products, the (superior) performance has to fulfil important customer needs, the performance has to be easily noticeable for the customers, the competitors may not be able to compensate this advantage and the (superior) performance may not be suspended by the environment. Each of these five aspects of the product advantage has to be integrated in the evaluation method for innovative product ideas. The product advantage or rather its five factors have to gain a high impact on the evaluation results because all relevant studies explain that these are very important aspects for later product success. The third important group of aspects related to new product success are market-related factors. Market-related factors are currently not included in the existing method. Some of these factors, like market growth or competition, cannot be implemented in an optimised evaluation method as there is no obvious correlation to later product success. Other aspects like the right timing of product launch seem to be very important. Therefore, this factor has to be included in the evaluation method. Since the correlation between the timing of product launch and the probability of product success is not obvious in every case, the implementation in the evaluation method is not simple. Thus, the timing of product launch has to be compared with competing products in a first step. Coming prior to competing products would be positively correlated to later product success. In this case, it has to be observed in an additional step if the product is launched too early. The other possibility is to examine the timing to offer a certain product regarding the customer requirements. This can be done by linking the timing of the product launch to some aspects of the product advantage cited above. For example, apart from fulfilling important customer needs, the superior performance of a product has to fulfil these customer needs exactly at the time when the product is launched. The fourth important factor related to new product success is synergy. In this context, synergy means that the resources of an enterprise and the skills of its employees fit to the needs of a conducted development project. This factor is not regarded within the existing method. However, it has to be included in the optimised version because all relevant studies state synergy to be an important factor related to new product success. However, the effects and the impact concerning the synergy depend on the enterprise and the industry in which a new product is developed. Therefore, the aspects of synergy have to be included but their impact has to be considered in the particular case. These results are summarised in table 3, too.

| Factor | Actual state | Target state |
|---|---|---|
| Customer orientation | • basic input parameter<br>• strong impact on the evaluation results | • Integration of current and future requirements<br>**or**<br>• Impact dependent on type/degree of innovation |
| Product advantage | • input parameter<br>• slight impact by means of the “market comparison index” (see table 1) | • definition expanded including the five aspects of the product advantage<br>• increased impact on the evaluation results |
| Market-related factors | • not included in the existing method | • factors with uncertain impacts on the product success (e.g. market growth, competition) are not included in the evaluation method<br>• factors related to new product success are integrated in the evaluation method (e. g. timing of product launch) |
| Synergy | • not included in the existing method | • included in the evaluation method<br>• impact dependent of the particular case |
| Degree of innovation | • one out of two results calculated by the evaluation algorithm | • factor is not regarded in the evaluation<br>**or**<br>• factor determines the evaluation criteria/method |

Table 3. Actual and target state of the integration of success factors in the evaluation method

The factors regarded so far are all positively correlated to new product success. However, the degree of innovation, a factor that is discussed controversially within the relevant literature, has been regarded in the chapters above because it is an important factor in the existing evaluation method for innovative product ideas. The results showed that certain conclusions related to new product success cannot be drawn because the correlation between the degree of innovation and new product success is uncertain. Some studies found positive, some others negative correlations. Still others found U-shaped, reverse U-shaped or even no correlations. Thus, the integration of the degree of innovation in the evaluation method has to be examined critically. It is not possible to integrate the degree of innovation as an evaluation criterion in the evaluation method when its correlation to later product success is uncertain. Therefore, other possibilities have to be examined. One possibility is to evaluate product ideas without regarding this factor. In the existing method, the degree of innovation is not used as an evaluation criterion. Instead, it is one out of two results calculated by the evaluation algorithm. This procedure is possible in principle. However, the question is what to do with this result. The other possibility is to determine the used evaluation criteria or the used evaluation method dependent on the degree of innovation. In this case, it is necessary to determine the degree of innovation of a product idea in a first step. In a second step, the suitable evaluation method and the suitable evaluation criteria have to be selected. The results concerning the degree of innovation are also summarised in table 3.

## V. Outlook

To be able to implement the results of the literature research for factors related to new product success in an evaluation method, the stated aspects have to be concretised. The factors have to be transformed into tangible, comprehensible and rateable evaluation criteria. Furthermore, the degree of innovation has to be examined more detailed. In order to determine the grade of customer orientation, respectively the used evaluation method or the used evaluation criteria dependent on the degree of innovation, this term has to be defined uniquely. It must be possible for evaluators to easily determine the degree of innovation of a certain product idea before the evaluation. After optimising the existing evaluation method by means of the stated results, other aspects of the method like the procedure also have to be examined. At first, it has to be verified if the existing procedure which is based on the QFD-method is principally suitable for the evaluation of innovative product ideas. In this connection, it is important to consider whether the procedure is too complex for such an evaluation. Secondly, it must be investigated if the QFD-method is suitable for all kinds of product ideas with a different degree of innovation. When concluding that the existing method is not suitable for all kinds of innovative product ideas, other evaluation procedures have to be examined, adopted, adjusted or invented. After the examination and the adaptation of the criteria and the procedure the evaluation method has to be validated in numerous projects in industry. The research project aims at an applicable and thoroughly developed evaluation method.

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# Strategic Environmental Scanning as a Management Tool for Innovation

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**Abstract:** In times of increasing dynamics and complexities of new technologies, methods of strategic technological foresight become increasingly important. Technological developments in manufacturing industry are often intertwined with or accomplished by changes in underlying firm-level concepts or paradigms of production systems or management regimes. Thus, the assessment of future developments in manufacturing should combine both perspectives: the technological and the conceptual dimension. While the technological dimension is sufficiently covered by patent indicators, the emergence of new production concepts is more likely to become visible in scientific publications. Deployed independently, the methods are likely to draw only a one-sided, either too focused or too diffused picture of new developments which provides only a weak basis for subsequent strategic decisions of firms.

This paper presents how the different advantages and explanatory values of patent analysis and bibliometrics can be integrated in a holistic tool of strategic environmental scanning for manufacturing enterprises. The results are based on a recent research project, jointly conducted with the German Machine Tool Builder's association (VDW). During the project such a tool was developed an implemented for their member firms. Based on the examples and results about technological trends in the Japanese machine tool industry and the German automotive industry, which have been generated by the use of the tool, the paper focuses on the practical realisation of strategic environmental scanning in the context of an industrial association. Besides that, the paper also elaborates on theoretical as well as on methodological aspects of strategic environmental scanning. The findings show that the integration of patent and bibliometric indicators is a fruitful approach to provide a solid basis for technological strategic environmental scanning in manufacturing industry.

**Keywords:** strategic environmental scanning, innovation management, bibliometrics, patent data analysis, dynamic capabilities

## I. Introduction

In a Schumpeterian world of increased dynamics in technology and competition, firms are constantly faced with new challenges. Product and factor markets are becoming increasingly complex and more integrated, new technologies shape new forms and rules of competition. For these reasons, firms are permanently forced to adapt to changes in their competitive environment to take advantage of them. Moreover, firms have to identify ways and possibilities to help shaping this change, for example by developing corresponding technological or non-technological innovations (Helfat et al. 2007). For this purpose, methods of strategic environmental scanning (SES) become increasingly important for manufacturing firms because they enable them a) to early recognize and identify important technological trends and discontinuities in their competitive environment, and b) to develop and implement adequate measures to adjust their strategic use of innovation resources according to these external requirements. As technological developments in manufacturing industry are often intertwined with changes in underlying firm-level concepts or paradigms of production systems or management regimes, the assessment of future developments in manufacturing industry needs to pay attention to both perspectives: tangible aspects of technological change in all phases of development and intangible dimensions of technological change such as emerging or changing paradigms of production or production management. For the purpose of providing a valid basis for future strategic planning of manufacturing firms, it is necessary to identify adequate indicators and methods for measuring these tangible and intangible dimensions of technological change and to integrate them into a tool of strategic environmental scanning.

In this paper first we give a short outline of the theoretical background, explain the project background and summarize the methodological aspects. We thereafter give some more detailed information about the implementation of the tool and underpin the findings by giving some examples for the results that have been received by using the tool. Finally we discuss whether the objectives of the project were fulfilled and draw some general conclusions on the use of such a tool for strategic environmental scanning for a group of companies.

The findings show that the integration of patent analysis and bibliometrics in one tool is a fruitful approach to provide a solid quantitative basis for strategic technology foresight in the field of manufacturing industry. Qualitative approaches are a valid amendment of such a tool.

## II. Theoretical background

Under the umbrella of resource-based theory of strategic management (Wernerfelt 1984, Barney 1986, Peteraf 1993), the concept of dynamic capabilities came up in the mid 90s and has addressed the central question of how firms can sustain competitive advantage by responding to environmental change, i.e. by using their strategic resources in correspondence to their dynamic and changing market and external environments (Teece 2007, Helfat et al. 2007, Helfat and Peteraf 2009). Within the so far existing frame work of the resource-based theory, competitive advantage can flow only at a point in time due to the ownership or control of scarce, but valuable and difficult-to-imitate assets and know-how. However, in fast moving business environments open to global competition, characterised by spatial dispersion of sources of innovation and manufacturing, persistent and sustainable competitive advantage and economic success needs more than the selective control of certain resources and competences.

According to the literature of the dynamic capabilities approach (Teece et al. 1997, Lei et al. 1996, Eisenhardt and Martin 2000, Zollo and Winter 2002, Helfat and Peteraf 2003), the answer to this problem lies in highly firm-specific, heterogeneous capabilities which enable the firms to continuously (re-)configure and adapt its firm-specific, intangible resources, competences, and know-how to dynamic environments (Teece 2000). "We define dynamic capabilities as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments (Teece et al. 1997: 516). Because dynamic capabilities aim at processes of renewal and reconfiguration, they particularly promote the attainment of Schumpeterian rents by supporting necessary changes in the resource basis of the firm which favour the development of corresponding innovations (Teece et al. 1997).

One of the probably most influential conceptualisations of dynamic capabilities has been developed by Cohen and Levinthal (1989). They described the “absorptive capacity” of firms as the ability to recognize the value of new, external information, assimilate it and apply it to commercial ends. Considering this definition, it can be stated that the absorptive capacity of a firm can be distinguished by two interdependent dimensions: a) the capability to search and acquire new, external information about technological trends, and b) the capability to adapt internal processes and resource configurations in such a way that their competitive potential is fully exploited (Zahra and George 2002). The basic assumption is that those firms which manage external knowledge flows more efficiently, stimulate innovative outcomes and thus obtain superior competitive advantage (Escribano et al. 2009).

Originally, the absorptive capacity of a firm was closely interlinked with the intensity of its R&D activities (Cohen and Levinthal 1989). However, there has been increasing critique on this firm-internal operationalisation of absorptive capacity. Thus, as recent studies (Schmidt 2005, Spithoven et al. 2010, Murovec and Prodan 2009) emphasis, absorptive capacity is a multidimensional concept which encompasses both firm-internal (i.e. routines, employee skills) and external resources (i.e. alliances, cooperations, or networks with other firms, stakeholders, scientific community). Subsequently, firms with only limited resources for internal absorptive capacity like small and medium sized enterprises (SME) may face serious problems in maintaining and improving their absorptive capacity. Therefore, it can be expected that SMEs strongly rely on third-parties (i.e. like industry associations) to help them build and maintain their absorptive capacity (Escribano et al. 2009, Spithoven et al. 2010). In the context of this theoretical background the main goals of the research project were defined as follows:

- Development of a tool for strategic environmental scanning to allow firms to search and acquire new, external information about technological trends related to the field of machine tool industry and thus to help them improving their absorptive capacity.
- The tool for strategic environmental scanning should provide information about new, tangible technological trends as well as about intangible changes in the underlying concepts and paradigms of technology providing a holistic and valid basis for the firms' strategic planning.
- Thereby, the tool should address technological trends that either emerge from scientific communities (i.e. like universities) or from actors closer to the market (i.e. competitors, applied and industrial research).
- The tool for strategic environmental scanning should be realized and implemented in as a third-party offer especially for SMEs by building upon the network infrastructure and expertise of the German machine tool builders´ association (VDW).
- Thereby the tool should offer a large group of SMEs cost-efficient access to information gained by using elaborated environmental scanning approaches and chargeable databases.

## III. Project background

Trade association are organizations founded and funded by businesses that operate in a specific industry. The main focus of such industry associations is collaboration between companies, or standardization. Associations may offer other services, such as producing conferences, networking or charitable events or offering classes or educational materials. The German machine tool builders association describes their services on the internet as: "Spokesman of the industry and an important source of new ideas for the companies. The VDW gathers available know how, accesses technological trends and developments, drives forward research, seeks the best new talent together with its members and advises on many everyday company issues." The German machine tool industry employs almost 70.000 people and is a rather small branch of industry. Only 4 per cent of producers employ more than 1.000 people. The industry´s competitiveness depends on the flexibility of medium-sized entrepreneurs. The majority of the member firms are facing limited resources for internal absorptive capacity. Since the association is focused on a specific industry the changing environment of all member firms is in parts overlapping and therefore suitable for a collaborative approach of environmental scanning.

Compared to building up a specific network for collaborative environmental scanning associations offer the availability of an existing organization, expertise on technological aspects and, to certain extend, trust among the member firms based on previous collaboration (Specht et al. 2006).

The Fraunhofer ISI investigate the scientific, economic, ecological, social, organizational, legal and political framework conditions for generating innovations and their implications. Scientifically based analysis, evaluation and forecasting methods are used for this purpose. The assessments of the potentials and limitations of technical, organizational or institutional innovations help decision-makers from industry, academia and politics in making strategic decisions and thus assist them in creating a favorable environment for innovations.

The project was assigned by the German machine tool builders´ association. The technological expertise on machine tools was provided by various experts from the machine tool association and selected experts from industry. The methodological expertise was provided by Fraunhofer ISI. The project was conducted in close cooperation with the machine tool builders association within a time period of 1.5 years. To ensure the alignment of the project with the requirements of the members of the association, a steering committee was set up consisting of representatives from industry.

In addition to the already described overall objective, the development of a strategic environmental scanning tool, the project aimed at testing the tool by applying the methodology to two different themes:

- Machine tool technology in Japan and Germany – status quo and possible future developments
- Future developments of the passenger car engine and drive train - implications on the manufacturing technology.

## IV. Methodological aspects

Environmental scanning can be accomplished by the use of diverse methods (Miranda Santo et al. 2006: 1017). Those comprise usually qualitative and quantitative methods as well as the analysis of primary and secondary data. Depending on the object of investigation and the time horizon considered, the methodological approach has to be adjusted and different methods have to be combined. Within the project the strategic environmental scanning covered: literature analysis, patent and publication data, qualitative expert-interviews and an online expert-survey (Figure 1).

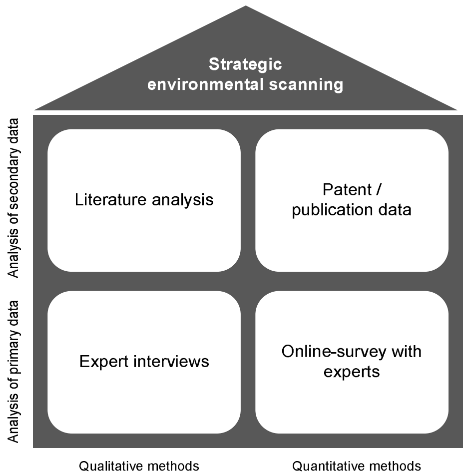


Figure 1: Set of used methods

The use of different methods was necessary because tangible aspects as well as conceptual aspects were part of the object of investigation.

Scientific publications and patents are sources of information for codified knowledge of an economy. They are used as indicators for measuring and illustrating technological change (Grupp and Schmoch 1991, Grupp 1997). Patenting activities are often an important precondition for the market success, thus they can be used as an indicator for future market developments (Schmoch 1990, Lichtenthaler 2002, S. 39). Thereby, identified trends can be extrapolated into the closer future. As patent analyses are based on IPC-classification which does usually not exactly fit the subject of interest, the transformation of conceptual changes into technological requirement remains difficult (Schmoch, 1990). Hence, it is very important to identify adequate search strings to capture the research objectives by using a combination of IPC-classification and keywords.

The patent analyses were mainly based on data of the European Patent Office (EPO). In the present situation the vast majority of foreign patents are filed through the EPO, and the number of direct foreign applications at domestic offices is negligible. In consequence, it is possible to observe internationally balanced technology trends using EPO applications from about 1990. At the EPO there is a certain bias in favour of European countries, but the number of Japanese applications is still considerable. To expand the time frame that can be covered at the current end of the EPO-databases, it has been accomplished by data from the World Intellectual Property Rights Organization (WIPO). Moreover, constructing such a fictive international patent reduces the risk that the findings are biased by home advantage of national patent offices (Schmoch, 1990).

Publications reflect a relevant part of the fundamental research activity and therefore they offer the opportunity to identify early signals. Publication analyses indicate developments in the scientific system and include the more general level of underlying production and management concepts at an early stage of discussion (Lichtenthaler, 2002). Thus in the context of strategic foresight they can offer the opportunity to identify early signals. Within the project three different databases were used to ensure a higher reliability of the results. Databases used for publication analyses were SCOPUS, ISI Web of Science and COMPENDEX. Comparing scientific publication and patent data the latter is predominantly technology oriented, while scientific publications cover tangible as well as conceptual aspects.

Qualitative methods, like expert interviews, are important to ensure profound understanding of the developments, and integrating diverse perspectives of different experts. Non standardised qualitative expert interviews on the basis of a guideline ensure the coverage of all relevant aspects and provide at the same time the opportunity to capture expert specific amendments. Excellent technological expertise of the interviewer and access to the expert-networks was provided by industry association and the member firms. These qualitative interviews are complemented by quantitative online surveys to prove the findings and their interpretation on a broader empirical basis.

In summary the relevant characteristics of the different sources of information and methods in the present project are shown in the following:

| Method/ Sources | Characteristics |
|---|---|
| **Patents:** | • sources of information for codified knowledge<br>• measuring and illustrating technological change |
| **Scientific Publications** | • addressing fundamental and applied research<br>• tangible and conceptual aspects |
| **Expert Interviews** | • to ensure profound understanding and interpretation of the results<br>• to prove the findings and their interpretation |
| **Online Survey** | • to build upon a broader empirical basis<br>• considering different perspectives and different expert knowledge<br>• integrating quantitative and qualitative approaches |

Table 1. Characteristics of different sources of information and methods

## V. Implementation

The topics that were used for testing the environmental scanning tool were selected by the steering committee. Cooperative environmental scanning has to pay close attention to select suitable topics for cooperative environmental scanning (Specht et al. 2006). The most important criteria for the selection within the project were:

- Information should be of high interest for almost all members of the association.

- Information should not be relevant to current competition among the members.
- Information should be difficult to attain for a single firm (especially SME).

The selected topics corresponded to those criteria. Cultural barriers and the restricted availability of information about the Japanese machine tool builders' strategy required extensive environmental scanning and the use of sophisticated methods and databases, not being cost efficient for a single SME. Reasons for the selection of the second topic were the complexity of the subject and the extensive but contradictory information about possible future developments of the drive train of passenger cars and their implications for the machine tool builders.

To analysis the two topics named above the integration and combination of methods was necessary. Therefore an iterative process building upon different methods was designed. This necessity follows from the different research and project experiences of the Fraunhofer ISI. Particularly in technological areas with incremental innovations such as the machine tool industry, innovations may take place in apparently unrelated fields of technology such as specific materials. The definition of search strings therefore require multiple feedback loops between patent and publication analysts and technology experts in industry and academia to check the plausibility of the data collected and the interpretation derived (Bradke et al. 2007). As every technology or concept is comprised of more than one element, several search strategies in parallel are useful as interim results may influence the next step of the analysis. Deployed isolated from each other, the methodological modules are likely to draw a one-sided, either too focused or too diffused picture of developments and thus provide a rather weak basis form firms´ subsequent strategy decision. Their integration builds a comprehensive, holistic approach to address tangible and intangible elements of technological change. Moreover, the methodological modules are able to cross-fertilize each other as the output of one module stimulates or serve as an input for other modules.

The project can thus be described by a parallel synergetic methodological framework with feedback loops between its methodological modules (see Figure 2).

Starting point for the analysis of each topic was an extensive discussion with the experts from the association resulting in the definition of key words and selection of IPC-classes for the bibliometric approach. Afterwards an interactive process was established where results of the analysis of patent data as well as scientific publications were revised by the representatives of the association. In this discursive process keywords and patent classes where tailored to the demands of the industry branch. For the patent data analysis a combination of IPC classification and keywords was used to filter out the relevant data. Input for the keywords was extracted from the search strings used for the analysis of scientific publications. For the analysis of scientific publications different databases were tested and thereafter the database offering the largest number of relevant publications for this specific topic was selected for in depth analysis. Fruitful interlink ages between the analysis of patent data and scientific publications were established throughout the process.

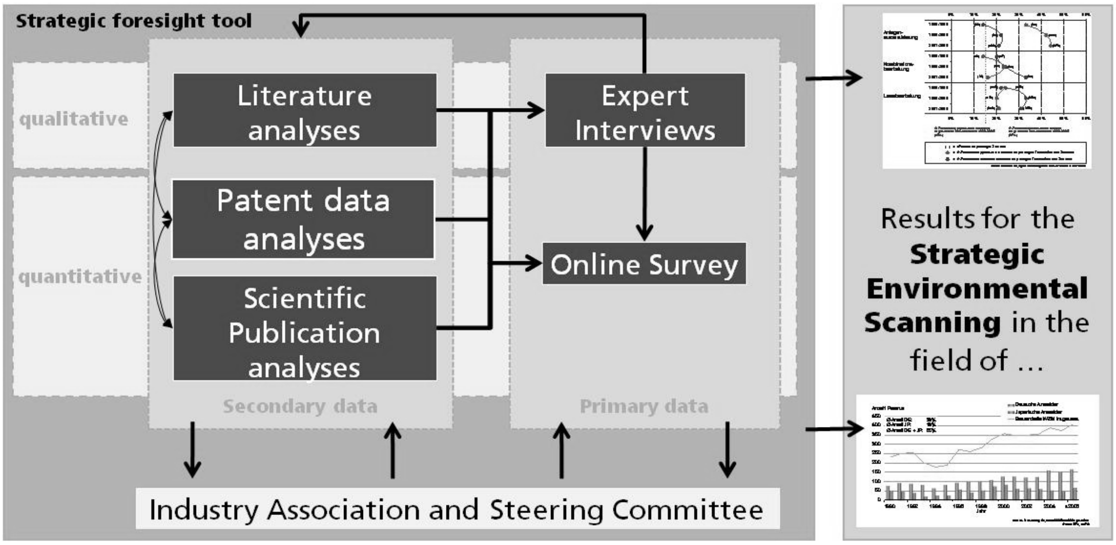


Figure 2. Implementation and Integration – Developing a strategic environmental scanning tool

The interpretation of the results of the bibliometric analysis was done in close cooperation with the representatives of the association. Based on these findings, additional qualitative interviews were conducted. For one of the topics even a completive online survey was carried out. For the online survey the close relation of the association of machine tool builders with other associations was exploited to gain access to a large number of experts from other branches. This online-survey was therefore tailored to the specific requirements of the machine tool builders' branch but has been answered from a large number of experts from other branches.

The statistic findings and the overall interpretations were finally discussed with the steering committee before providing the information in a short report to all members of the association.

## VI. Selected results

For the first topic selected by the steering committee, a comparison between German and Japanese machine tool builders, the analysis of patent data and scientific publications offered valid comparison between the technological developments in the two countries. To allow a comparison between the dynamic developments of research activities in the two countries a time horizon of at least 10 years in the past was defined. As described before there is a certain bias in favour of European countries at the EPO. Therefore close attention was paid to take this bias into account (average share of patents from German applicants in the field of machine tools compared to average share of patents of Japanese applicants).

On the basis of these reflections it was possible to show that the leading position of the Japanese machine tool builders in a specific field is not likely to be challenged by German machine tool builders within the next years. Patent data and scientific publications showed over many years more comprehensive research activity in this field in Japan compared to Germany. Discussing these results with the steering committee revealed that this information was very interesting for many member firms. German SMEs observed mainly the activities of their German competitors and had not gathered sufficient information about the activities of their Japanese competitors.

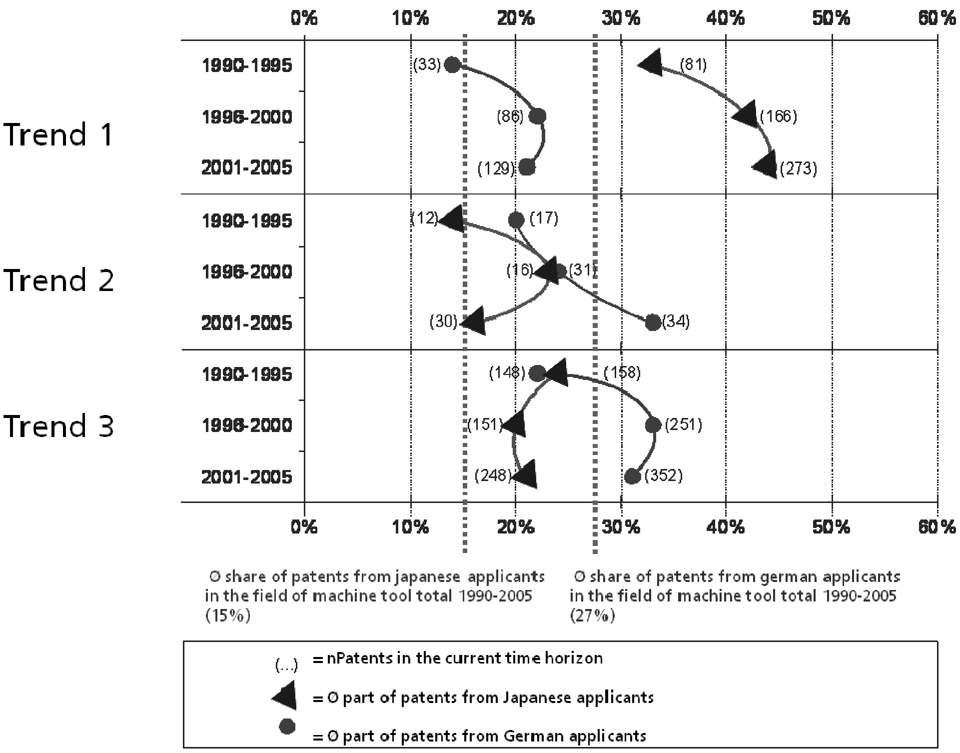


Figure 3. Comparison of German and Japanese patent applications in different fields of machine tool

Concerning changes in the manufacturing concept it turned out to be difficult to use patent data as an indicator for research and development activities. No reliable information on manufacturing concepts was found when analysing patent data. Therefore the environmental scanning focused on scientific publications. Since scientific publications aim to reach an international community, many journals are international as well publications can only be classified by the address of the authors. Very few publications were found with co-authors from Germany and Japan.

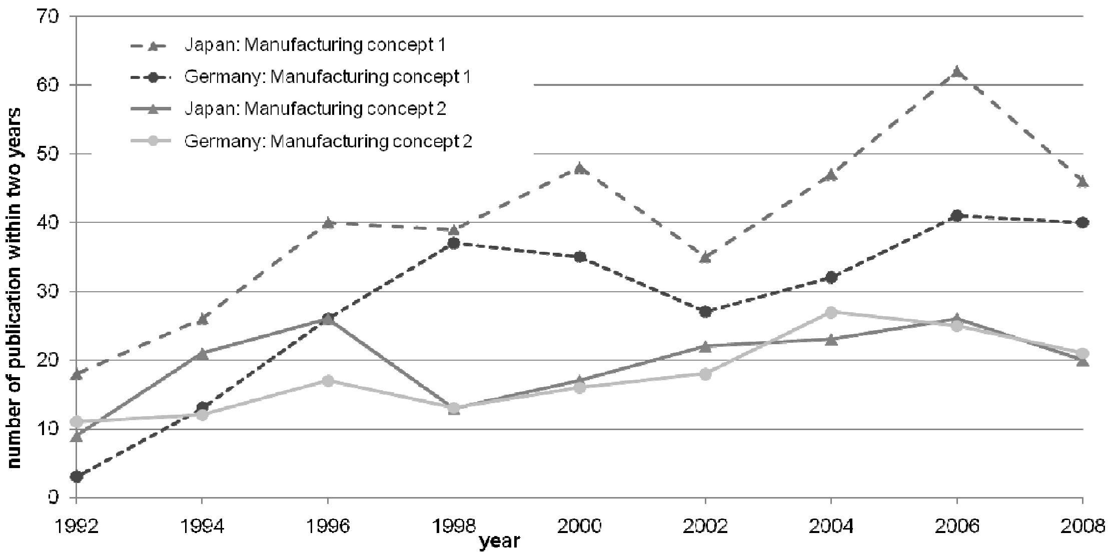


Figure 4. Comparison of the number of scientific publications of German and Japanese authors (database SCOPUS).

Figure 4 shows the results of analysing publication data for two different manufacturing concepts. Publication activities remained at the same level for many years for manufacturing concept 2. For manufacturing concept 1 an increase in research activities was concluded, based on the rising number of scientific publications starting in 1992. For both manufacturing concepts a very similar development was observed in Japan and Germany. The results affirmed the expectations of the association and their member firms.

Publication data analysis was not also used to derive a more comprehensive picture of the world wide research activities by including other countries in the comparison. As shown in Figure 5 a very dynamic development of scientific publications linked to machine tools was observed in a third country. This analysis was the starting point of further investigation subsequent to the project described. When using publication data for analysing a very specific subject the approach is often constricted by the small number of publications per year allowing no statistical analysis and hindering a trend extrapolation. Therefore it is particularly important to use the database best fitting for analysis this specific subject and it can be necessary to compare the suitability of different databases.

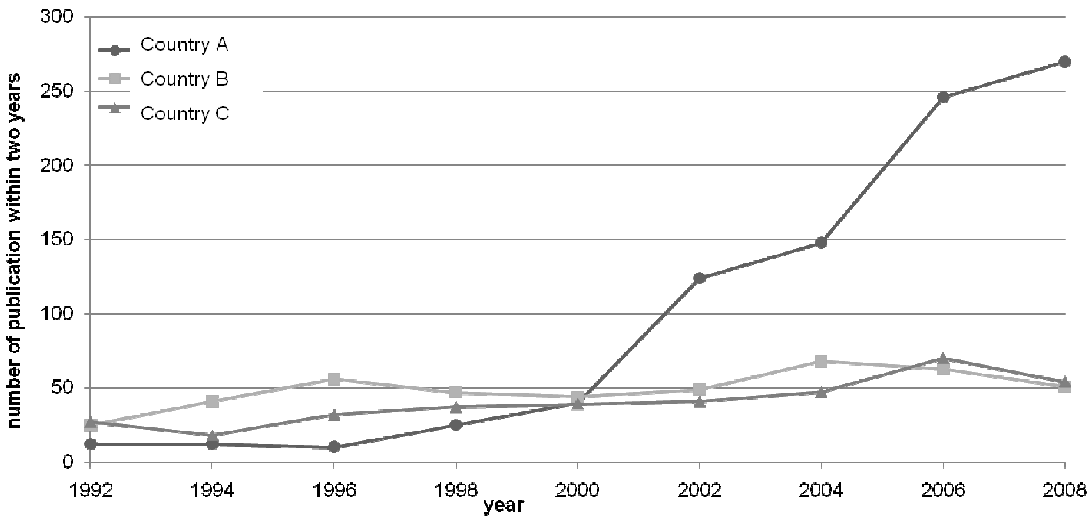


Figure 5. Comparison of the number of scientific publications of authors from three different countries (database SCOPUS).

Scientific publications and patent data analysis were not only used to investigate the intensity of research activities in the different countries but at the same time the analyses gave an overview of the dominant research institutes, researchers and journals within the field of interest. During discussions with the steering committee this information was used to ensure the reliability of the results, demonstrating the all relevant actors and journals familiar to the steering committee were considered within the analyses.

Using patent data for the analysis of future material usage for components of the engine and the drive train turned out to be difficult, even when using a combination of IPC classification and keywords no suitable patent data information was extracted. Therefore other methods were chosen such as qualitative expert interviews and as an amendment an online expert survey. The survey focussed on components that require the extensive use of machine tools during manufacturing. One of the most important drivers of change in manufacturing technology for those components turned out to be the usage of new materials, requiring adjusted manufacturing technology. Therefore, changes in the usage of materials for these components have a relevant impact on the machine tool builders (see Figure 6).

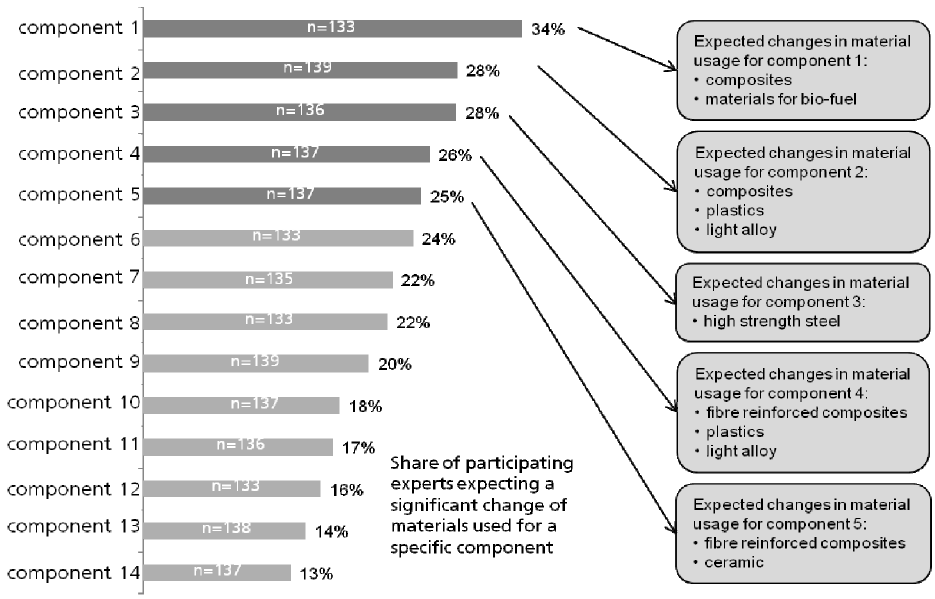


Figure 6. Example of results from the Online Survey – Expected changes in material usage for different components of the engine and the drive train

The results of the survey showed that a differentiation between the components is necessary to assess the use of new materials. While for some components there seems to be a clear trend towards the use of new materials, this does not hold true for all the components. On this basis firm specific conclusions can be derived.

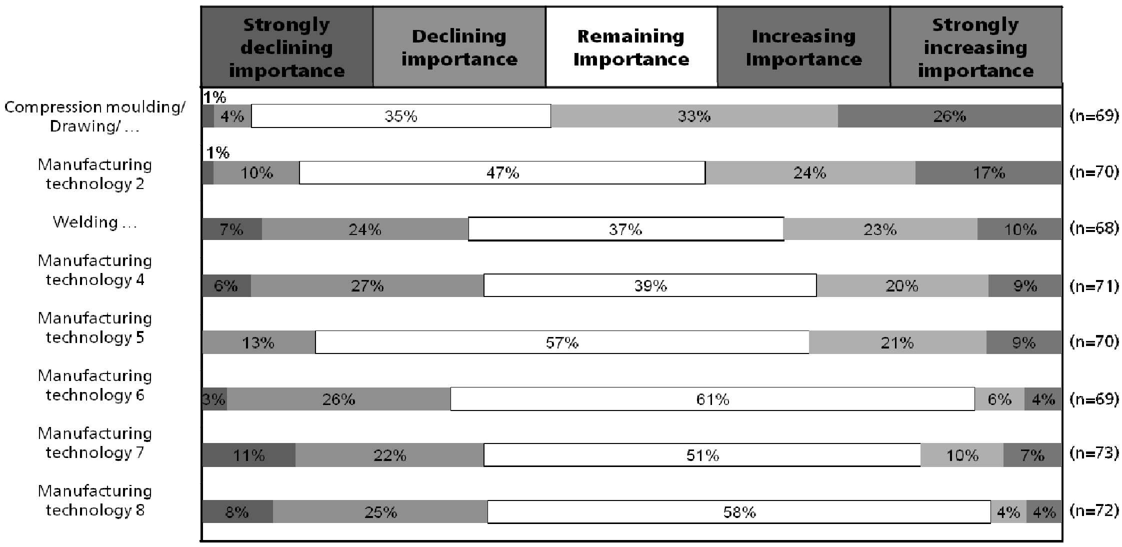


Figure 7: Example of results from the Online Survey – Changing Importance of manufacturing Technologies according to experts expectations

After discussing different alternative materials the experts were asked to assess the future importance of specific manufacturing technologies, compared to the extent of use in car manufacturing of today. Figure 7 shows an example for the resultant ratings/assessments of the experts in the online survey. The Figure shows that for many technologies there is no consensus among the experts about the expected development in the future. While one third of the experts expected a declining importance, one third expected a remaining importance and about one third expected an even increasing importance. For these technologies no reliable forecast can be expressed today, but instead effected companies should become more flexible.

Using only a small number of qualitative interviews can lead to different conclusions, when not all groups of experts are represented within the sample.

## VII. Conclusion and Outlook

Within the project the objective to develop a tool for strategic environmental scanning to allow firms to search and acquire new, external information about technological trends and thus to help them improve their absorptive capacity was achieved.

It proved to be possible to investigate tangible and conceptual aspect of technological developments by using the combination of qualitative and quantitative methods. Therefore the tool can provide a step towards a holistic perspective by offering information on topics that are often "blind spots" for SMEs since they require the use of elaborated, combined methods and commercial databases such as for example information on the research activities in Japan which have been required.

While the cooperative environmental scanning for a group of companies offers enormous opportunities for using sophisticated methods, it is restricted to topics that are not adjacent to information relevant for competition. Therefore it can only be a supplement for the corporate environmental scanning activity.

The implementation as a third-party offer by an association turned out to bring about important advantages not only by providing the necessary technological expertise, but also by ensuring reliability of the information to the companies, by acting as a multiplier and by providing access to a network of experts outside the branch.

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# Learning Virtual Teams: How To Design A Set of Web 2.0 Tools?

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**Abstract:** This paper suggests a process to help virtual teams define their requirements and set up their mix of web 2.0 tools. It is based on four steps: definition of the requirements of an Aided Competence Management for Virtual Team Building System (Aided CMVTB System) and formulation of its functions, tools' identification, evaluation of their response to each function and, as a consequence, designation of the web 2.0 tools which are most correlated. The process has been applied to the requirements in terms of project virtual teams. The outcomes are compared to the actual use and evaluation of the web 2.0 tools by 34 Marketing Managers who are used to working with virtual teams and work in large companies with over 5000 employees. The final section of this paper deals with managerial recommendations. It contains the concluding remarks and perspectives for future work.

**Keywords:** web 2.0, virtual team, project management, virtual team management, Aided CMVTB System

## I. Introduction

While the globalization of business processes offers wide growth opportunities, project teams become virtual and team members have to overcome the challenges of geographical distance. New collaborative behaviors have to be developed; on top, the use of the publishing mode in intranets (Banck 2005). Web 2.0 consists of a set of tools which provides distance collaborative interaction between team members (DiNucci, 1999). It is thus considered as a technical solution which can be used to overcome distance. Web 2.0 offers important concepts of web applications that make the web a more intuitive and social place. The key elements in web 2.0 are the users, their opinions and the collaboration between them. As it helps to create collaborative systems, it is also well-known as "social web" and the tools are named "social technologies". Social networking capabilities can help to capture unstructured tacit knowledge and make it re-usable (Stevens et al., 2009). They have reached a state of maturity that makes them easily useful to simplify communication, exchange of data and knowledge. This may enhance the entire organisational communication, collaboration and productivity and support innovation processes. Over 17 web 2.0 tools exist today and having to choose between them becomes a managerial issue anytime a virtual team is set up. This choice is becoming possible to a larger number of organizations for two reasons. First, the tools belong today to collaboration suites of intranet solution providers. Second, they are provided for free or almost free on the internet by more and more players; access providers, search engines, social networks, etc. DeLucca (2006) suggests using lean tools which generate compensatory adaptations from the virtual teams' members and due to this more efficiency. We suggest a specific four-phase learning process which will enable virtual teams to build their web 2.0 collaborative environment. This process is open; it is not linked to a closed list of tools and can integrate new tools.
The paper is structured in four main sections that represent phase 1-4 of the learning process. In phase 1 of our suggested process we define requirements by formulating functions due to the Aided CMVTB System. The Aided CMVTB System is briefly explained and an extract of functions that describe the system is presented. Phase 2 contemplates the identification and the choice of the web 2.0 tools using a sample survey with 34 Marketing Managers. In phase 3 of the process a correlation between the functions and the web 2.0 tools is established to show in which degree the web 2.0 tools respond to the demand of the requirements. Phase 4 present the correlation of the total of the presented functions with each respective web 2.0 tool and compares these results with their actual field popularity due to the sample survey. The paper finishes with managerial recommendations and our conclusions.

## II. Phase 1: Defining requirements and functions

In phase 1 of the process we use a set of tools called Aided Competence Management for Virtual Team Building System (Aided CMVTB System). The Aided CMVTB System provides best practices for virtual team building adapted to the requirements of each specific organization. One of the outcomes of the Aided CMVTB System is to provide recommendations, guidelines to take a choice of web 2.0 tools. The Aided CMVTB System is considered as a system that is described by functions. The process starts with the description of the environment of the virtual team, and the requirements of this environment. The functional analysis helps to define the functions that the system should cover to satisfy the requirements. The functional analysis with its systemic point of view is the tool that we use to be as objective, generic and exhaustive as possible. We decided to use the systemic approach of the functional analysis because its power lies in its ability to identify needs and requirements, show interrelations and apply a united symbolism and theory to deal with the important central features of the topic (Le Moigne, 1999, Yosida, 1978). The functions describe the optimum behavior of the system and its terms of usability. They are based on environments that are in interaction with the Aided CMVTB System. An identification of typical virtual teams' environments was based on a literature review (Schumacher et al., 2008). They are seen in figure 1.

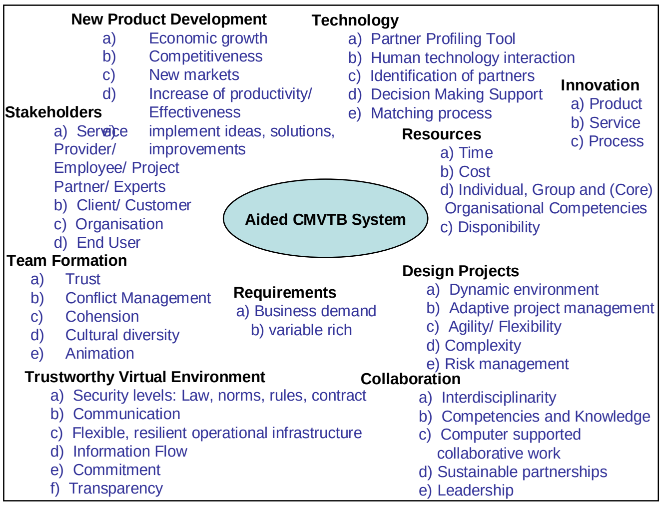


Figure 1. Virtual teams' Environments due to the Aided CMVTB System

In this rich example, the identification of 10 theoretical environments and 43 sub-environments of a virtual project team' Aided CMVTB System was made. This previous work (Schumacher et al. 2009, 2010) was continued with the detailed analysis of the interactions between environments, based on the functional analysis. It identified 243 transfer functions (FT) and 38 constraint functions (FC) by regarding each component of the system that interacts constantly with its environment. Transfer functions include at least two different environments that interact by the means of the system while constraint functions are generated by only one environment.

Managers of virtual teams can identify their own environments, their interactions, and determine the key functions. In this paper we present an extract of 12 functions that are classified due to four categories of Montoya (2009). They help classifying the functions and ensure the requirements are well covered and functions are coherent with the scientific demands of team interactions. They serve as positioning framework. The four categories are the following:

1.) Project management and production focus on operating procedures such as work performance, schedule, budgets or decision making

2.) Conveyance and member support tasks focus on the information exchange behavior of team members when conveying data, information and knowledge.

3.) Convergence tasks characterized by problem solving and decision making that involve team members critically examining others' contributions.

4.) Social relations and team well being tasks. Those categories are suggested with regard to the fact that virtual teams perform various simultaneous activities as they work towards set goals.

In this paper, we illustrate the process with an extract of 12 key functions which are representative of virtual teams dedicated to project management. In order to better visualize the following example, we chose to include only three functions for each category in table 1.

| | |
|---|---|
| **Project management and production** | |
| **FC2** | The system should help to **manage cross functional design projects** |
| **FT11** | The system should help to **manage the complexity of design projects** with variable, rich requirements. |
| **FC35** | The system should **generate and implement ideas, solutions** and improvements to improve innovation. |
| **[…]** | |
| **Conveyance and member support** | |
| **FT13** | The system should **foster communication** among project members. |
| **FT19** | The system should **make competencies accessible** and useable to all project partners. |
| **FC24** | The system should **extract, produce** and make **knowledge** accessible. |
| **[…]** | |
| **Convergence** | |
| **FC19** | The system should consider **principles of risk management**. |
| **FT34** | The system should manage dynamic environment with **fluid boundaries** and fluid team memberships. |
| **FT7** | The system should help virtual teams to **adapt their structure** to the requirements by agility and flexibility. |
| **[…]** | |
| **Social relations and team well being** | |
| **FC4** | The system should increase project **member's satisfaction**. |
| **FC17** | The system should allow **team leader animation**. |
| **FC29** | The system should allow **distance reduction** and easy socialization in trustworthy virtual environment. |
| **[…]** | |

Table 1. Extract of the functions due to the Aided CMVTB System within to the four categories of Montoya (2009)

## III. Phase 2 : Identifying and qualifying Web 2 tools

The list of web 2.0 tool increases and their use vary over time. Therefore, the sample provided the input needed to identify them. It allows finding the tools in use today, and eliminating old tools which are no more in use. The sample was focused on large organizations, for two reasons. First, the geographical distance challenge is a day to day issue to their project teams. Second, the large organizations are used to be early adopters of new technologies. We asked 34 Marketing Managers working in France for large companies (5000+ employees) and used to working in virtual teams, which web collaborative tools they used. This figure of 34 organizations with over 5000 employees worldwide can be compared with the 82 organizations with over 5000 employees in France (INSEE 2009). Out of the 34 companies, 16 belong to the 40 highest market caps of the French Stock Market Index CAC 40.

In order to help their identification, the definition of all the tools mentioned by the interviewees is provided in table 2. 17 tools enabling interaction between team members were mentioned. Each tool was explained to the interviewees, before getting their answers. This process took between 30 minutes to 2 hours according to the level of web education of the respondents. Any new tool was added in the list to the following respondents. A second round of interviews was necessary in order to get the opinions from everybody about the tools mentioned.

| Tools | Definitions (synthesis of Wikipedia 2010 definitions) with comments |
|---|---|
| **Chat** | Instant written conversation area, where the real-time dialog appears line by line as in a book's dialog. |
| **Forum** | Area opened by a moderator who suggests specific topics and invites members to post messages and comments. Previously called newsgroups. |
| **Web conferencing** | Live meeting combining voice on the phone and onscreen presentations by a speaker. Guests see the screen of the leader, who can give the lead to anyone. The white board, where every participant can write on the screen, chat, and pool are common additional tools. Also called webinars. |
| **Blog** | Personal web site where the owner posts messages and invites people to post comments. The site looks like a chronological list of messages and their comments. |
| **Wiki** | Web site which pages can be created and modified by visitors. A specific writing rule – for example a capital letter in the middle of a word- allow to create a new page with this word as its title. |
| **Posting** | Ability given to visitors to upload documents in a web site area. |
| **Sharing** | Ability given to a group of individuals to modify a unique document located in a web site place. |
| **Commenting** | Commenting is the ability given to web site visitors to add a written remark below a document, a video, a photograph, a product description, etc. |
| **Rating** | Evaluation by web visitors of content in a web site. It can be a document, an article, a product or service, a proposed project, a person, etc. The evaluation is made on a scale and the average mark is published close to the rated content. |
| **Polling** | Surveying internauts' opinion with online questionnaires |
| **Social networking site** | A site where community members post in a personal area their profile, photo, interest and links with other person. This area is completed by the comments of authorized visitors, as an indirect conversation. The site informs members about their linked individuals' activity. It allows creating groups, and provides interaction tools as chat, forums, document posting, email, IP voice, or web conferencing. |
| **Tagging** | Ability to add and share favorite keywords linked to a document, photo, video, etc. Also called bookmarking, they share links to pages. Associated with RSS they allow to be kept posted. |
| **RSS** | Really simple syndication, ability to get a message when specific tagged pages or documents are new. The new content can be automatically published into another web site. |
| **Mobile messaging** | Ability to send short messages (tweets) to groups on their mobile devices and get their feedback |
| **Remote control** | Ability to use the PC of a person remotely. The mouse and keyboards of both persons become active on one of the two PCs. |
| **Podcast and video casting** | Ability on specific viral-based web sites to post rich media documents, tag them, comment them and send their link to groups. Used for videos, audio documents. |
| **LMS** | The Learning Management System is dedicated to tracking learner's online activities. Many include forums, blogs, and web conferencing. |

Table 2. Definitions of the 17 main web 2.0 tools

To facilitate the perspicuity of the presented process in this article, the 11 out of 17 most used by the sample were selected. Then, a precise qualification of each tool was made with three web 2.0 experts according to its level of technical capability and management need as well providing the understanding of the virtual teams' activities allowed by the tools. The results of this qualification are given in table 3-1 and 3-2.

| **Tools** | **Publishing** | **Interacting** | | | **Searching** | | |
|---|---|---|---|---|---|---|---|
| | | **Co creation** | **Co decision** | **Feedback& information addition** | **Search help** | **Message Search ability** | **People finding** |
| **Chat** | X | X | X | X | | | X |
| **Forum** | XX | X | X | XX | XX | XX | |
| **Web confer.** | | XX | XX | X | | | X |
| **Blog** | XX | X | | XX | | X | X |
| **Wiki** | X | XX | X | XX | XX | XX | |
| **Posting** | XX | X | | | | X | |
| **Sharing** | X | XX | X | XX | | X | |
| **Commenting** | X | X | X | XX | X | | |
| **Rating** | | | X | XX | X | X | |
| **Polling** | | X | | XX | | | |
| **Social network** | | | | X | X | X | XX |

Table 3-1. Tools qualification with technical capability level

| **Tools** | **Content owner need** | **Moderator need** | **Interactivity easiness** | **Anonymity ability** | **Confidentiality ability** |
|---|---|---|---|---|---|
| **Chat** | | X | XX | X | |
| **Forum** | X | XX | XX | X | X |
| **Web confer.** | | XXX | XX | | XX |
| **Blog** | XX | X | XX | | X |
| **Wiki** | XX | XX | XX | | XX |
| **Posting** | X | | X | | X |
| **Sharing** | X | X | XX | | X |
| **Commenting** | | X | X | X | |
| **Rating** | X | | X | X | |
| **Polling** | XX | | X | | |
| **Social network** | | X | XX | Variable | X |

Table 3-2. Tools qualification with management need level

The qualifications presented in table 3-1 and table 3-2 are evolving fast with the tools' technologies and should be regularly updated. In order to show a comprehensible process in this article, the 11 most popular of the 17 tools were selected and organized into the 8 following tools or groups of tools: Document posting with Document sharing, Instant messaging chat, Web conferencing, Forum, Commenting with Rating and Polling, Social network, Blog, Wiki.

## IV. Phase 3: Computing the aggregated tools correlation to functions

For each function the different tools were analyzed according to the degree to which they satisfied the demand of the functions. A theoretical score of -1 to +1 was given. The "blog" tool for instance, is an expert's personal and professional interactive site and therefore has a high score of 0.9 with the functions FC19 …make competencies accessible and useable to the team and FC4 …increase project member's satisfaction. It has no impact and is scored 0 with the function FC11 …help to manage the complexity of design projects with variable, rich requirements.

The different scores yielded by linking each tool to each function allow us to compute the correlation between the aggregated tools and the functions. Functions are then classified in figure 2 from worst correlation to best correlation. We conclude from this theoretical exercise that tools satisfy well the demand of generation of ideas (correlation 0.9) but do weakly satisfy the demand of extraction and production of knowledge (correlation 0.45). All tools allow interaction and therefore ideation, but specific tools (wiki, forums) allow better knowledge extraction. This figure helps virtual team managers to balance the priorities of functions to be addressed with the level of tools matching the demand. While some functions are easily backed by tools, others will need further management investments or tools other than the 11 most used identified in our survey.

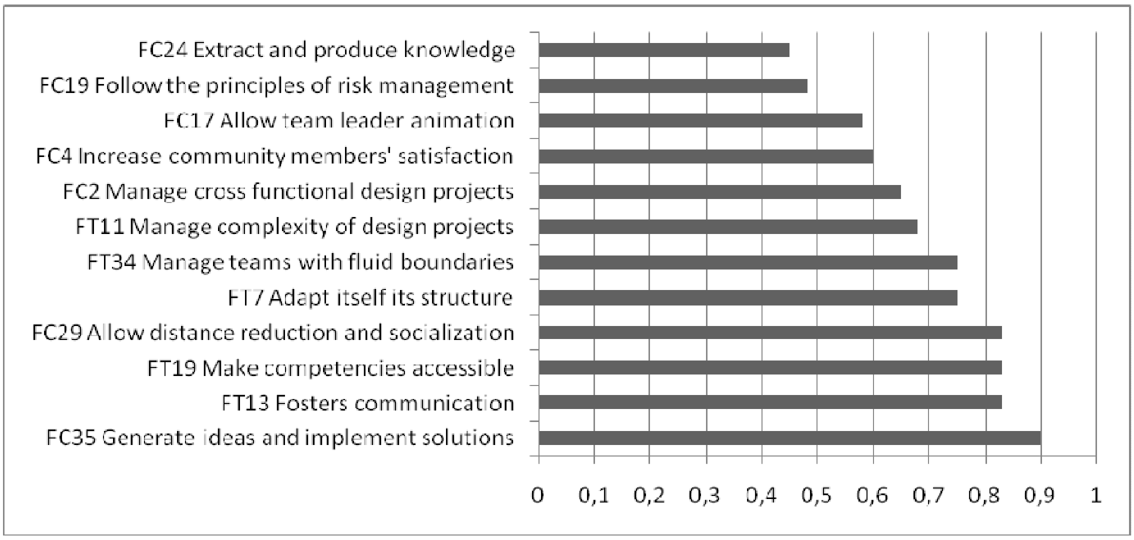


Figure 2. Correlation of aggregated tools to the detected functions

## V. Phase 4 : Computing tools' correlation with aggregated functions and comparing results with their actual field popularity

In this phase 4 we evaluate each web 2.0 tool in three different ways. First, the correlations between each tool and the aggregated functions are computed using the theoretical scores. The results are represented in figure 3 below by the line with Xs. Theoretically; they represent the ideal set of tools. Second, we compute the actual popularity score as a percentage of use in the sample. It is represented by the line with squares. The tools are ranked from most popular to the left to least popular to the right. Third, a second popularity score was added. When the tools were ignored or misunderstood, an explanation was made. Then, the interviewees were asked to rate their interest for the tool from 1 (least probability of future use) to 10 (highest probability of future use). This leads to the result of the second popularity score, represented by the line with triangles.

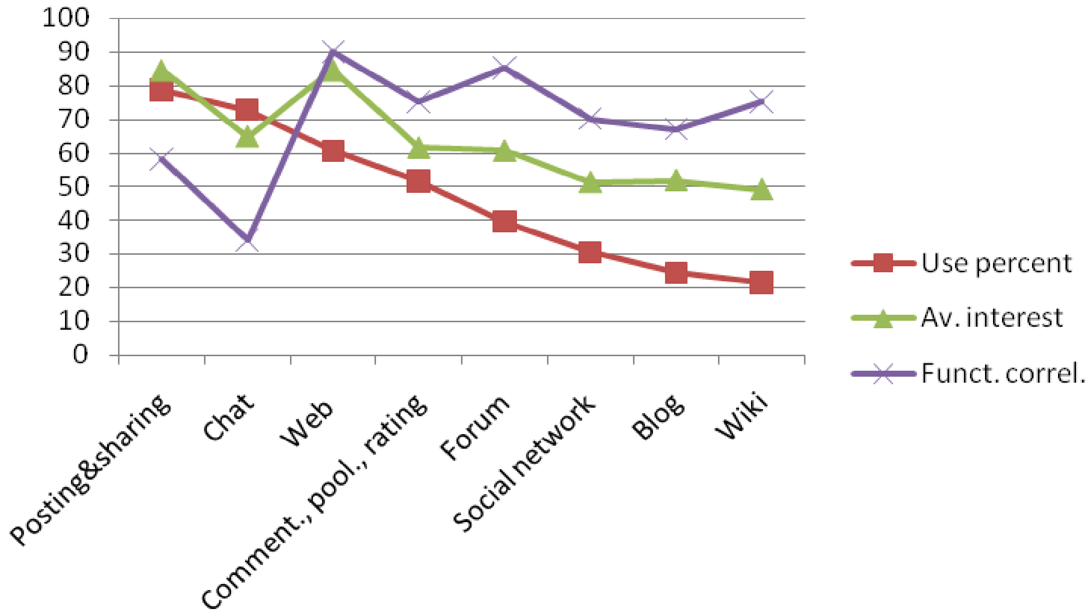


Figure 3. The three valuations of the Web 2.0 tools

The percentage of use, the average interest, and the response to the function are compared figure 3. In this case, the most correlated set of tools was "web conferencing, commenting, rating, pooling, forum, wiki". "Chat" does not satisfy the demand of the functions, but is "overused" and "over evaluated" by the interviewees. Conversely, "wiki" responds to demand of the functions but is not used or has not raised interest.

## VI. Managerial recommendations

One of the main highlight is that several functions needed to virtual teams do not get proper response despite the 11 evaluated tools. *Our first proposition for discussion is that virtual team managers should not rely on web 2.0 tools for specific requirements until the industry dynamics complete this gap and new specific tools appear.*

The ideation process is well supported. The knowledge generation and learning processes are complex (Stevens 2009) and will trigger new tools. A *level of learning maturation* of each tool is visible in figure 3 with the comparison gap between "use" and "interest". The tools "posting, sharing and chat" are mature, their use and interest are rated at the same level. The "web conferencing" tool is used by 59% of the sample and has the highest rate for interest (8.4). This result forecasts that the use will continue to grow. All other tools are not mature and much less used than they are rated. Among them, we can point out the tools which satisfy the demand of the functions and move to o*ur second proposition that "blog" and "wiki", the tools with the largest gap, and which respond to the functions, should therefore be encouraged through learning programs.*

The "chat" tool does not satisfy the demand of the functions, but is on the second rate in use and interest. *Our third proposition is that the use of "chat" should be discouraged as soon as team members start dealing with the project.*

## VII. Conclusion and further steps

In this paper, we have suggested a process which can be applied by virtual teams to learn how to define their web 2.0 collaborative environment. A theoretical application was compared with a sample which led to practical recommendations. This process implements the concept of functions of an Aided Competence Management for Virtual Team Building System specific to virtual teams, and the designation of web 2.0 tools from a field sample of large companies. It can be used by different virtual teams having different system's functions to cover, and in future with new web 2.0 tools. It allows discouraging the use of tools which do not correlate to functions, and encourage the use of those which satisfy the demand of as many functions as possible. Therefore, a set of web 2.0 tools is designed to a set of functions. The main recommendations come from an application of the process to a specific list of functions derived from project virtual teams 'environments. They recommend tools as the web conference which are also preferred by the sample, tools which are not preferred today and to be encouraged, as the blog and wiki, and tools to be discouraged, as the chat.

A discussion raises up about the web 2.0 tools to be encouraged, like wiki and blogs. They help sharing unstructured information based on projects or processes that are not strictly pre-defined but help to collaborate in an adaptive way to find innovative solutions. They provide a level-one structure with limited constraints and easy capability to modify the content or to comment it. The verbatim of the interviewees gives an understanding that their lower level of use is linked to companies' cultural factors: high tech culture, secrecy culture, centralization culture…which are moving. A second discussion derives from the clear gaps between functions and availability of tools suitable to cover them. They concern knowledge, animation, risk management. They show large needs of virtual teams and trigger a forecast on future tools, knowing the industry creation rhythm, with 17 tools created in 11 years.

We intend to validate these conclusions and give them a larger scope, first to widen the number of tools (microblogging, LMS, rich media…), track their usage to confirm trends. We want also to evaluate the optimum number and specialization of tools. A second validation will utilize the tool of the House of Quality (Hauser, 2009), to define the best practices of virtual teams in terms of competence management, project management and virtual team building of the Aided CMVTB System (Schumacher et al, 2009). Functions are the "Whats", quality characteristics the "Hows". The support of the web 2.0 tools to the quality characteristics needs to be theoretically evaluated and compared to their support to functions. The authors are presently processing this research, which add another link between functions and tools.

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# A framework for assessing the business impact of innovative industrial services

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**Abstract:** This paper discusses the elements and viewpoints of assessing the business impact of industrial services beyond the transactional, separate after-sales services. In order to do this, the paper also concerns the typology of modern, innovative industrial services. Based on this, we finally propose a preliminary management model that can be applied when assessing the service business impacts.

**Keywords:** Industrial service, industrial service business, service logic, business impact.

## I. Introduction

Service business has been topical in industrial companies' development agendas during the last couple of decades. The focus in developing new service business has shifted from traditional after-sales to life-cycle services, knowledge intensive services and even to service dominant logic. This development has changed the value creation logic: the value is not created in internal processes but in the systemic processes of the service value network. This has also brought the customer value creation into the focus: how the service supports the customer, what are the impacts on his value creation?

Despite it has been recognised that the service business focus, content and logic are evolving, and the related business models are changing, less attention has so far been paid for assessing the business impacts commensurably - or taking the impact on customer's business into account. Especially, if we consider assessing the impact in terms of value that is co-created in the service value network and the effect on customer's business in monetary terms, there remains a lot of space for research.

## II. Objective and Scope

In this paper we will [1] propose a preliminary management framework for assessing the business impact of industrial services, and [2] discuss the typology of service business. In this way we increase understanding of the elements that need to be considered when assessing the impacts, and we also increase common understanding of different kind of modern, innovative service business.

The paper focuses on industrial services on different industry sectors, and it is based on a Tekes funded Asserpro-research project in the domain area. In that project as well as in this paper, we have chosen a systemic view as we consider the stakeholders in service value chains and service value networks holistically. The regulatory bodies and authorities that may in practice affect service business a lot are recognised but they are not in the very core of this study.

## III. Research design and methods

The research applies a constructive approach. The research design is shown in Figure1. At the time of writing this paper, the research project is in the "Interviews" –phase: total five representatives from four case companies have been interviewed, and the analysis of these interviews is underway. In total the aim is to interview six companies during the project.

The analysis is supported by steering group, which has representatives from four companies (two of which were also interviewed) and external researchers from Cranfield University and Imperial College. The steering group discusses the preliminary findings and provides guides and contents for improving them. The project also applies reflection groups that will workshop in order to refine the preliminary findings. There are two reflection groups in total. In reflection group one there is nine companies from machine manufacturing sector and in reflection group two, there are ten companies from building and construction sector.

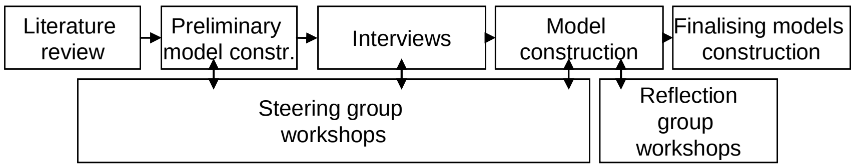


Figure 1. Research design.

## IV. The Evolution and Revolution in Industrial Service Business

### From product centric after sales to product lifecycle services

In the context of machine manufacturing industry, the recent emphasis on developing service business has lead to enlarging the offerings from products towards services that support these products even beyond the traditional spares and wears during the product's life-cycle (Kalliokoski et al., 2003). The life-cycle services are not limited to traditional after sales (for after-sales and its potential, see e.g. Cohen et al., 2006), but they cover also other phases of the product's lifecycle.

According to Mathieu (2001a) the product lifecycle services can temporally take place before, during or after sales. Examples of services during the different life-cycle phases are product designing, project management, maintenance services and performance based services. In fact, customers are increasingly interested in the total costs of the lifecycle of a product. This includes all service costs in addition to the purchasing of the product itself.

In practice, these services supporting the product during its lifecycle include both transaction and relationship based services that target either the product or an end user process that interacts with the product (Oliva and Kallenberg, 2003). For instance, scheduled maintenance programmes are targeted to a product, while performance based services may need to consider also customer processes – and take place in close collaboration with the customer. The challenge is that different companies have different perceptions concerning the content and logic of even the basic services and measuring their business impact – not to mention more advanced life cycle services.

### Customer centricity

Galbraith (2002) speaks about customer centric company and the best solution for a customer. According to Galbraith, this means in practice a combination of products, which support the customer in the best way over the lifecycle of the customership. The novelty in this approach is that it looks the lifecycle of the customership instead of a product lifecycle.

While the business focus has shifted from product centric approach to customer centric approach, the business objectives have also changed. Instead of the number of new products, market share and revenue share of new products, the companies in service centric business are also interested in customer satisfaction, share of most valuable customers and lifetime value of the customer.

In Galbraith's customer centricity the customer is still approached very much from the supplier business viewpoint in mind: the supplier and customer are seen as rather distinct entities.

### Customer value creation and customer business centred services

A more philosophical view on service business has gained increasing attention during the 2000's by many scholars – some of them have called this view as a more matured step of service business (e.g. Wikström et al., 2009). Vargo and Lush (2004) call this approach as service dominant logic and Grönroos discusses about service as business -logic (e.g. Grönroos, 2000 and 2006). The service dominant logic's basic concept is that all business should support customer (and eventually customer's customer) value creation and the business logic should build on this.

In the service dominant logic –thinking the customer value creation should be supported by the most effective means there are. These means may include products and service processes that are designed and executed with other stakeholders of the service network – including the customer. The value is co-created in these processes, which may cover different functions of the companies – and which may extend from the operational level to the strategic level in involved companies (Grönroos, 2006, Salkari, 2007).

Mathieu (2001b) has noticed that increasing customer centricity can also be seen in business models, where serving a customer instead of a product is emphasising. Despite this, the practical challenge in the service dominant thinking is the fair value sharing between the customer and the rest of the service value network, including the service provider(s). While the impact to the customer value creation is in the focus of the service dominant logic, the impact on the supplier's business has been paid less attention. This may even have compromised developing a wealthy business for the supplier in some cases. (Walter et al., 2001; Möller and Törrönen, 2003).

## V. A preliminary management framework for addressing service business impacts

In this chapter we will propose a preliminary management framework for assessing service business impacts. The preliminary model is based on the findings from the literature review and it is also affected by the findings from the interviews. The model includes elements that need to be considered when assessing the impact, and it also includes potential viewpoints to the business impacts.

### Business Logic in Services

*Services*

The focus of product centric services have widened from one life-cycle phase, e.g. after-sales (Cohen et al., 2006), to the entire lifecycle of a product (Mathieu, 2001a). In consequence of this, the awareness of life-cycle costs has increased among customers and the customers have gradually become interested in the life-cycle costs rather than getting the best deal for a single purchase.

Further, instead of lifecycle costs, the profits have been considered important. This in turn has lead to taking the customer processes, in addition to the machine, into the focus of services (Oliva and Kallenger, 2003). In this way it is possible to have a more holistic view in improving the performance of a machine than there would be if one only focused strictly in the machine: often the (operative) working processes, or work steering, effects considerably on the performance of a machine. This approach is in many cases in the background of business models that are based on the performance of a machine or a defined operative process. In these models benefit sharing between the stakeholders may be applied.

The interviewed companies all identified services that they are offering to their customers. These services included e.g. following:

- "The objective of the lifecycle services is to support the installed base of machines that the company has delivered in all geographical business areas."
- "Lifecycle-services include repair and proactive maintenance programmes."
- "Equipment performance management agreements, which include benefit sharing models that base on equipment efficiency."

*Service instead of services*

Galbraith (2002) looked at the customer lifecycle, and how it could supported, instead of the lifecycle of a single product. While this approach still is to great extend based on the product based business, Vargo and Lush (2004) among Grönroos (2000) have introduced the idea of service based business logic – or service dominant logic. In the service based business logic, the objective is that service provider's main aim is to co-create value in joint processes together with other stakeholders in the service value network, including the customer, in such a way that the customer gets the most value out of his business.

Service -logic has enabled also new business models that base on joint value creation and earning, and complex benefit sharing. Thus, the approach emphasises the value ability to assess the financial impact of service business to customer (that is value to customer), because that is the key for sustainable, long term service business in the first place.

In the interviews, the companies had some services that are based on the idea of service – based business logic. In many cases companies identified the need to consider customer value creation, but the implementation of this into practical level was considered challenging. Examples of services that seem to be based (at least at the time and case in which they were developed) on service logic include:

- "Full service where the productivity of a customer plant is holistically taken care of was first offered to a customer that was struggling with profitability issues. In that case we could utilise our experience in favour of the customer. Today, the full service is conceptualised and offered globally. The concept allows local configuration per customer needs or business environment. We are working on similar future cases, where we try to understand the emerging customer needs and to fulfil these in order to provide value to customer".
- "Taking the responsibility to own and / or operate a unit that used to be the responsibility of the customer. Taking it to this level is a long journey – in one case it took five years with a customer. During that five year period there were a lot of different services and service levels that were sold to the customer. Only during this long interaction it become apparent to us, what are the actual needs of the customer – and we could bundle a service that helps the customer in achieving his needs".

**Extent of service system**

Service processes are often, but not always, systemic towards the customer, i.e. service provider and customers interact in the service process (Grönroos, 2000). In the most simple services, like for instance a transactional calibration service as a technical performance, the supplier's internal business impacts may be in the focus.

However, this seems quite insufficient, if we consider more complex services, not to mention service logic, where the value to the customer is dependent on the value the customer can create, and thus in assessing impact, the customer – or the whole service value network – needs to be considered (Grönroos, 2010 in Ostrom, A. et. al, 2010). These dense network relations in the service value network reach from the operative level to the strategic level between the companies (Salkari et al., 2007).

Therefore, when addressing the question of service business impact, the service network needs to be considered - services have a business impact on suppliers, customers and other stakeholders in the service value network and all these stakeholders may have different perceptions of the desired impacts.

The interviewees in many cases emphasised the impact to customer – and that considering the impact to customer is relevant if we are building a sustainable long term service business. Similarly the rest of the service network was often discussed in the interviews: what is the role of external companies in delivering the supplier's service – or as an independent provider of a service, which is part of the total set that supports customer value creation. In the interviews, owning the customer relation was often considered problematic in cases where partners delivered the supplier's service. Similarly, it was by some interviewees considered that the information funnel between the service supplier and the customer may be compromised by the companies in the service delivery chain if these companies act opportunistically. This may take place if the fair benefit sharing (in practice impact to these companies' business) is not thought of thoroughly and agreed upon.

**Viewpoints to the business impact of service business:**

Artto et. al. (2008) have studied how services may impact the business of a project based company that offers services in the context of technology industry. They identified six potential impact types: [1] Service provides a customer entry point; [2] Service creates additional value to customer; [3] Service increases the competitiveness; [4] Service helps to make delivery activities efficient; [5] Service is business as its own right and therefore can be delivered independently; [6] Service is an opportunity for creating new knowledge or capabilities.

The impacts that were identified during the interviews contain similar or same impacts than those identified by Artto et. al. but with greater concretisation. After the interviews, the researchers categorised the impacts into four generic categories, namely: Strategic impacts; Operational impacts; Quality impacts; Financial impacts. The impacts that were identified during the interviews can be seen according to this categorisation in the below list:

- Strategic impacts: Access to new markets; Access to new know-how; Long-term development potential; Reputable partner or brand; Building competitive advantage.
- Operational impacts: Enhanced delivery capacity; Better product support; Improved process performance; Better manageability.
- Quality impacts: Better / more extensive functionality; Enhanced design / usability; Better technical quality; Better fit to purpose / use context.
- Financial Impact: New revenue potential (directly from services or through increased sales); Less operating expenses; Less capital expenses.

It seems probable that these impacts are interconnected with multiple and complex connections. This interconnectedness seems to apply also between the business logic (service vs. services) and the extent of the service system (internal vs. service value network). Figure  summarises and depicts the management framework: its elements and viewpoints to be considered.

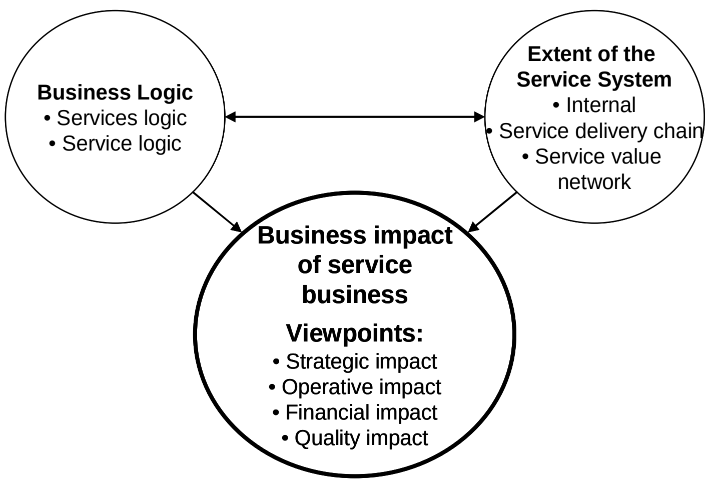


Figure 2. Preliminary management framework for assessing service business impacts.

## VI. Conclusions

This paper discussed how to get a grip of the business impact of industrial services, and how to assess that. During this, we also considered the typology of service business. Based on this we built a management model for assessing the business impact. The model proposes that the assessment is based on:

1. Understanding the applied business logic, which may be the logic of providing services, or the logic of customer centric service business. On operational level, the activities may contain similar or same components, but from the impact perspective these approaches differ in respect of taking the impact to customer value creation into account.

2. Taking an appropriate extent into the analysis. It seems that the analysis of internal impacts at service provider is in many cases inadequate. Hence, a more holistic view to the service system needs to be taken. This increases the challenge from impact assessment viewpoint: instead of looking at internal impacts, one has to get a glue of the impacts at service delivery chain or network – including the customer. The level of details and depth of analysis may vary per organisation in the service system, but the more details and concrete impacts should be in focus, the more challenges will probably rise.

Finally, we propose a set of viewpoints for assessing the impacts, namely: strategic impact, operative impact, financial impact and quality impact.

The proposed management model still needs to be enriched and finally verified. The prevailing preliminary model helps in taking into account the elements and viewpoints to value creation, but it probably has limitations concerning model extent, depth, and also business cases where it can be applied. The research on these will continue.

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# Bridging the Technology Marketing Gap by Project Management

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**Abstract:** Innovations often depend on a new technology. There exists a methodical gap between the developed technology and the search for applications. The utilization of the technology can vary about a lot of business lines, the market is totally unknown. In this case, a systematic methodology is essential to tell engineers and marketing people how to find additional applications of the new technology in different business lines. A project is outlined to solve the problem and to determine who should act in this case. An example is given for this methodology.

**Keywords:** Innovation, Product Design, Technology, Project

## I. Introduction

This paper describes a new technology looking for its market. Normally the specification of a new technology applied in a new product is not yet established, because it depends on the utilization and the business line. There exists neither a specified product nor a market. A market analysis cannot yet be designed. There is a methodical gap in the innovation process.

The proposal of this paper may be regarded as a first approach to this topic, before more particular instruments are used for investigation, e.g. methods of the Fraunhofer Institut IPA (FraunhoferGesellschaft 2009). This analysis is dedicated to middle sized mechanical and electronic companies, which are producing products with their own development department.

The classic way goes about the customer survey. This is a proven and successful methodology. But it is not sufficient to find the fields of application systematically and completely. A company does not have own customers in all lines of business. Frequently the marketing department is looking for applications with the help of the field service. In this way there is no opportunity to find all potential customers. The situation is shown in figure 1.

The specification of the technology is defined. Now the project task is formulated. It presupposes, that the applications and the market are known. The analysis of the methodical process between these two steps was not found in literature. Often it is enclosed in the strategic product planning what is not at all possible in this phase of a technology-driven innovation. Some authors look at marketing parameters at the same time without differentiating, if the innovation is technology-driven or strategy-driven (Meißner, 2009). The methodology described in chapter II. can be integrated in the well known roadmap of Eversheim (Eversheim 2003).

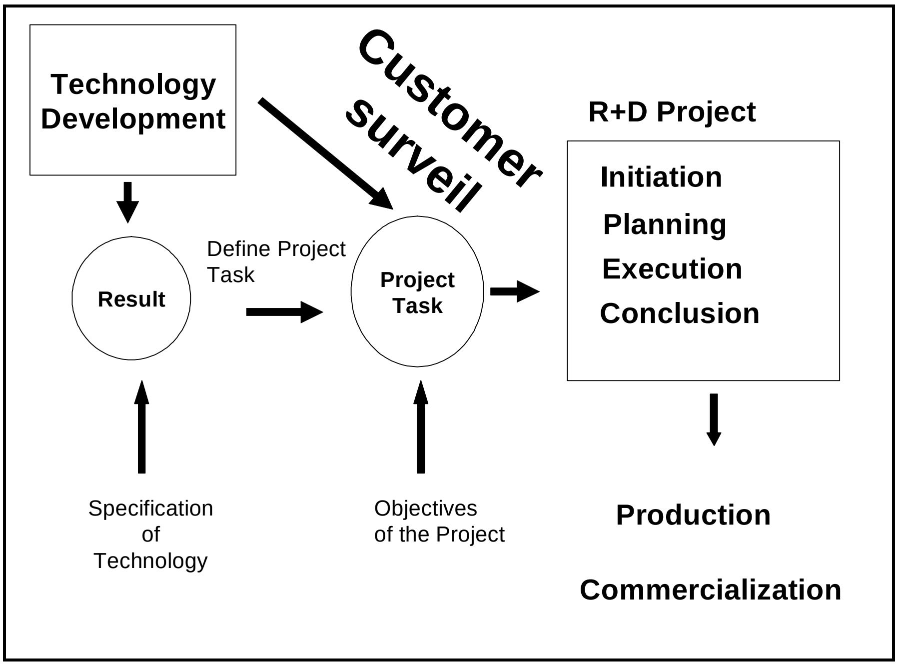


Figure1. Innovation Process

## II. Systematic approach by establishing a project

A well-tried methodology to solve problems like this one is the use of project management. This methodology is known as having a defined target, a sufficient planning method, a permanent target/actual - comparison and an assignment of people. Project management structures the process tasks as a process organization and integrates staff levels in a company.

Crucial points for introducing professional project management are

- Definition of project aims
- Building up a project team
- Task planning
- Time and process planning
- Reporting
- Resources

A systematic expiry follows the project phases. A check list which demands decisions is situated at the end of every phase. The procedure leads to the most promising applications. These can be analysed with well known methods like Quality Function Deployment, Value Engineering, Systematic Construction, KANO-Analysis. The final idea is a task for a feasibility study or a product development project. Planning a project begins with the analysis of a work breakdown structure and defining the work packages. This is shown in figure 2.

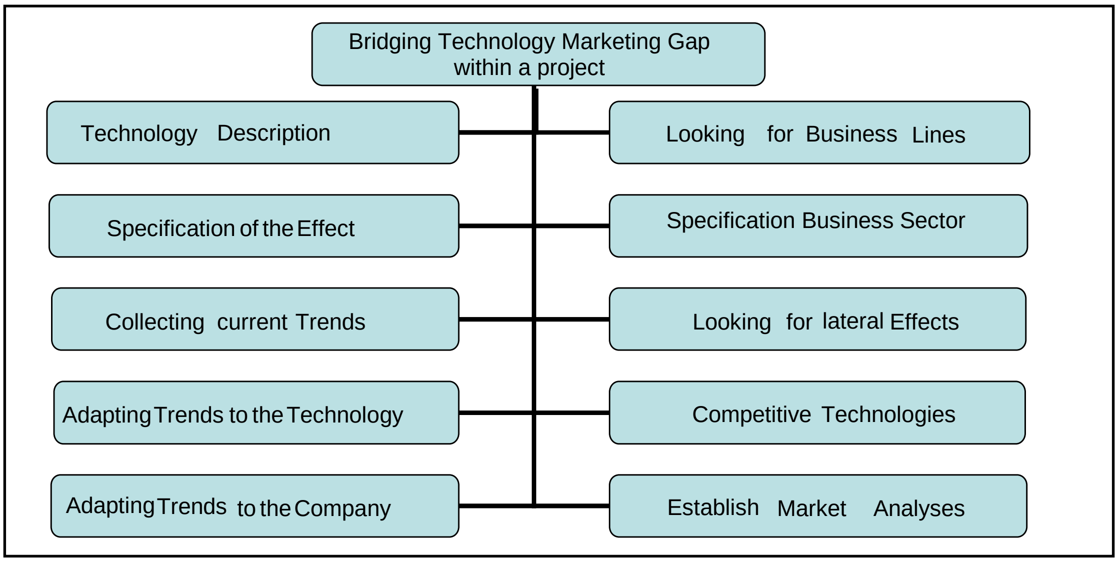


Figure 2. Work Breakdown Structure

A short explanation of each component of this plan follows:

**Technology description:** It is necessary to write down the main features and the opportunities given by the new technology.

**Specification of the effect:** The technical specification should be noticed with respect to the actual situation and to the expected situation after a research development has been finished.

**Collecting current trends:** Before starting a product development project many companies work with the instrument of trend analysis. It offers several advantages. With this vocabulary the management experts and the engineers can communicate with each other. A trend is a hint of what is going on in the market, a success factor for an innovation. There is a lot of literature about trends, but unfortunately rarely a quantitative description of the life cycle of trends. Horx delivers some monographs (Horx2002), also Häusel (Häusel2007) and Haderlein (Haderlein 2007) with an enumeration of the top 100 trends of today. Forecast instruments like scenario techniques are helpful for the qualitative future prediction. Furthermore management tools like the interview of experts of a predicted Delphi situation are suitable.

With this vocabulary the management experts and the engineers can communicate with each other.

Table 1 delivers an example of regular trends for an enterprise of heating and air conditioning engineering in the environment of a new technology. The trend can be developed with the help of master mind methodology and judged roughly with a brainstorming method after strength and the interim progress of the trend (A extremely high, B medium, C weakly).

As a result a preselection follows for the further procedure. This is indicated in the last column. Looking for trends is therefore of importance because trends already give references to the sales argumentation of the product. A trend is a vision about the future behaviour of the market. It looks for things that are coming in future times.

| Trends for an Enterprise<br>Heating and Air Conditioning | | |
|---|---|---|
| | Strength / Priority | Selec-tion |
| Deployment of flat monitors | A/A | |
| Computers with more power and storages | B/B | |
| Less oil and gas for heating facilities. | A/B | |
| Increase of the number of electronic devices in our buildings. Intelligent heating facilities. | B/B | |
| Scientainment: Sciens conqueres adventure culture (from /8/). | B/B | |
| Mood Management: Upgrowth of balance and good feeling (from /8/). | B/B | |
| Miniaturisation | B/B | x |
| Construction of Modules | B/B | x |
| Sensorintegration | A/B | x |
| Digital circuits instead of analogue ones | A/A | x |
| Software instead of hardware | A/A | |
| Time saving in Development and Production | A/A | x |
| Improving reliability | A/A | x |
| Remote controlling | A/A | x |

Table 1. List of trends (own investigation)

**Adapting trends to the technology:** The idea for a product develops out of two basic considerations. The first one comes from the technical feasibility of a technological idea, the second one from the trend analysis. The new technology and the expected trends must fit together. The new product needs to fit in the strategic planning of the portfolio. The enterprise has to prove the trends with consideration to the customers and the product portfolio. Even now the technological features for selling the product have to be developed. A rough outline describes the application. Information about this is obtained by literature, competitive products or best by an expert.

| Fields of Application | Technical Description | Business-Approach |
|---|---|---|
| Hygrometer | Basic material is only weakly hygroscopic, maybe works by conductivity measuring | Poor technical application know-how, poor market knowledge. |
| Force sensor | Material must be able to form strong deformations by use of the strain effect. Precision and stability demanded. | Only application competence, if metrologically not very demanding, good market competence. |
| Temperature sensor | Good interaction, unclear stability and linearity. | Low application competence in this technique. No market competence. |
| Pressure sensor | Weaker connection, since application medium is not a compression spring. | No application competence in this technique. No market competence. |
| Distance measuring | Good chances by forming potentiometers | Good application competence, good market competence. |

Table 2. Business participation in the trend "Sensorintegration" (own investigation)

The example of the first step is continued in table 2.The trend sensor integration is examined here for a manufacturer for printed resistances as an innovative product technology.

**Looking for business lines:** The list of all possible business lines is being checked step by step. Are there applications of the technology which meet the business line? A real hard job starts with this task here. E.g. in Germany a trade directory can be chosen as a literature basis from the Internet (Branchenregister 2010). Some cases surely are not found because they simply are not listed here. It is advisable that only such applications are taken into consideration about which a minimum of knowledge is available. This leads to the fact, that the choice of the participants discussing these facts is extremely important.

The considerations of the numerous business lines with respect to the products are really different. In the liquid level measurement technique the accuracy especially of the zero point is important. This is not the case for toys. Here a sensor every time can be readjusted and in addition, the prize is also extremely low. In addition, there is a decision needed, whether the sensor should act as a switch or as a continuous measuring device. A force sensor for consumer market, e.g. a weight sensor, demands less long term stability because of continuous self calibration.

| Industry | Characteristics | Application |
|---|---|---|
| Aero-space | high certification level | |
| Medicine | high accuracy and certification level | position |
| Consumer | price important, not accuracy | scales weight measurement,<br>blood pressure sensor |
| Automotive | price,<br>reliability | flow measurement<br>touch sensor, safety belt |
| Military | high price and certification level | |

Table 3. Business Lines (own investigation)

**Specification depending on the business sector:** The considerations of the numerous business lines with respect to the products are really different. In the liquid level measurement technique the accuracy, especially of the zero point is important. This is not the case for toys. Here a sensor every time can be readjusted and in addition, the prize is also extremely low. In addition, there is a decision needed, whether the sensor should act as a switch or as a continuous measuring device. A force sensor for consumer market, e.g. a weight sensor, demands only less long term stability because of permanent self calibration.

The technical specification must be newly designed for every scheduled application. An example is indicated in table 4. It illustrates how the technology is able to meet the requirements of this application. It also has to fit the line of business. If a product is extremely accurate and the line of business does not need this at all, it can lead to increased costs. As a result a verification shows, whether this product runs as scheduled.

| Determing the set/actual Comparison Values | | | |
|---|---|---|---|
| | actuel | set | remark |
| Accuracy | 5 % Full Scale | 3 % Full Scale | to be fit |
| Stability | 9 % Full Scale /a | 4 % Full Scale/a | to be fit |
| Hysteresis | 1 % FS | 3 % FS | to be improved with the mechanical construction |
| Prize | 5 € (10.000 compo-nents) | 3 € (10.000 compo-nents) | production problem |
| Overload | feasible | feasible | mechanical bedstop construction |
| Sensibility | 5 % per Full Scale and strain unit | 5 % per Full Scale and strain unit | to be fit |

Table 4. Comparison of specifications (own investigation)

**Looking for lateral effects:** Innovations rarely go the straight way expected for them. They frequently fulfil, besides their intended purpose, still a number of properties which were not in the context of the original philosophy. Examples for this are: Edison invented the gramophone with the intention to record conversations and to safeguard them for contractual questions. He celebrated the trump, however, with the adaption to music in the consumption area. The personal computer, originally established as a typing machine, was driven in its performance by computer games and videos, programmes which need extreme CPU performance and storage capacity. A counterexample is also true: an innovative electronic iron without the well-proven bimetal controller. An innovative renewal with electronics needs a power supply, monitoring system and switches. The iron gets more exact. The customer, however, does not notice this. Only a replacement of electronics instead of mechanics is not sufficient. The lateral possibilities of the new technology need to be introduced. Additional features have to be placed. Functions like the switching off in fear of danger or burning of clothes should be considered. Engineers are demanded here ,who can propose a technical application and know how to combine it with a market trend..

**Comparison with other technologies:** In the last work package the new product is compared with other technologies to ensure the capability of the new idea and to define the The project planning process continues as shown in figure 3 with a network list to define the process structure of the project. In this section of the project a review is given and decisions are taken. Three milestones are included in this network. Decisions are made about the following subjects.

**Planning the project:** the project planning process continues as shown in figure 3 with a network list to define the process structure of the project. In this section of the project a review is given and decisions are taken. Three milestones are included in this network. Decisions are made about the following subjects:

M1: Important trends and applications of the technology
M2: Clarification of the application cases
M3: Final decision

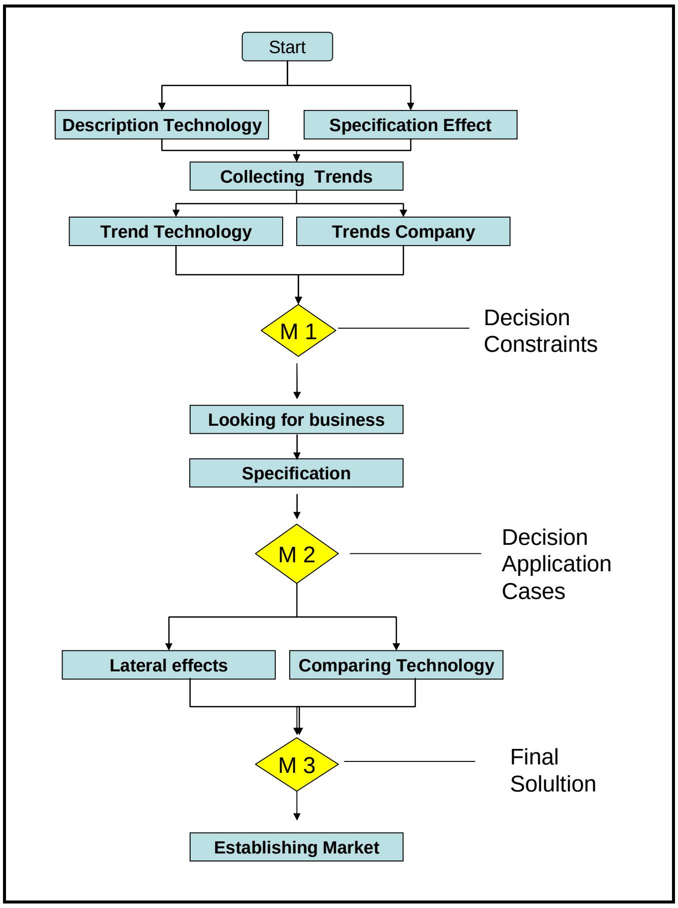


Figure 3. Network plan of the Project

**Resources:** The next step is to determine the human resources for the project. These are people of three different levels: management level, operative level and external people, e. g. customers.

**Checklists:** A checklist is helpful and also a part of the knowledge safe for a company. It should be developed specially depending on the company.
unique selling points.

## III. Conclusion and outlook

Finally the idea for a product has designed and also can be quantified. All features are written down in a list. Now it is clear what kind of applications can be afforded with the new technology. Target markets can be defined, advertising, distribution channels. New within this methodology is the strict sequence with which this problem is worked off. A language is used which is also accessible to engineers. This working paper can be picked up later again and again and updated at every time. It corresponds to the execution of a creative process. It represents a knowledge-safe for the enterprise and also makes sure, that no product concept is established for which the relation to future trends is not contained.

This methodology was tested with several individual examples among medium sized enterprises for mechanical and electrical engineering. In the completion it can be realized with the software excel or word. But a computer program alone wouldn't solve the problem. It is crucial, that a master version is laid down in a server in which also variations are documented.

In a next step this methodology will be widened up to the scope of bigger companies and the organisational context will also be included. Also other business lines like service industries, trade and commerce, will be considered. We are optimistic that the methodology also works satisfactorily in these cases.

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# Do innovations only concern highly innovative companies? A qualitative inquiry

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**Abstract:** In today's fast-changing environments, companies are expected to deploy innovations and to govern innovative activities in order to gain sustainable competitive advantage. The importance of innovations is widely acknowledged in science and practice alike. However, there are companies that upon observation of a single point in time seem to bring about only incremental innovation, if at all; nevertheless these companies are quite successful as their operations are build upon former radical innovations. Up until now, there are hardly any studies considering how such companies go through the period of low-level innovation to either termination of operations or a new radical innovation. We seek to address this research gap by conducting qualitative interviews in a large company. Semi-structured interviews were conducted with seven persons. An analysis of these interviews highlights that even though the company is not necessarily reliant on being innovative in the present period, it intensively deals with the topic of innovation. It becomes apparent that by caring about and actively engaging in informal innovative activities the company aims at preparing for changes in the environment. This study aims at providing a better understanding of these activities, as well as of organisational strengths and weaknesses concerning innovations.

**Keywords:** Innovation, Innovative Cultures and Behaviours, Innovation Strategy, Qualitative Inquiry, Informal Activities

## Introduction

In open markets, global competition and economically rough times, the competitiveness of a company consistently determines its success or downfall. Teece and Pisano (1994) point out that those companies are successful, which react to changes in time; i.e., those that react fast and flexible to innovation, and also have a management, which effectively coordinates internal and external capabilities. The importance of innovations in general is widely acknowledged in science. For example, Pleschak and Sabisch (1996) highlight that innovation has become an indispensable requirement for the successful development of all companies. In practice, one can observe many firms that are highly driven by innovation and R&D activities. In contrast to that, numerous companies – in particular small ones – exist, which choose to forego formal R&D activities and appear as organisations with seemingly stable operations. Considering that, one should bear in mind that many R&D activities in small companies do not take place within formal boundaries (Sterlacchini, 1999).

In particular financial constraints, minimum scale requirements and uncertainty of R&D outcomes may hinder small firms to set up formal in-house R&D activities (Rammer, Charnitzki, and Spielkamp, 2009). Sterlacchini (1999) finds in his study of small firms in non-R&D-intensive industries that innovative efforts relating to the fabrication of products do even matter for this type of firms. In the same line of reasoning, Rammer, Charnitzki, and Spielkamp point out that SMEs can "yield a similar innovation success as R&D performers" (2009, p. 35) by for instance well-organised human resource management and team work as innovation management tools. So far, small and medium-sized enterprises have been the focus of analysis as there exist higher constraints for formal R&D and thus innovative activities for these types of firms. In that regard, it appears to be relevant to take a closer look at potential R&D and innovative efforts at larger companies which operate globally on a large scale and do not face constraints from minimum scale requirements or a lack of financial resources like SMEs. It seems particularly interesting as companies, operating in a phase of low-level, incremental innovation might be encountering uncertainty with respect to organisational capabilities, relationships, organisational culture or technological skills. It seems worthwhile considering why and how such large organisations engage in non-R&D-related activities for meeting the challenge of coping with increasing environmental complexity and radical changes.

However, up until now, there are hardly any studies dealing with this topic. We seek to address this research gap by conducting a qualitative, exploratory study in a large German-based company.[1] The underlying study is part of a larger research project funded by the Federal Ministry of Education and Research in Germany and by the European Social Fund. In particular, semi-structured interviews were conducted with seven persons working in leading positions of the company under investigation. An analysis of these interviews highlights that the company that we investigated intensively deals with the topic of innovation in order to be prepared for changes in the environment and to find the necessary transition to the next radical innovation. It is further analysed in detail what types of activities take place with respect to innovation. We believe that our study will make the following major contributions: On the one hand, our study seems to be the first to empirically investigate potential innovative efforts at a large company which undergoes a phase of low-level and only incremental innovations and thereby the study contributes to the extensive body of literature on innovation. On the other hand, we could identify some key success factors with regard to innovation and challenges during the transition from incremental and low-level innovation to radical innovation. By focussing on these factors and by continuously working on these key issues, large companies might gain sustainable competitive advantage and bridge times of low-level innovation especially in times of growing environmental complexity and continuous change.

Our paper is structured as follows: In the next section, we present the relevant theory for our study; i.e., we elaborate on innovations and innovation management. The following section two exhibits the methodological approach guiding our research. In section three, the results of our study are outlined and our propositions are put forward. Theoretical and practical implications as well as future research avenues are discussed in the concluding section.

## I. Innovations and Innovation Management

The importance of innovations for organisations is widely acknowledged in science (e.g., Teece and Pisano, 1994; Pleschak and Sabisch, 1996). Some authors even point out that innovations have become an indispensable requirement for the successful development of all companies (Pleschak and Sabisch, 1996). Innovation is often defined as a “problem-solving process” (Dosi, 1982). The reason for this is that, in contrast to inventions, innovations do not refer to a particular point in time, but emerge in a more or less extensive process. Literature suggests that there are diverse approaches, dividing the innovation-process into several phases (e.g., King and Anderson, 2002, p. 159; Sundbo, 2001, pp. 113). Nevertheless, in the literature, the general understanding of the term innovation differs significantly. On the one hand, there are definitions that focus on the economic use of a newly invented product or process as a prerequisite for an innovation. For example, Jaberg (2005, p. 5) highlights that an invention will not turn into an innovation until it is economically used in a reasonable way. On the other hand, definitions do exist that describe innovations as something new (Van de Ven, 1986) without referring to the necessity of being economically used. Relying on the latter definition, we understand innovations as something new that can neither be planned nor controlled, as planning and controlling assume that a goal is known from the outset.

With respect to the issue of innovation it must be highlighted that one can observe and divide various kinds of innovation. A common distinction is made according to the degree of

[1] For reasons of anonymity the industry cannot be named as it would allow drawing conclusions about the particular organisation’s identity.

innovativeness, that is whether the innovation is rather radical – meaning that it fundamentally "transforms existing markets or creates new ones" (Leifer, O'Connor, and Rice, 2001, p. 102) – or that it is rather incremental and thus perpetuates the business on the existing path. In contrast to radical innovations which are characterized by obvious deviations from established practices, incremental innovations appear as minor adaptations or expansions of existing practices (Duchesneau, Cohn, and Dutton, 1979). According to Leifer, O'Connor, and Rice (2001) radical innovation goes along with a significant degree of uncertainty. On the one hand, the amount of technical uncertainties – market uncertainties as well as organisational and resource uncertainties – have to be stressed in this respect (Leifer, O'Connor, and Rice, 2001). Technical and market uncertainties can be partly accounted for by, for instance, a solid scientific and technological skills basis as well as market research, respectively. Yet, in particular organisational and resource uncertainties constitute considerable challenges to the innovation process. The corporate culture and informal processes, routines and basic assumptions about the way of work constitute potential obstacles to radical innovations (Leifer, O'Connor, and Rice, 2001). Next to this, existing capabilities, people, and relationships are aspects that introduce uncertainty into the innovation process as it seems in the beginning hardly predictable whether capabilities will be sufficient and whether people will be able to deal with the radical innovation within adequate relationships. Given these uncertainties, many firms choose to forego radical innovation and thus rely on the common and known which they only marginally improve, refine, and update (Leifer, O'Connor, and Rice, 2001).Thereby, they achieve quite a broad impact, in a process which is more linear and involves less uncertainties and above all lower costs (Detienne, Koberg, and Heppard, 2001; Leifer, O'Connor, and Rice, 2001). Tushman, Newman, and Romanelli (1986) found that "the most effective firms have relatively long periods of convergence giving support to a basic strategy, but such periods are punctuated by upheavals – concurrent and discontinuous changes" (p. 593); that is many companies are characterized by comparatively long periods in which only incremental innovations are brought about, interrupted by rare radical innovations that introduce fundamental and improving change. Still, it seems important in today's dynamic business environment to continuously reinvent the existing company with process, product, and organisational innovations.

## II. Methodological Approach

### a. Data and Sample

This study is based on a sample of seven semi-structured interviews with managers of a large German-based company with nearly 68,000 employees worldwide. "The semi-structured interview […] has the advantage of being reasonably objective while still permitting a more thorough understanding of the respondent's opinions and the reason behind them" (Borg and Gall, 1983, p. 442). That is, the semi-structured interviews allowed us to collect rich information, while ensuring some degree of objectivity by means of the previously determined questions. For that reason, we regard the use of semi-structured interviews as appropriate for examining our research question. The seven interviewees have been chosen according to judgement sampling (Blumberg, Cooper, and Schindler, 2005). At this, interviewees were selected who worked in leading positions and therefore had in-depth knowledge about strategic aspects. Initially, ten interviewees were selected. However, due to lack of time, three of them could not participate in our research. All interviewees were male, with age ranging from 38 to 52 and a mean age of 44 years (SD = 4.68). The average job tenure of those interviewees was approximately 14 years (SD = 6.01) at the time of investigation. The duration of employment seems to be of particular importance in this case because all interviewees but one started to work for the company under investigation straight after the completion of their degree at university. This is why we are further ensured that deep insights and rich knowledge about the organisation is possessed by the interviewed persons.

The semi-structured interviews which took two hours each were conducted in July 2008. The research team that conducted the interviews consisted of two researchers from a German university of whom one was a male professor having been in charge of asking the questions and one was a female research associate having been responsible for taking minutes. Questions for the semi-structured interviews were constructed based on strategy and innovation literature (e.g., Welge and Al-Laham 2008; Burr 2004). In particular, in each interview the following questions were addressed: (1) What is the vision of your company? What do you expect to be characteristic of your company in two years? (2) What are the strategic objectives that your company has set with regard to innovation for the next 18 to 24 months? What role do innovations play in your company? (3) How do you assess the current and future competitive situation of your company? (4) What are the current strengths of your company? Do these strengths contribute to reaching the strategic objectives with regard to innovation? (5) What are the current weaknesses of your company? Do these weaknesses come along with risks for reaching the strategic objectives with regard to innovation? (6) What are the most important (employee) competences within the next years? Which ones are particularly pronounced, which ones are weakly pronounced?

### b. Analyses

As qualitative data have been collected by means of the semi-structured interviews, our data analysis is also of qualitative nature. In a first step, concurrent with consensual qualitative research (Hill, Thompson, and Williams, 1997), we formed a primary research team, which consisted of the two researchers who jointly conducted all interviews. In order to ensure a high quality of data analysis, two employees working in the organisational development department were chosen as independent auditors. The employees were selected depending on their conformance to certain criteria (Blumberg, Cooper, and Schindler, 2005). At this, it was considered important that the employees were interested in the topic of innovation and that they were working in a department that allows for holistic, independent judgements. On the one hand, it was advantageous to have two persons from this organisational support function as auditors as they could critically reflect upon the interview answers and had the knowledge to corroborate or invalidate certain statements. On the other hand, we could enquire unclear aspects as well as we were able to make sure that answers were interpreted in the right way and the right context.

Based on the notes taken during the interviews, the primary research team identified the most important topic areas which referred to the general areas of innovation, organisational strengths, organisational weaknesses, organisational structure, and competition. Those topic areas served as a basis for grouping interview data during a subsequent content analysis. In order to be able to draw conclusions from the interviews with regard to the representativeness of the sample, the grouping of data also comprised an analysis of how often certain aspects were mentioned by different interviewees. In a second step, the resulting categorisation was presented to the two independent auditors, who then were in charge of critically reflecting and challenging the facts being presented to them. A consensus on relevant content categories and the interpretations was found after several hours of in-depth discussions of the prepared documents.

## III. Results

The company under investigation operates in an industry sector which has been characterised by high entry barriers over the last decade. Thus, it traditionally faces low competition. In the past, the organisation has been able to highly expand its operations worldwide while maintaining high quality of operations and products as well as cost leadership. Up until now – which means a term of 10-15 years –, all business activities have been built upon one primary radical innovation. Since that point in time, every incremental product, process, organisational, and business model innovation has been financed by this radical product innovation. It appears that the organisation faces an evolutionary phase of low-level innovation since then. However, the interviews reveal that the organisation is not absolutely non-innovative. Although product innovations have not determined the business in the last decade, three types of innovative efforts which are continuously taking place informally are mentioned in all interviews. These informal innovative activities have been found at the level of employees who informally established a large network for exchanging and developing new ideas. Within this network, extensive cooperation takes place among diverse regional and functional units of the organisation. The idea of the network has been taken up by management recently in the form of a matrix structure in which service functions and regional units are brought together. Thereby collaborative work and networking activities are partly also formally supported. Furthermore, it became apparent during the interviews that organisational culture is highly based on trust in and appreciation of the individual. Thus, the adequate environment also for the afore-mentioned employee network is established. Furthermore, the cultural aspects of trust and appreciation are beneficial as they imply a good working climate and room for creativity and innovation. One encourages risk-taking and fosters an environment that prevents excessive simplifications and rigidities. Another beneficial point for innovation is HR management: The organisation highly values employees, their experience, and know-how as human resources are considered the most important factors for innovation and ongoing organisational success. This fact is reflected in intensive and individualised HR development for top performing employees, which is considered highly significant. Strikingly, many innovative dynamics arise from the afore-mentioned informal efforts. The R&D department only brings about occasional incremental process innovations, but is highly supported by the informal knowledge-sharing and innovation-fostering activities. In the following, these dynamics are described in more detail.

*Employee Network*

As described above, the organisational matrix structure was inspired by informal employee networking activities. By means of this formal structure, the organisation is internally cross-linked and able to achieve – also at the level of management and as a whole – some kind of knowledge exchange in line with the exchanges occurring among the workforce. It shows the acknowledgement and appreciation of the achievements of the informal employee network. The employee network is described as being extremely fast in communication of experiences and new knowledge as well as the creation of ideas and generation of new knowledge. Furthermore, it is remarkable that it exists absolutely independently of formal line organisation, but across units and regions. By means of this informally cross-linked organisation, opportunities for extended cooperation, knowledge-sharing and various views on diverse topics can develop.

Experiences with, for instance, routines are exchanged and the same are questioned. Yet, most importantly, the employee network allows keeping established, formal rules to a minimum. That is, organisational relationships and interactions do not necessarily rely on formal rules and structures. In contrast, mutual agreements are established discursively within relationships and interactions when they are needed. Such negotiated understandings and informal arrangements are much more fragile and can be easily adapted if necessary or broken up if they are not needed anymore. With the aid of such a network the reliance on established formal and often too bureaucratic rules is minimized in favour of discursively negotiated rules that allow for flexibility and a reflective, questioning atmosphere which is not only change-receptive, but allows for the initiation of modifications. These aspects seem to foster an environment that is beneficial for the emergence of innovative ideas. This finding is on the one hand consistent with the statement by Leifer, O'Connor, and Rice (2001) who purport that good ideas could come from every area within the organisation. On the other hand, it supports the statement by Van de Ven (1986) that the innovation process is a product of a networking building effort and the finding by Detienne, Koberg, and Heppard (2001) that intra-firm linkages indeed are predictors of both incremental and radical innovations. Thus, we propose that employee networks, established on mutual agreements and negotiated understandings, foster an environment for innovation and contribute to continuous innovation efforts.

*Proposition 1: Formal rules are less important than mutual agreements. Agreements within employee networks foster an environment conducive to innovations.*

*Culture*

The above-mentioned employee network with its informal, discursively established agreements can only work if it is surrounded by adequate environmental conditions. The fact that organisational culture is grounded in trust in and appreciation of the individual results in an organisational climate in which employees feel comfortable and show a high degree of loyalty as well as initiative. There is low fluctuation among the company workforce, which also means that expert knowledge and know-how stays to a large extent within the firm. Besides that, employees are granted a high degree of freedom in their work to pursue own creative ideas as well as to become intrapreneurs. Security is provided for example with respect to jobs and salary. These aspects imply on the one hand content as well as motivated employees and thus, it allows for a good quality of work; on the other hand the organisation permits – or even invests in – inefficiencies in operations for the benefit of letting creative dynamics unfold. Even more importantly than this, the security with respect to features like jobs and salary is supplemented by insecurity and ambiguity with regard to processes and structures. That is, employees are gently forced to continuously experience a healthy insecurity about the validity of processes, structures, agreements, etc. Risk taking and the ignorance of rational arguments for sticking to routines and relying on simplifications are actively encouraged. Bureaucracy is seen as an illusion of control. By means of these radical attitudes, the organisation is held in a state of flux, characterised by constant constructive questioning, reflecting, and active coping with ambiguity. In so doing, the organisation minimises the danger of falling victim to the temptation of simplification and rigidities accompanying path-dependence. Thus, it seems that the company invests in preparedness for innovation and continuously changing environmental conditions. It appears that by this culture a significant amount of uncertainty, associated with organisational culture and its receptiveness as well as adequacy for creating changes and innovations can be reduced and another facilitator or even catalyst for innovation is present. Against this background, we pose the following proposition:

*Proposition 2: Risk taking is more important than safety. An open, trusting and ambiguity-tolerating culture will foster an environment conducive to innovations.*

*HR development*

As reflected in organisational culture, employees are considered an important organisational resource as well as a source of innovation. Therefore, the organisation pays a significant amount of attention to HR development. This occurs highly individualised and is not formalised within a concrete system or according to particular mechanisms. That is, top performers and promising employees are supported corresponding to their own needs and wishes. Thus, not only employee competences and skills are developed, but employee loyalty is fostered in addition. This again adds to the fact that expert knowledge and experience can be kept within the organisation which is favourable with regard to incremental innovations. The observation of individualised HR development is also stressed by Leifer, O'Connor, and Rice (2001) who point out the importance of recruiting, developing and retaining the right people. In addition to that, the informal HR development measure used by the examined company allows accounting for the diverse needs of employees driving innovation. Thus, a relevant aspect to the development of innovation in general and the preparation of radical innovation in the organisation, called for by Leifer, O'Connor, and Rice (2001), is realised at the investigated company. Yet, what makes the informal HR development particularly interesting and special is that the organisation actively pays attention to what drives people. One tries to tap into their deepest, inner passions and enable employees to reach self-actualisation in the workplace. At this, one accounts not only for the specific needs of highly creative employees. More than that, one strives for activating intrinsic motivation of general employees, thereby making them intrapreneurs. In that respect, particular regard is given to enabling and motivating employees to engage in self-organisation. Employees were described as being highly self-organising, a fact further corroborated in the self-established employee network. Self-organisation in itself is highly important as a basis for any innovative work, as innovations are only developable in a self-organised way (QUEM, 2004). From the preceding findings, the following proposition is derived:

*Proposition 3: Self actualization is more important than fulfilling concrete demands. Individualized HR development increases the diversity that will foster an environment conducive to innovations.*

## IV. Conclusion

By means of the semi-structured interviews that have been conducted in this study, we found out that also large organizations seem to consciously engage in informal innovative efforts. The company under investigation meets the challenge of coping with increasing environmental complexity and radical changes during an organisational phase of low-level and incremental innovation primarily by building on existing organisational strengths to extend already existing incremental innovative efforts. It becomes apparent that by being aware of its current strengths with regard to potential sources of innovation – mainly concerning an informal network structure among employees, the organisational culture as well as its HR development – the company meets the challenge of maintaining operations and success with marginal improvements through incremental innovation and simultaneously working for a new radical innovation. In addition to that, uncertainties arising from organisational culture, employee relationships and capabilities that were found to be significant obstacles to radical innovations (Leifer, O'Connor, and Rice, 2001) seem to be reduced. Strikingly the above-mentioned aims are accomplished by on the one hand making use of micro-politics instead of attempting to control and limit micro-politics. On the other hand, structural insecurity and ambiguity are fostered to create an environment in which innovative things are allowed to "unfold" within an innovation-oriented and ambiguity-tolerating culture that actively encourages the extraordinary, rethinking as well as risk-taking instead of falling victim to path-dependence and competence-traps. Thus, the organisation dares to refrain from (bureaucratic) rules and simplifications, but instead relies on potentially more powerful informal measures that intrinsically involve employees. Finally, innovation is not solely a distinctive and separated task of one functional unit; it is embraced by all units across the organisational levels.

In practice, these insights could help other organisations which are confronted with an innovation-demanding environment. Particularly, cultivating an environment in which employees feel on the one hand appreciated and on the other hand free to perform own creative work while continuously questioning or breaking loose from old paths as well as searching to exchange knowledge among each other, seems to be beneficial. Besides that, these efforts should be supported by intensive, individualized HR development, which should allow employees to reach self-actualisation in the workplace, to develop skills and competences alike as well as it should retain valuable knowledge and experience within the organisation. In science, these results are valuable, as this paper seems to be the first to investigate how large organisations, being in a phase of low-level and incremental innovation, manage to stay highly successful in an increasingly complex and continuously changing environment without introducing bureaucratic, formal measures, namely with refraining from rules and formalisation and accepting risks and inefficiencies.

As with all case studies, there are several limitations that readers should keep in mind in relation to this study's contributions. First, the sample consisted of only people working in leading positions of the company. The use of managers' perceptions as the main information source for a study like the present one has been criticised by researchers with respect to their validity (Lant, Milliken, and Batra, 1992). Nevertheless, it appears that "there is little convincing research that supports or contradicts the generally accepted belief that CEOs and top administrators can provide reliable information about their basic environmental and organizational characteristics of their organization" (Detienne, Koberg, and Heppard, 2001, p. 12). Therefore, we are confident that we could gather adequate and reliable information for the purpose of this exploratory investigation, although, due to the lack of random sampling, the answers of the interviewees might not reflect attitudes and efforts of the whole workforce with regard to innovation. This limitation goes hand in hand with the limited generalisability of the results. In addition to that, it cannot be ruled out that responses of our interviewees have been influenced by social desirability. However, the latter limitation applies to all interviews and surveys and we tried to minimise this problem by assuring the interviewees of anonymity as well as involving independent auditors from the organisational development department.

Based on our methodological proceeding we developed a set of propositions which may indicate various avenues for future research. These propositions might be tested in future studies comprising larger samples within different industries. If the propositions can be confirmed empirically, they may serve as a basis for the development of a general approach for fostering innovation in companies. At this, it would be particularly interesting to get deeper insights about concrete actions that are undertaken by companies which have undergone a phase of low-level innovation and could manage to be successful with regard to radical innovations later on.

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# Knowledge Exploration to Enhance the Product Develop Process

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**Abstract:** Product development is highly focused on the problem solving within product generation instead of understand the problem. This paper states the importance of stretching the view within product development to the early stage in the development process where products are defined. Within this phases the corpus of product development costs are determined. A broader view on the problem or customers demand could open the horizon for new and innovative solution with a unique selling proposition against competitors. The broader view is based on the knowledge exploration – a phase within an enhanced product development process presented in this paper.

**Keywords:** Product development, Early-Stage, Innovation, Knowledge

## I. Introduction

Nowadays product development is very much focussed on the technical improvement of products rather than understanding a demand or problem in depth. From an economical perspective this approach is efficient as man power is dedicated to the generation of a new product and therefore to the object generating the return on invests.

At the same time the competitive situation becomes more and more challenging for companies with new emerging companies e.g. from Far East and product life cycles getting shorter. Today's successful companies therefore offer extended products - physical products in combination with additional services for their life span – to provide unique selling propositions against competitors. To successfully develop and place an extended product into the market a deep understanding of customer's demands is needed.

Publicly product development is associated with the design, technical development or testing of prototypes and new products. This is determined in the specific product development phase. For companies product development starts much earlier with – in case of a product replacement – the analysis of data from the usage of the current model, the definition of requirements for the new product based on market knowledge and the specification of the new product e.g. in a product profile. In literature two main drivers for innovations can be found; the market pull and technology push. In this fields information is provided by internal and external sources like marketing, sales, R&D, customers (especially lead customers), competitors and the tacit knowledge of product developers. These work steps take place in the non-specific or early stage of the product development process. Up to 75 % of all costs within the course of product development are determined in the phases from idea generation to product conception [Gebhard 2003]. Taken into account the high costs in product development the understanding and the successful support of the early stages becomes indispensible for economical success. Studies within the engineering industry indicate that companies which reduce uncertainties in the early stages in the product generation are more successful in product innovation [Verworn 2006, 2008].

This paper states an approach as a guideline for acting in the early stage in the innovation and product development process. The approach presented here underlies the persuasion that collaborating teams with members of diverse disciplines will produce a higher quality within their results as their diverse knowledge is taken into account. As the approaches, methods and models applied within the engineering discipline focuses on technical activities the work presented here targets the preliminary and operational activities within the phases of knowledge generation, product finding and planning. The sensitisation for the importance of the preliminary activities to product development is mandatory to enhance the quality of PDP.

## II. The Product Development Process

The product development process (PDP) covers all phases from first ideas to the conversion into prototypes or market ready products. Westkämper describes the phases of the PDP on top level to be reseach, product planning – the early phase of the PDP - and product development [Westkämper 2006]. The product planning is broken down into the strategic, including e.g. identification of business areas, and competitive strategies and the operative product planning – the fuzzy front end of PDP. Within this phase product ideas are developed and converted into product concepts. Afterwards these concepts will be planned in more detail to become reality in the product development phase with e.g. exact product documentation and blueprints as an outcome. Within the early phases of the PDP there are operational similarities to innovation processes. Innovation is defined to be the invention or new combination of known objects and their successful implementation to a market [Schumpeter 1952]. The innovation process contains the phases of idea generation, concept development & product planning, development, prototypes & tests and production and market penetration [Herstatt 2007] with Idea generation and concept development defined as early stages.


Figure 1: Innovation Process (c.f. Herstatt 2007)

Especially for idea generation creative techniques like brainstorming or 635 methods are well known and used in product development. Ideas are not only based on the tacit knowledge of developers. The input to these phases comes from several internal and external sources like customers (lead users), competitors, marketing (market pull) and research and production (technology push) [cf. Pahl et al. 2005, Westkämper 2006]. These information need to be taken into consideration for idea and concept developers. Sources like marketing focus on customers (future) demands and on learning from previous products.

Technology Push information might be an answer to a demand. This information is of high importance for product development but in parallel we see a need to bring in a new driver for innovative product development. To become really innovative and be ahead of competitors product developers need to broaden their view on information leading to new customers demands and opening new fields of action for economical success. Therefore we suggest the enhancement of the early stages of the PDP and innovation process by the phase of knowledge generation to broaden the view of product developers on new fields of action and create a deeper understanding of the problem to be solved or a demand to be answered.

## III. Enhancing the PEP by the Knowledge Generation Phase

The phase knowledge exploration as an additional phase to the early stages of PDP and innovation processes should not be seen as a replacement for today's' sources of information. It enhances well known information provision for product development by a broader and more strategic oriented perspective.


Figure 2: Enhancement by Knowledge Exploration

Traditionally, problems have been seen as complicated challenges that should be solved by breaking them down into smaller and smaller chunks. However, most modern problems - and ideation problems in particular - are complex rather than complicated. Complex problems are messier and more ambiguous in nature; they are more connected to other, often very different problems; more likely to react in unpredictable non-linear ways; and more likely to produce unintended consequences. To successfully support the early stages of the non-specific design phase any approach to structure the work processes needs to focus on the real way of working and the intuitive processes of innovators [Cross 1984]. The approach presented is based on a state-of-the-art analysis in the field of innovation management, design theory and product development. Additional primary research by observing innovators, innovation teams and designers lead to incremental insights of the daily work to be performed within working in ideation projects.

Because of its fuzzy nature, where details and even goals are not defined exactly the early stage in the PDP cannot take place in a linear process. Iterations are the nature of the related workflows.

*Structuring the Knowledge Exploration Phase*

The process presented supports preliminary activities to the PDP and the creation and development of knowledge and ideas, viewing ideation as a working process rather than moments of divine inspiration.The work is performed by persons on two levels: the operational (project members) and the management level. Both interact with each other. The field for operational work of the innovators is the field of exploration – the information basis for the innovators: the **levels of action** (represented by arrows).

A single work step is defined as activity. **Activities (**represented by circles) are performed by an individual or a team to create, enhance or evaluate the information basis for the product development.

**Routines (**represented by boxes) describe the interrelation between activities. They consist of two or more activities but also generate a value on their own. These routines are of an iterative nature. Innovators or other persons involved in the process run through them several times before generating a defined result.

The **field of exploration** is the target for research and the source of learning. It comprises secondary research, field and user research or primary research. This means existing and potential users and other external stakeholders. The field of exploration gives resistance and direction to new insights and interpretations made by the team of innovators, thus ensuring that their results are relevant to the world. It is a source for problems to work on, needs and values to take into account, and solutions that could be possible.

The **project members** are the team or the individual that does the majority of the work. They are learning from the field of exploration, they are creating insights, and building hypotheses. They are identifying opportunities, generating new ideas, and making robust concepts. The team can be small, only consisting of a few persons, or it large with several subgroups. A large group will, however, still have a small core that manages and governs the project - both in terms of resource allocation and to drive integration of insights and ideas.

The **decision maker** is the guide and mediator for the team of innovators. He is the link to the overall organisation or overall strategic interest, the supplier of resources and the operational decision maker. Depending on the teams and project size there might be a project management team.

The **implementing organisation** consists of the people who can – and perhaps will – implement the decisions and ideas resulting from the innovation project. They are the internal stakeholders who need to be taken into account in order to ensure that implementation is likely to happen, and in order to avoid resistance to the new ideas.
To a high extent the organisation is also the primary source of the knowledge and competence that is necessary to implement the ideas from the project, whether they result in new products or services, transform market positions or internal processes, or change the relationships with external stakeholders.

Key to new ideas and concepts is the knowledge and information about the products' environment, the users and their usage of products, competitors and developments. This can be intrinsic knowledge of the developers but also a wider view on the product to be developed and therefore research in related fields – the **knowledge exploration** - is necessary.
This means that traditional approaches to action planning and project management can be problematic to apply. Early commitments of resources (money, time, attention, and expectations) make it difficult to react to and build on new insights gained.
The resulting insights from **knowledge exploration** will thus emerge from the research of the team rather than being planned in advance. Each task produces a stepping stone which helps the team venture further into the unknown. By focusing on iterations of small research tasks surprising insights are more likely to emerge than by working in larger chunks.
New knowledge and understanding is the backbone in the innovation process. This phase is the key in producing new knowledge and in transforming the shared understandings for usage in the product development. The phase ends ostensibly when a number of opportunities have been identified, settled and selected.

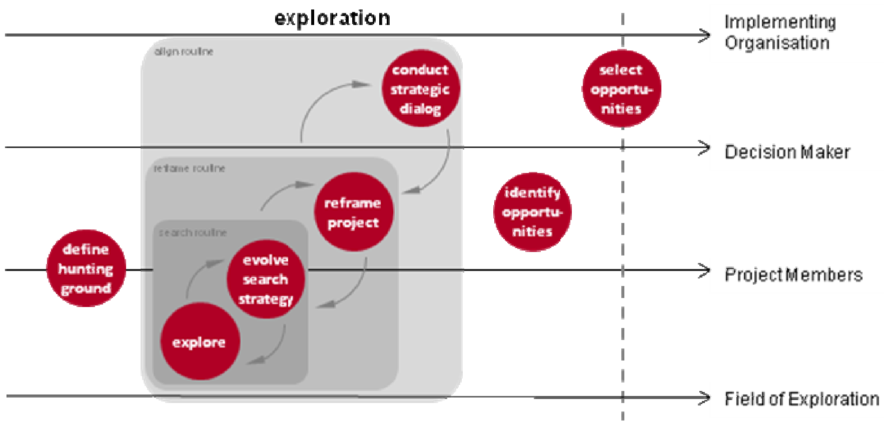


Figure 3: Knowledge Exploration Phase

**Defining hunting ground** is about identifying the interesting themes and questions that the innovators can use as a point of departure for in their exploration. This activity can be initiated in a meeting, where all the team members brainstorm together. After the brainstorm, each should think further about the themes, perhaps consulting different knowledge sources to broaden their minds. New ideas for questions and themes should then be collected and organised, before the process continues to the next activity.
Metaphorically speaking the innovators are developing lenses that help them find surprising facts and relationships. Interesting themes and questions serve as new perspectives on domains that might otherwise be well known.
It is important for the team to go beyond well known ways of perceiving their universe. That is why they have to think about perspectives that are new to them and could yield interesting results. This process should be divergent and generate as many interesting themes and questions as possible.

A good idea is to cluster and organise the themes in a visual map like a mind map.. For each theme the team of Innovators can try to identify interesting and open questions. Some relevant perspectives for generating themes and questions are:

- *Problem perspective:* About the challenge they are addressing
- *People perspective:* About the actors, their interactions and experiences, in different situations
- *Change perspective:* About trends or stabilisers pointing to the future
- *Business perspective:* About their company's current or potential assets, partner networks, value creation activities, costs, value proposition, customer relationships, distribution channels, customers, and revenues

After defining the *Hunting Ground*, the team has its first innovation meeting. They select a question for each team member that he or she will work on. The team should collaboratively identify good approaches to find interesting answers. Here the diversity in the team can be very helpful, as they likely will be able to find more and better approaches than a single person alone. This step in the activity is about **defining a search strategy**.

After the search strategy has been defined, individual tasks are specified and distributed. Then **exploration** begins. Each team member will consult relevant sources or do empirical research to find surprising and relevant answers. This process is also called creative search. The goal of creative search is not to find a specific answer to a closed question, but to learn about a topic or an area, to generate ideas, to identify outliers, or to find conflicts and inconsistencies.
It is not important to systematically find all there is to know about a topic. Instead it is much more productive to pick up bits here and there that can serve as promising leads. Growth of knowledge is not systematic but driven by serendipitous discoveries.
Such search is carried out in many ways, but it does almost always include desk research (such as internet research or consulting books and journals) and field work (such as interviews or observations of users and their interactions).
Each team member should not spend more than 25-30 hours researching for task (per iteration). The findings are then reported to the rest of the team in writing before the next meeting. This ensures that all have time to read and respond to the knowledge generated before they meet, thereby increasing the quality of the discussions.

After a round of Exploration and after the team members have reported their findings in writing, the project manager reviews what they have reported and learned. This serves as input for planning the major discussion point for the next meeting - the **evolvement of the search strategy**. When the team of innovators meet, they should - based on the reports - identify important learnings and knowledge gabs.

The goal of the innovation meeting is to make sense of the findings and on developing productive questions that can generate new insights. This will evolve the sarch strategy and promote double loop learning in the team. The meeting is therefore not about accumulating information, but about transforming it to interesting knowledge and questions.
When exploration is successful and produces a large amount of interesting findings it can result in meeting where it often is difficult to keep focus. Some good process rules for these meeting are:

- Be clear, explicit, and concrete
- Only say things that make the team progress
- Be clear when you make assumptions
- Try to stick to things you actually know
- Listen and be open to the others
- Ask when you don’t understand

The different perspectives from the Define Hunting Ground activity can be very helpful when trying to be creative about how to refine or generate new questions to pursue. This is about updating the search strategy. After this the process repeats itself, with new task assignment, exploration, reporting, review, and meetings.

Exploration and Evolving Search Strategy are mutually dependent activities, which take turns iterating in the overall **Search Routine**.
The meeting is the prime tool to support the self-organising exploration process. It creates a focused interaction in time and space that drives the innovation process and ensures discipline in research tasks. Slow projects can work with loops involving several months (or even years) of research per iteration. Such projects are often doing research of very basic nature. Unless basic research is a necessary part of the overall innovation strategy, such long loops should be avoided in strategic innovation. Here fast exploration is much more important. There is often so much to learn about so many things, that speedy search, feedback, and realignment are crucial if the innovators want to avoid being lost in details. They need to move beyond their zone of comfort as much new as possible - relevant new that is. This is ensured by the search routine.

Within the process of working the knowledge generated might lead to the accommodation of the development project. This is represented in the **reframe activity**. This activity is the interface between the project owner and the innovators. It ensures and renews their shared understanding and helps the project owner learn from the team.
The innovators and the project owner meet and discuss the new insights and questions that have arisen. The strategic implications are considered and weak signals probed carefully rather than dismissed because of lack of conclusive evidence. To a high extent the meeting is about the innovators presenting questions rather than solutions. Together with the project owner they will - if relevant - reformulate the initial project scope and brief to reflect their new level of understanding. They will also prioritise overall team efforts and select which search avenues should be promoted or closed down.
Reframing sets some important requirements for project owner, who must be willing to challenge initial assumptions, accept ambiguity, postpone conclusions, and invest time. If the requirements are met, there is a strong basis for transformative learning and leadership.

The **Reframe Routine** is linking research, reflection, learning, and leadership in an iterative process. Without this routine the Innovators would be impotent, being disconnected from the project owner. The project owner would also stay in his or hers existing world view, having difficulty understanding what the Innovators actually do.
Companies that are successful at doing strategic innovation are good at linking leadership with the concrete exploration activities. Then strategic thinking becomes much more informed and search better directed and supported.

The “not invented here syndrome” is an important source of failure in innovation. The syndrome is about unwillingness to adopt ideas for an innovation if they originate from outside the organisation (or just from a different place inside the organisation). The effort needed to overcome this challenge can become quite substantial. The earlier the relevant stakeholders in the organisation have been engaged in the thinking behind the ideas the easier it is to create a sense of ownership and willingness to change. Engagement can happen in the form of workshops and personal dialogue. It is important that this interchange takes the stakeholders seriously. However it is equally important that the stakeholders understand that they are part of an early stage innovation process, where deferral of judgement is critical in order not to kill the fledgling ideas. The stakeholders give feedback in order to enlighten the innovators (and the project owner), and not to decide on which ideas should live. Within the process step **conduct strategic dialog** the decision maker takes care of the organisation understanding of the learnings and knowledge of the innovation team. To a high extent the *Strategic Exploration phase* is about changing world views. The changed world view improves the criteria for evaluating action and new ideas. This has not only implications for individual ideas put for the whole portfolio of ideas. It is therefore a strategic issue. In order to help not just the innovators and the project owner but the whole organisation to change their world view, dialogue is necessary. In this activity key stakeholders relevant for the project are invited to one or several workshops, where the findings are presented and discussed openly. Barriers and opportunities are deliberated as are implications. It’s a very good idea to make the workshops as visual as possible. Photos, videos, diagrams, sketches, storyboards, and mock ups are all very helpful in making the possibly vague ideas and insights come to live. If the conversation is kept to words alone there is a risk disconnection with the new insights that the Innovators have brought to surface.

Strategic Dialogue, Project Reframing, and Exploration help bring each other forward in the overall **Align Routine**. In the end this routine is the true enabler of strategic innovation, making the organisation move forward. Even organisations with charismatic top-down oriented top executives need this routine to be able to make large changes and react to new changes in their environment. Without the learning this routine contributes with, it would be difficult to know which - if any - changes to react to.

The search and reframe routines lead to the **identification** of new **opportunities** for product development. Identification of some opportunities happens throughout the process. The innovators and the other actors naturally get ideas when they work and learn. However systematic work on identification depends on new knowledge and insights. Therefore it shouldn't be the first thing the team does in the *Strategic Exploration Phase*. But it need not necessarily be last, even though it's put there in the process diagram.
**Identification of Opportunities** is about finding challenges that relevant actors have. By mapping the actors' challenges it is possible to find commonalities and potential platforms that can serve as solutions for several actors. Such opportunities can have large impact and be of strategic interest.

If identification of some opportunities happens early in the process, the opportunities can be discussed with the project owner at the reframe project meeting or with important organisational stakeholder in the *Strategic Dialogue*.

**Selection of Opportunities** is the end-goal of the Strategic Exploration Phase. This activity involves top management, who deliberate over the portfolio of opportunities. Opportunities need not necessarily fit with current strategy. They are by their very nature often challenging current thinking.

However they should fit with what future strategies the leadership team might want to pursue moving. forward from the strategic innovation process. They are probably the only ones who know the answer to this question and are therefore critical participants in this activity.
Opportunities should be presented with consideration for long term trends, documenting important actors' needs and challenges, and indicate where there is potential for contributing to and controlling key interactions and technologies.

## IV. Conclusion

The approach presented in this paper is a guideline for innovations within their work in the early stages of the product development process. Process participants should represent the stake holding disciplines in a product. This includes stakeholders inside a company from all relevant markets as well as the customers from different the markets the product should be introduced to. The intrinsic knowledge of customers is very valuable in the process of product definition. The approach defines phases to give a guideline to innovators and companies and wants to raise the attention to ideation processes and create awareness for the importance for product development. The approach does not substitute today's information provision to product development but to broaden the focus to problem and demand understanding before defining products as an answer. It might lead to new, innovate and not obvious in the beginning solutions with a higher chance for market success.
The process has been implemented successfully in some of the largest industries in Denmark and proved its value for the early-stage of innovation. By using the process industries increased their efficiency within this phase drastically. Still further implantations in the industrial context is aspired.

Within the Laboranova project several tools have been developed which support single steps in the early-stage innovation. The tools interact via the idea repository – a common data base of idea representations. Some tools have already been implemented in industrial practise and have proved their value. Other tools are part of the education of students. Some of the tools became part of a companies product range or lead to Spin-Off companies. Still - as much as for the process - tool implementation and testing in industrial context is eligible.

## V. Acknowledgements

The approach presented in this paper is rests up on the research carried out by the European Community funded Integrated Project Laboranova in FP6. Further information of the project and the approach presented could be found on www.laboranova.com.

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# eUreka – An Innovative Approach to Project Work Management

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**Abstract:** This paper traces the rationale for the design and development of an online platform to better facilitate project work management at Nanyang Technological University. The intent seeks to enhance the documentation of the learning and knowledge discovery experience of students in the creation and management of knowledge assets prevalent in both formal and informal projects undertaken by both faculty and students. Project work has long been an established learning engagement activity for university students. Its many forms include final year (capstone) projects, term projects and group projects. Here, NTU explores an extension of eLearning to widen this original purpose of traditional project supervision and mentorship to an online platform. eUreka (after Archimedes' 'I have found it!) system is an institutional web-based management system for project work and knowledge management. The system was designed and developed based on instructional and learning design principles to provide an easy-to-use and useful platform for project planning, documentation, collaborative work and independent reflections on the learning experiences in the course of the project work duration. (170 words)

**Keywords:** Project work, knowledge creation, knowledge discovery, innovation, constructivist learning

## I. Introduction

Since 2000, Nanyang Technological University (NTU) has actively promoted the use of IT in education through its unique e-Learning initiatives The Centre for Excellence in Learning and Teaching (CELT) takes the lead in such effort. Its main initiative, edveNTUre, is an all-in-one eLearning eco-system that provides an online platform for content delivery, community learning and assessment for faculty and students. With up to 9.5 million page views accessed weekly, edveNTUre and eLearning has become a crucial yet common part of the student learning experience.

NTU has explored an extension of eLearning - from "eLearning as a means of knowledge transfer and delivery" to that of "eLearning as a means for knowledge creation and discovery". eUreka (after Archimedes' 'I have found it!) system is an institutional campus-wide web-based system for project work and knowledge management. The system was designed and developed based on instructional and learning design principles to provide an easy-to-use platform for project planning, documentation, collaborative work and reflections on the learning experiences of students throughout the project work duration.

To maximise the usefulness and benefits to the students' learning journey while in the University, eUreka system is integrated with NTU's Blackboard-based edveNTUre (http://edventure.sg) learning environment. This provides a holistic environment for the total learning experience and engagement of student learning and independent knowledge creation, discovery, understanding and application.

This paper traces the rationale for the design and development of eUreka system, the extent of its use by students and its transformation of the traditional paper-based log-book documentation to an online platform with ease of use and 24 x 7 access. As a consequence, students are better advised, supervised and mentored, resulting in improved learning and research outcomes.

Project-based learning is a comprehensive instructional approach to engage students in a sustained, cooperative investigation (Bransford & Stein, 1993). Within the constructivist pedagogy setting, students apply their understanding to independently or collaboratively work together to achieve a higher learning objective. This process also seeks to encourage deep learning by allowing the students to adopt an inquiry based approach in dealing with issues, problems and questions that are real world and relevant in their learning own lives.

Project work in NTU includes case studies, field work, problem-based learning, term research projects and postgraduate (Masters and PhD) projects. Outside academia but relevant to students are their own informal projects, such as students fund raising events, committee work, events, conferences *etc*.

## II. Pre-eUreka Practice

Before eUreka was introduced, project work at NTU was traditionally managed by formal and informal communication channels via e-mails and face-to-face meetings between (team) student(s) and project supervisors or faculty advisors. Students would keep records of their project plans, execution, observations, analysis and monitoring of milestones, activities, experiments and tasks in their hand-written logbooks or journals. Supervisors would then review this logbook periodically (and in some cases, decipher the student’s hard-to-read handwritten records) to monitor progress and assess the student’s progress and performance. The project outcomes are thereafter evaluated through a formal project presentation.

Like many campuses, there was a lack of a centralised platform to track work processes and to document the discovery of knowledge assets by project students/teams. Often, the original project log-books are put aside (or lost), with the formal project report, dissertation or publication papers being the sole documentation records remaining. This often means that the informal daily journals of failed experiments, considerations of options, processes attempted that did not worked, frustrations of failures and joy of success, personal thoughts and reflections are lost.

These can often be insightful and inspiring. If appropriately documented, such records will ensure that innovative ideas, inventions, theories, principles, experiment data sets, discourses, models as well as failed experiments in the project process can become part of the institutional intellectual property and historical archives.

## III. Post-eUreka Practice

eUreka does not attempt to replace the face-to-face advisor-student meetings. Among the many tools in eUreka system is the weblog, where students type in their project updates. These can include images, graphs, video clips, URLs, tables, data-sets either embedded as part of the weblog, or as a file attachment. Significantly, they no longer have challenges in reading “hard-to-read” log entries hand-written by students, but instead focus on what they have done. Project advisors can keep themselves updated of the project progress (or lack thereof) by reading the project weblogs online anytime from anywhere. With a good grasp of the student’s progress, face-to-face discussions have become more focused and agenda specific.

As in weblogs, each log entry is dated automatically. In addition, and more significantly, the project advisor can comment on the weblog in a more timely way, rather than wait for the next face-to-face meeting. These can be feedback, comments or words of encouragement and insightful advice. Knowing that their weblogs are read regularly by their advisors motivates students to keep good updated and well written log entries .Project students recognise and appreciate this close awareness of the virtual presence and close support of their advisors. Immediately, students are now in closer connection to their advisors than before, though they might have less face-to-face meetings. Interestingly, there have been occasions in which advisors have proactively contacted students for ad hoc meetings after reading some significant development through the weblog.

## IV. Design Considerations

As part of the design consideration efforts, NTU conducted review and evaluation of readily available project management tools to seek the match to effective use in the management of ***academic projects***. However, in most cases, such tools under evaluation cater to the context of commercial and industrial projects. In the case of educational environment, there is a need to provide useful features to enhance the documentation of knowledge creation and learning experiences that are unique to the students' involvement in project work. The system in mind should incorporate extended features for communication and collaboration, support for reflection and authentic assessment of project work management. Moreover, this system should not be so overwhelming for the students to cope and that the learning curve cannot be steep.

The evaluation process covered established project work management tools, such as Microsoft Project, BaseCamp, Teamspace, Task Manager, eProject and @Task, and the focus related to the project work-flow process and scope for documentation. These tools focus more on resource and timeline management and might be overly complex for the student/learning environment. These tools do not provide a document repository or a project log that will better cater to the learning experiences and knowledge discovery that could be evident in the project work duration within the educational context

With the emergence of Web 2.0 technologies, Information and Communication Technology (ICT) can find meaningful adoption in project work to facilitate knowledge discovery. The emergence of the net generation of learners provided a compelling motivation to rethink, repurpose and re-invent learning processes that would challenge and engage a very techno-savvy generation of students joining the University.

In designing eUreka system, the student was recognised to be the centre of this learning process. Instead of going through a learning pathway to attain competency, students using material provided by the advisor consider, decide and plan the process of design, implementation, experimentation, analysis, discovery, and documentation. Essentially, the student owns the eUreka project site, much like a professor owns the course site in a LMS. Accordingly, what is in the project site can be used to assess the student accurately and objectively by the advisor, and if need be, by an external moderator or examiner.

eUreka provides tools to help the student to perform his work. Laffey *et al*. (1998) advocated that the design of project-based learning support systems needs to consider the instructional and learning processes. The instructional processes include scaffolding and coaching, while learning processes cover planning and resourcefulness, knowledge representation, communication, collaboration, experiential learning, reflection and self-discoveries. These pedagogical designed tools support:

a) a knowledge File Repository (see Figure 1) where papers, reports media files relevant to the project can be stored; This can also include project progress reports, data sets as well as presentation files.

b) an Activity Tool using a Gantt Chart in which project advisors can discuss, plan, negotiate and agree on timelines, activities, tasks and deliverables. The Gantt chart is an easy to understand chart to visualize project plan and its various activities. The scaffolding and coaching support using the activity tool enhances the learning processes in project planning and management. It provides direction under the over-sight of an experienced advisor-mentor.

c) knowledge creation, discovery and documentation of their learning journey using the Weblog Tool; this effectively replaces the hand-written project log book. Like a personal diary, the student records his/her work, literature surveys, experiments, observations and results. This 'weblog' can be defined as a "frequently updated website consisting of dated entries arranged in reverse chronological order" (Walker, 2003). Besides it being a means to document and disseminate information from readings and research sources, it can also be a reflection tool for personal and group sharing (Montecino & Smith, 2004).The weblog also facilitates strong mentorship by the advisor as (s)he comments, guides, supports, encourages and challenges the student.

d) Discussion Forum Tool for group project to facilitate project related exchanges between team members. This support collaborative learning as real world issues are articulated, discussed, and decisions of "next steps" are made. To enhance its collaborative value, the Discussion Forum Tool incorporates a scaffolding structure (figure 2), where classification of postings will facilitate the flow of discussion and guide group members towards resolving conflicts and moving towards a solution of the project's goal.

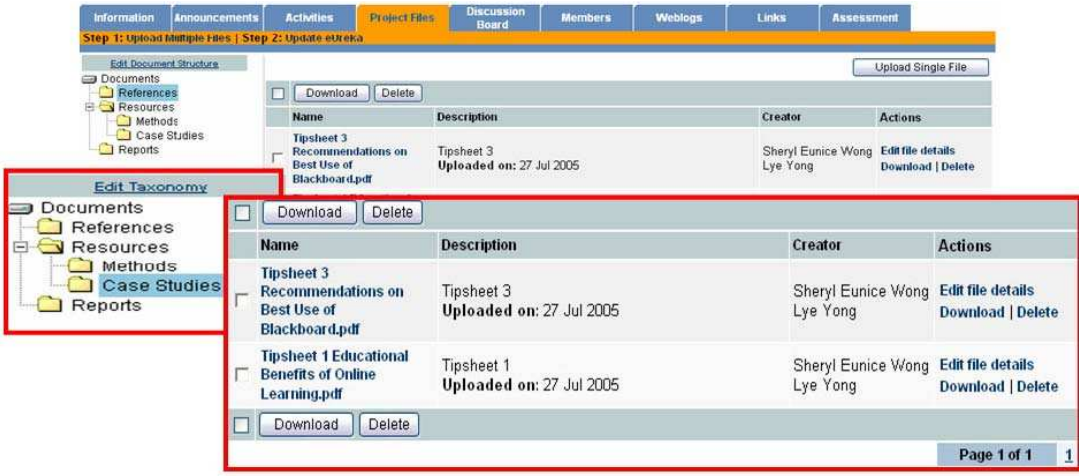


Figure 1. Document Structure in file repository

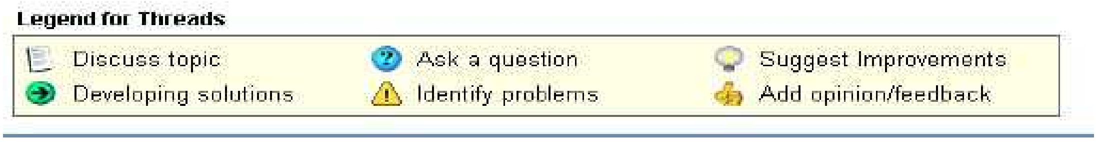


Figure 2. Scaffolding aids to make discussion more effective

## V. Innovative approach to project management

eUreka provides a centralised platform to manage the internal quality processes of invention and innovation and its use can be extended to research labs, institutions and organisations involved in cross cultural and cross boundary collaborative work. The intellectual process of due diligence and investigation in research initiatives will eventually produce greater knowledge of events, behaviours, theories and laws. Such knowledge or experience when captured or documented could facilitate future search, use/reuse and sharing amongst fellow researchers in the relevant field of expertise. A faculty member or student project team member can choose to share their project findings with fellow colleagues or even an external collaborator from another institution or industry by enrolling the individual in the eUreka project site, granting the appropriate access including 'read access only' (Guest), read and write access (Member).

The viable ***intellectual assets*** that can be created in the course of project work include the products of ***creative effort*** such as inventions, innovations in processes, designs and models. Such project outputs may have future ***commercial value*** *or* ***competitive advantage****.* Indeed, the detailed project documentations recorded in eUreka provide an invaluable reference for the student should he wish to continue to develop the prototype into a commercial product during his post-graduate studies or professional career. In addition, eUreka allows the student to 'export' or download a copy of the completed project sites which he can use to enhance his **curriculum vitae,** showcasing his achievements and talents to prospective employers or graduate supervisors.


Figure 3. Users can choose to download a HTML copy of the project site by clicking on the 'export ' button located under 'Action'

eUreka has also proven itself to be an innovative tool in the context of Industrial Attachment (IA) for NTU undergraduate students, whereby the work flow process and documentation for the IA has been automated and the online platform now provides easy access to Industrial Supervisor (IS) and NTU Tutor to better monitor and mentor the student on attachment.During the Industrial attachment, the Supervisor (IS) and the NTU tutor will work collaboratively to assist he student on attachment to gain the appropriate exposure, knowledge, skills and work attitude to prepare him/her to cope with the demands of the working world. With eUreka, the physical logbook used previously for IA documentation has been replaced by online eLog (blog) and this ease of online access as well as timely feedback on attachment progress increase the productivity of supervisory process to better direct the achievement of expected outcome for the attachment.

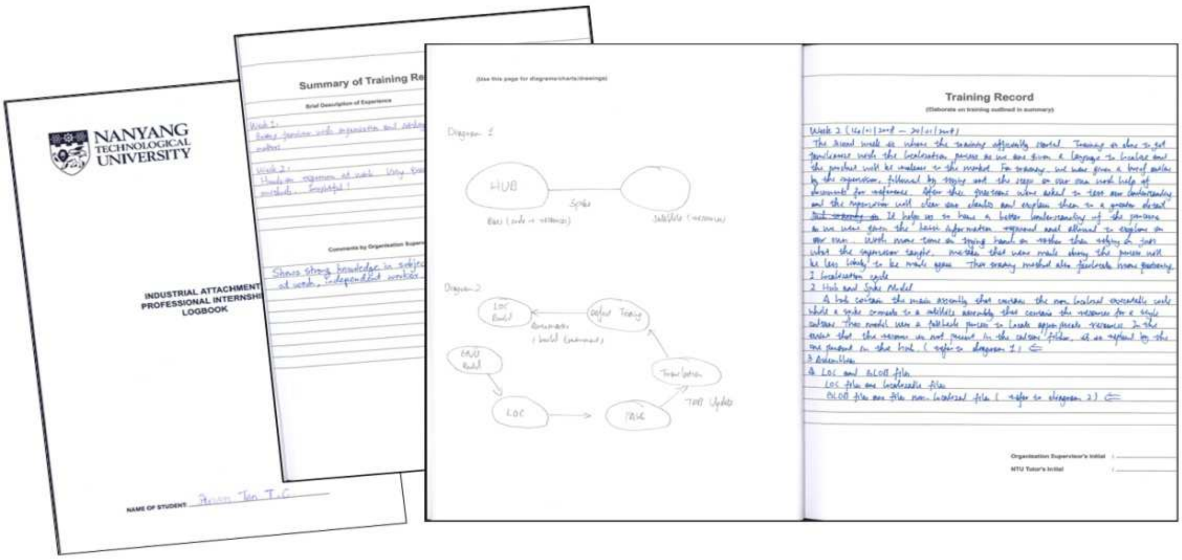


Figure 4. Physical logbooks are used traditionally in NTU to document the student's IA experience, however, such manual documentation is subject to wear and tear or loss

Project Files module in eUreka has been used innovatively by tutors and students in an academic writing course, "HW102 the Art of Academic Writing". In this project-based writing course, recursive writing methodology has been adopted by the tutors and students upload their draft assignments into the file repository (Project Files module). The document will be given a time-stamp on each upload and this enables course tutors to better monitor the different draft versions submitted by students. The edit cum versioning feature in the module allows tutors and students to provide feedback/ comments for improvement to the drafts uploaded by the student members for the group assignment.

This peer review process by fellow student members and monitoring by the tutors provide good mentoring and scaffolding support to the students gaining better grasp of the ropes in academic writing skills. User feedback gathered from the students using eUreka for their HW102 group assignment indicated that they could see progressive improvement in their academic writing skills and the documentation of personal reflections via weblogs provided deep insights on the learning journey they personally have gone through.

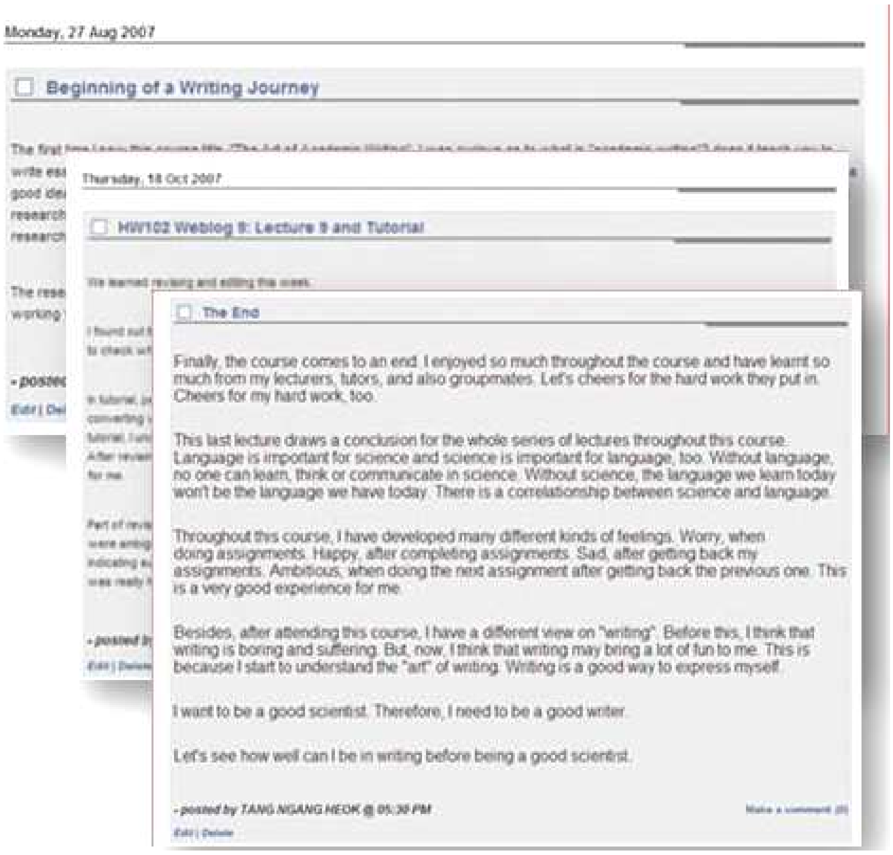


Figure 5. Samples of weblogs documenting the learning journey of the student in the course of using eUreka for HW102 group assignment

Tutors can also choose to reference completed project sites to be used as exemplary assignments to head-start the next batch of students.

## VI. Usage of the eUreka system to manage project work in NTU

Since its adoption in September 2004, there has been steady growth in the number of project sites and usage of its tools. The total number of project sites for 2008/2009 is 11,431 as compared to 65 project sites when it was first made available in 2004/2005. The system was earlier viewed as a useful repository for files upload in 2004; since then, there has been substantial increase in the use of collaborative tools such as weblogs and discussion forums in the online management of project work:

| Weblogs Created | | | | |
|---|---|---|---|---|
| Year 2004/2005 | Year 2005/2006 | Year 2006/2007 | Year 2007/2008 | Year 2008/2009 |
| 124 | 138 | 416 | 2002 | 6559 |
| **Discussion Boards Created** | | | | |
| Year 2004/2005 | Year 2005/2006 | Year 2006/2007 | Year 2007/2008 | Year 2008/2009 |
| 68 | 229 | 343 | 745 | 1017 |
| **Projects Using Activities** | | | | |
| 5515 | | | | |

Figure 6. Usage Data for Weblogs, Discussion Forums and Activities in eUreka

There is a 50 times increase in the creation of weblogs in the corresponding period (124 in 2004/05 to 6,559 in 2008/09) and for nearly 15 times for discussion forums (68 to 1,017 forums). The latter is due to that the nature of many projects does not involve groups where a forum used mainly for group projects will be needed. As at the time of this writing, there are 5,515 active project sites with activities/project timeline drawn up to monitor and document the project work flow.

It was also noted that while the eUreka system was designed for academic project work, it has extended its use by the campus community to internship (local & global) programs with external organisations, ad-hoc research projects (like postgraduate projects, including PhD work), field trips, seminars and student club activities. Some administrative departments have also used it for their own internal projects as well.

## VII. Conclusion

eUreka provides a campus-wide platform to support project work. The system was built and enhanced with feedback from the student and professor user communities". While originally intended for managing the Final Year (capstone) projects, today it is used widely by the campus community for purposes beyond that. It provides a unique, if not innovative way for students to manage, document and showcase their project achievements, and for faculty to implement the pedagogical approach adopted for an academic writing course. Serendipitously, it has also become a curator of the institutional memory of its intellectual property. It also provides a centralized platform to manage the internal quality processes of invention and innovation, as completed project sites as serve as an archive not only of "what" was discovered, but the "how" and "what really happened" in that discovery journey.

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# Changes Handling Architecture for Co-Evolution of Products and Networks of Partners

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**Abstract:** With the growing complexity of business context, the mutual dependencies with a company and its partners are considered more and more seriously in New Product Development (NPD) projects. These dependencies define numerous constraints that must be known from the very beginning of the project ensuring successful target product development. The Co-Evolution of Product and Network of PartnerS (CEPS) framework, developed in our research team, proposes a methodology to manage the couplings between the product design and the network of partners' fields. One of the phenomena that are studied in this framework is change management. Basically, the idea is to understand what kind of changes can be generated within each of the considered fields and model them trying to determine the changes propagation mechanisms. Changes and modifications can be generated during the product life-cycle either regarding the product characteristics (needs, requirements, solutions, functionalities, ...) or the partners (improvements, contracts problems, technical aspects, ...). These changes will be propagated through explicit or hidden links from product to the network of partners and vice versa. This article describes some exploratory results. We propose a Changes Handling Architecture (3H) to identify, analyze, qualify/quantify and estimate the changes' propagation in the CEPS framework. Based on the scenarios we categorize the changes into several types.

**Keywords:** Changes Handling Architecture; CEPS; change propagation.

## I. Introduction

Today launching New Product Development (NPD) projects, managing technical and technological issues or coordinating actors (internal and/or external) and resources are among the greatest challenges for companies. Projects have to deliver successful products on time and budget minimum industrial risks, while building up long term links across their supply chains. The Co-Evolution of Product and Network of PartnerS (CEPS) is a framework that considers in parallel the product development process and the design and deployment of its suppliers' chain or more generally the network of partners. In CEPS, both end products and enabling products are considered. This global framework underlines the systematic influence of decisions made in product development on the supply chain design/deployment and vice versa. Zouggar et al. introduced the methodology to identify the hidden dependencies in the network of partners through analysing the product model. Compared the linkages weight and dependencies between the components with those between the partners in the network, the hidden dependencies are revealed to be concluded into several categories. While referring the work concerning the mutual dependency from network of partners, M. Zolghadri et al. suggested the management aspect of the network of partners should be considered as soon as possible at the very early phases of the New Project Development project and proposed an approach which allows analysts to identify the architecture of the network of partners based on decisions made about the product architecture.

## II. Category of Changes

Although the research work concreting the connection between product design and the network of partners starts rising, the mutual influences of the two domains become more and more critical because of the existing cause-effects loops or coupling highlighted in the CEPS framework. Here we quote the concept of engineering change introduced by Jarratt and modify it slightly to define and describe the concept of change in our research: "A change is an alteration made to parts, activities or capacities that have already been released during the various process of the life-cycle of product and the corresponding aspects of the partners (organization, coordination, participation and exit, etc)". The change can be with various granularities; meanwhile the influences and the effects of change can involve the stakeholders and the processes concerned in the product and network of partners. Internal changes are generated and survive only within the two respective domains (product or network of partners) and their direct propagations are still limited in the same domain. External changes are the changes whose direct propagations pass across the boundaries of domains. Furthermore, we identify and analyse a change from two aspects: possibility and gravity. Possibility describes the quantified ratio of the change being possible and gravity describes the impact of the change onto the considered fields. We use a two-dimensional coordinate system to illustrate categories of changes depicted by the above two parameters, in which the vertical axis stands for the Possibility value while the horizontal axis stands for the Gravity, and the origin of the coordinate is set as the pre-defined minimum value of the both axes (see figure 1).

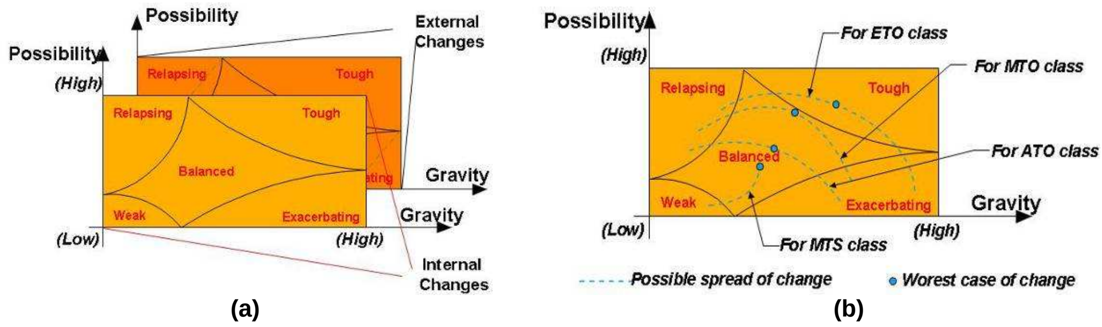


Figure 1. Category of Changes in Coordinate

With the various levels in respective axes to indicate the corresponding values of possibility or gravity, internal and external changes can be characterised by the following characteristics:

- Balanced: The balanced changes can be regarded as the intermediate type of changes. On one hand they imply a medial manner that all the other four classes of changes are just the consequences in the categorical situations; on the other hand they can also be understood as the transition from one of the following types to another.
- Weak: The weak changes are low in both the possibility and the gravity. It means that such changes occur not frequently, and even though they occurred the influences are trivial.
- Tough: It is the worst case of changes because of the highest levels in both possibility and gravity. It means the particular change is very probable to happen and once it happens it will cause a “disaster”.
- Relapsing: It is a kind of changes with high possibility in the particular domain or the phase, while the impact of such changes is low.
- Exacerbating: It is a kind of changes with high impact to the particular domain or the phase despite rarely met with.

## III. Evaluation of Changes in Manufacturing System

Fricke et al. (2000) proposed five attributes to implement a better change management. In our work, change management is an integral process to identify, analyze, qualify/quantify and estimate the changes, which is used to improve the capability of accommodating, reducing and preventing the negative impacts from the changes and their propagations.

- Less: Preventing changes can be achieved by a more “in depth” analysis before designing and implementing with the changes.
- Earlier: Consider that the earlier a change is implemented into a design the less costly it is.
- Effective: Asserting the changes and their potential side-effects in a better way in the later stages of product design can be used to avoid them.
- Efficient: Improving the change processes to make best use of all the resources.

- Better: Learning from previous change cases and change processes for gather experience to improve the capability to manage changes in the future.

With the categories of changes, we select manufacturing system to present the scenarios of the categorized changes, in which the system is composed of four main phases of the product in-house lifecycle: Design, manufacturing, assembly and inventory of final products. The point where the customer order is perceived by the company's organization is called the decoupling point; which represents how deeply the customer order penetrates the supply system. Correspondingly, four classes of management policies are set up in the scientific literature: Make-To-Stock (MTS), Assemble-To-Order (ATO), Make-To-Order (MTO), and Engineer-To-Order (ETO). Considering the three aspects of evaluating risks brought by the changes mentioned above, we mainly present the evaluation of ETO class in the coordinate system of categorizing changes. Engineer-To-Order (ETO) is a type of manufacturing process for highly customized products which are required to be designed and engineered in detail as per the specifications in the order placed by customers. The challenge arises mainly from the social, economic or technical difficulty of synergizing various parties along the procurement chain according to Pandit and Zhu (2007). This means that design activities will take place before any manufacturing. The product adaptation could represent either high level design or small improvements.

In figure 1.b, the line standing for ETO class goes across four areas--Exacerbating, Balanced, Relapsing and Tough because of the following reasons. First, ETO class has the longest life-cycle, and there are more scenarios where changes are generated. Therefore the possibility of changes' occurrence turns to high correspondingly. Second, the four phases defined in ETO class are in different weights for estimating the influences of changes. It is obvious that the phases of design and manufacturing are much more susceptible and sensible when facing the changes. Moreover, from the rule of "ten times" we also know that the later the changes are generated, the higher the cost would be spent on. Therefore, as a more complex manufacturing system with long life-cycles, both the possibility and the gravity of the changes generated in ETO class could be more serious.

## IV. Strategies to cope with changes and change propagation mechanisms

To cope with the changes illustrated with couples of qualified parameters in various levels, we must introduce the concept of robustness as the assistant issue for presenting the strategies to cope with the changes. The thresholds set in possibility and gravity fields respectively can illustrate this ability. It means that to all the changes we can set an area in coordinate system. First, we predicate that the changes can be accepted depending on the capability of robustness. We identify such changes as controlled changes. Then, we can discover the changes out of the control, which means they are over the robustness and may cause some unexpected chained effects. We name this type of changes as exceptional changes. To the both possible types of changes, we can accept the former existing in the CEPS framework while should take measures to force the latter towards the acceptable area to maintain well performance. From our analysing methodology mentioned above, we present a set of strategies for evolvement, which is illustrated in figure 2.

- Mitigation: It is a strategy only to decrease the gravity level of the given change to make it release lighter influence in spite of the possibility is still in the original level.
- Prevention: It is a strategy only to decrease the possibility level of the given change to make it generated in a seldom case or even prevented from occurring in spite of the impact from the changes are still in the original level.
- Mixed: It is a strategy to conjoin the mitigation and prevention strategies together, which is designed to decrease the levels of gravity and possibility in parallel.

In figure 2, the hexagon labelled with "C1" stands for a change under control in a triangle area set by two thresholds (pt on the axis of "Possibility" and gt on the axis of "Gravity") illustrating the robustness capability in a given scenario, and "C1" can also fluctuate in the neighbourhood represented by an ellipse. The hexagon labelled with “C2” stands for an exceptional change requiring evolvement. With the above proposed strategies, we can set the customized handling solution to evolve the exceptional changes through weakening an individual measuring aspect to decrease the negative impact and then make them under the ability of robustness. Besides especially to the changes in much worse situation, we can also take the mixed handling solution from the both aspects synchronously.

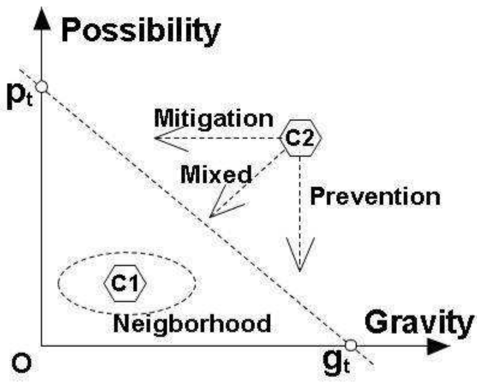


Figure 2. Evolving Strategies

In the above context, we mainly discussed the classification of changes, which is limited to regard changes as separate objects. In the following, considering the mutual relationship between them, we will concrete to identify and analyse the propagations of changes. Generally speaking, the changes can propagate with various trends of the measured issues (possibility and gravity). Based on our qualifying methodology presented above, we suggest a category of changes’ propagations with the trending characteristics of the propagations as following.

- Isolated Change Propagation (ICP): This type of change propagation does not bring any obvious transformation to the original changes.
- Expanding Change Propagation (ECP): This type of change propagation increases the possibility of generating the changes. In this case, the change propagation can be regarded as the main element which causes the change to occur more frequently.
- Shrinking Change Propagation (SCP): This type of change propagation decreases the possibility of generating the changes, which is the main element to drop down the frequency of change occurring. The area of distributing the changes shrinks into a smaller one.
- Aggravating Change Propagation (ACP): This type of change propagation can be described as the element of aggravating the difficulty of managing the changes due to the result from propagated changes’ stronger impact, though the possibility of the change is still in the original level.
- Curing Change Propagation (CCP): This type of change propagation leads the changes towards the situation that the gravity is reduced with the possibility in the original level.

Through categorizing the change propagations, we can discover the transitions between the changes to adopt corresponding measures to cope with the impending changes in advance, which enhance the capability of control changes in the CEPS framework.

We also adopt the same coordinate system to illustrate the various propagations’ characteristics in figure 3. (In figure 3, “RC” stands for Regular Change illustrating an example of change in the coordinate.)

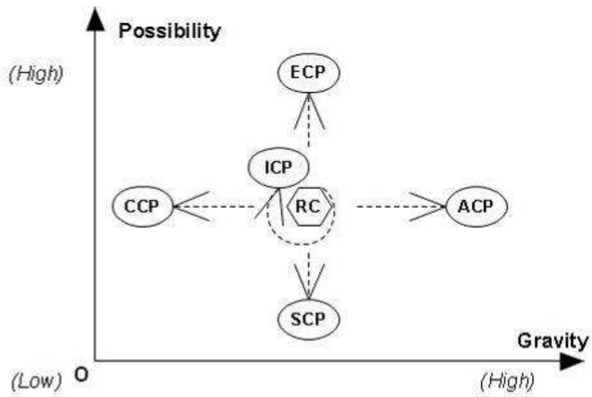


Figure 3. Category of Changes' Propagations

In the figure 3, a given regular change represented by the hexagon propagates to five possibilities and the corresponding definitions in the category represented by ellipses demonstrate the edges between the various types of changes presented in above context, and table 1 summarize the deliberation in details.

| Change Name | Edge(s) | Qualified Elements | |
|---|---|---|---|
| | | Possibility | Gravity |
| Balanced change | ICP | Medium | Medium |
| Tough change | ECP, ACP | High | High |
| Weak change | CCP, SCP | Low | Low |
| Relapsing change | ECP, CCP | High | Low |
| Exacerbating change | SCP, ACP | Low | High |

Table 1. Relevance between Changes and Changes' Propagations

From table 1, we can examine both the changes and the changes' propagations with the identical qualified issues and discover the relevance. It implies the changes propagation through identifying and analysing the changes at high level. As we explained above, the internal changes are with the direct influences acting on the same domain while the external changes with the direct influences on the opponent domain. Besides their concepts we also clarity that all the change propagations can be composed and demonstrated as the chains of one piece of direct influence or more between the changes. Therefore, through the particular change propagation as a pipe, the changes can be regarded as the contacts in the pipe, in which we regard the single change propagation through direct influence between two changes as the unit to quantify the change propagation. We can conclude three cases illustrating the corresponding constitutions. First, the purely internal changes are connected by the propagations; second, the purely external changes are connected; third, the mixed changes from internal and external collections are connected. Referring to the first two cases, they can also be analysed and qualified as the category directly, which means that the change propagations only continue within the same domain of initializing the original change, however, as to the third case we will inspect the ones in it in a more complex manner.

## V. Conclusion

In this paper, we present our work of Change Handling Architecture (3H) in Co-Evolution of Products and Network of Partners (CEPS) to manage the changes and the change propagation during the activities of the product life cycle and in the domains of product and network of partners. With the categories of changes and the propagations, we identified and analysed the changes and estimate the trends of the influences. In our work, 3H is not only an architecture to define and present our idea and work of managing changes and the propagations but a solution to resolve the problems in the both domains. In future, we will design and develop a prototype based on 3H.

## VI. Acknowledgement

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# An Evaluation Infrastructure for the Validation of Living Labs analysing Service Innovations

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**Abstract:** This paper aims at presenting an evaluation infrastructure for the validation of service innovations tests delivered by Living Labs. At first, it is shown that the term "innovation" needs a conceptual definition to develop a common understanding. In a second step, collaboration models are differentiated showing that companies have different options for their innovation processes. As a methodological result, the concept of Living Labs is introduced as a new approach for testing service innovations. They have been proven as a suitable method to test service innovations. Based on this, an evaluation infrastructure to validate Living Labs' quality is proposed with the ultimate goal to provide an infrastructure capable of analysing service innovations.

**Keywords:** service innovation, Living Labs, evaluation infrastructure

## I. Introduction

During the last decade, distributed and collaborative innovation has been the subject of many studies and investigations (Borchert 2006, Goos 2006, Eschenbächer 2009). This can be partly explained by the increased specialisation in most industry sectors and thus very specific and distributed value chains. Also, the increased complexity of today's products and solutions contribute to the change of innovation structures. This is why large multinational companies have already adapted these ideas and practices as a part of their world-wide innovation and research efforts (Bouteillier et al 2008). New innovation concepts such as collaborative innovation (Hippel 2005) or open innovation (Chesborough 2003) are furthermore gradually becoming accepted and utilized among smaller and medium sized companies, who have found new interest in strong and innovative business collaborations. Consequently, new challenges and research areas need to be addressed.

Two fundamental questions regarding the innovation of products and services are whether the collaboration model should be open or - to a certain extend - restrictive-, and whether the governance model should be flat or hierarchical. As a matter of fact, the theoretical discussion regarding open and collaborative innovation versus closed innovation is currently getting a lot of attention (Pisano and Verganti 2008, Gassmann and Sutter 2008) and splits the scientific community. Some like Almirall and Wareham (2008) take the position that openness to business partners is the key to success, while others point out the severe risks implied by open innovation regarding IPR and piracy issues (Pisano and Verganti (2008). Despite the discussion, open innovation and collaborative innovation models are based on evolutionary and interactive learning perspectives (Endqvist, 1999) and therewith build upon the latest research.
Studying these publications, the common euphoria regarding open innovation processes needs to be assessed carefully.

To achieve a better understanding of these controversial positions and the dynamics behind these ideas, the following communities are distinguished:

(1) *Practitioners from industry* who mainly support closed innovation. Historically, the main force driving innovation as recognized by Schumpeter already in 1930 (Schumpeter 1930);
(2) *Researchers in the area of open innovation*, which is a rather new concept, introduced by Chesborough (2003);
(3) *Researchers in the area of explorative research and development and innovation (RDI)* who adopt an intermediate position, supporting the Living Labs concept developed in late 2004.

The European Network of Living lab (ENOLL) stresses the importance of open Living labs as a "magic formula" (Farmer 2006). A Living Lab can be defined as follows:

*A Living Lab empowers users to drive research, development and innovation for ICT based services addressing major socio-economic issues (energy and environment; well being, e-health and inclusion; media and creativity; logistics and manufacturing regional development…).*

After having introduced the main concepts, the state of the art regarding collaboration models is outlined. The presented model can be used to evaluate collaboration from various perspectives of Lab actors They can focus on different roles, relationships, interactions and openness of the distributed innovation process. The multi-disciplinary framework is based on the assumption that the partners of Living Lab collaborations have several objectives besides value maximisation, e.g. collective learning, access to new technologies, image and opening new market opportunities. The framework will elaborate and evaluate the current Living Lab approaches in means of services, technology platforms, organisational arrangements as well as business models, and identify the main challenges and areas of further development. The results show that there is not one such way of open or closed innovation but rather a number of different options every organisation has to implement in the best possible way to support their respective innovation processes. Some findings concluded the paper.

## II. Views about innovations

A lot has been written about the term innovation (Boutellier et al, 2008, Garnig, 2007, Geoffrey, 2004, Hauschildt and Salomo, 2007). As a result, many different understandings are found in literature (O' Sullivan and Dooley, 2008). Figure 1 reveals a possible categorization of different innovation types. The underlying concept resulted mainly from the studies of Granig (2007) and Geoffrey (2004) et al. and orders innovation by their respective nature, that is, innovation of products, processes, services, etc. The categories of distinct innovation types also meet the demand for a more differentiated picture of innovation in science. The categories are shown in Figure 2 on the left side.

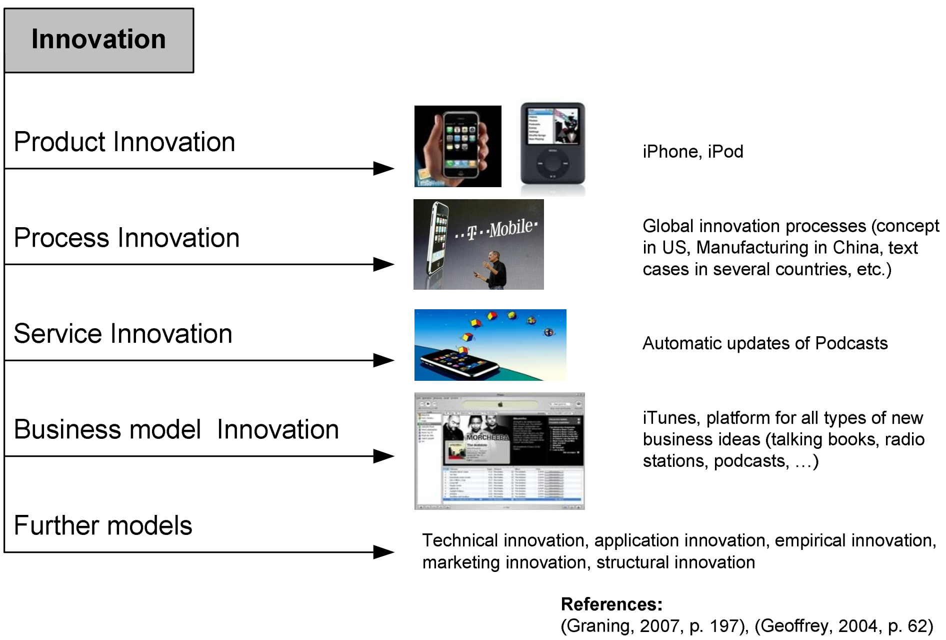


Figure 1.  Categories of innovation

The categories support the differentiation of innovations, which makes it easier for both practitioners and researchers to build up common understanding and definitions. Although this concept offers a systematically classification of innovations and can be of great value for practice, it is still too superficial for the correct description of innovation. Despite its sophistication, the concept misses the dimension of uncertainty, which undeniably constitutes a crucial success factor for most innovations. A common adjustment process finally led to the results shown in Figure 2. It divides technical and market uncertainty and therewith presents a portfolio of four different terms. The basic idea is to clearly separate different types of innovations, because their mechanism for creation is totally different. The main message is that an incremental innovation generally means very little uncertainty when dealing with it. In contrast, a radical innovation is very difficult to achieve because both technical and market uncertainty are very high.

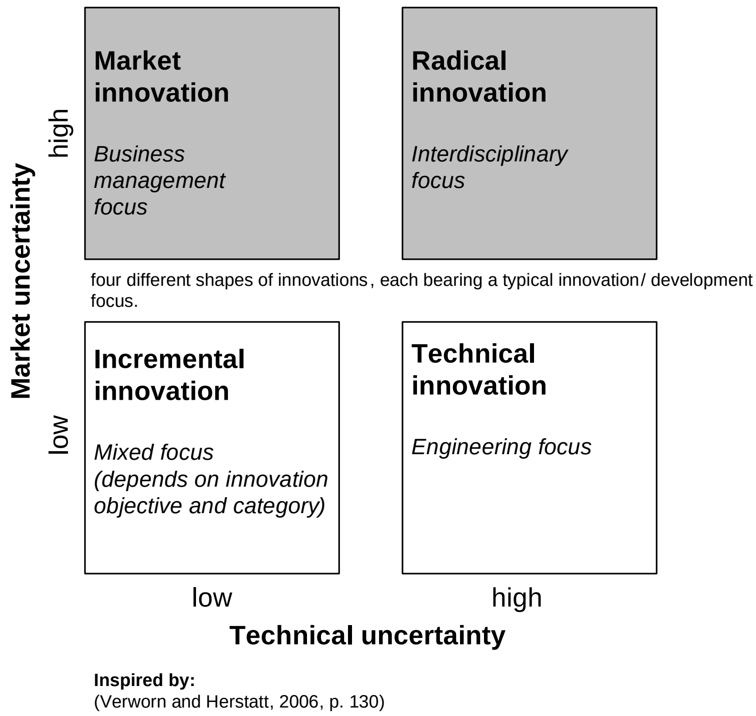


Figure 2. Types of innovation (Eschenbächer, 2009)

In conclusion, the authors recommend the careful use of the various terms characterising innovation. Indeed, it would make sense to specify each innovation with the two attributes just presented. This could promote a less superficial and unspecific dialogue about innovation among both scientists and practitioners, and thereby break ways for further research and insights. The authors believe this would make communication among the research community and practitioners – and between them - much easier.

## III. How to choose the right collaborations modes for Living Labs

### *3.1 Collaboration modes in practice*

The following sentence illustrates well the issue of collaboration modes: "An era in that great ideas can sprout from any corner of the world and IT has dramatically reduced the cost of accessing them, it’s now conventional wisdom that virtually no company should innovate on its own (Pisano and Verganti 2008)". The good news is that both the potential partners and collaboration options have grown enormously in numbers. The bad news is that the wide range of options has made the perennial management challenge of selecting the best strategy even more difficult.

Questions such as need to be answered:

- Should you open up and share your intellectual property with the community?
- Should you nurture collaborative relationships with a few carefully selected partners?
- Should you harness the “wisdom of crowds”?

Notwithstanding the fervor for open models of collaboration such as crowdsourcing, there is no best approach to leveraging the power of outsiders. Different modes of collaboration involve different strategic tradeoffs. Companies that choose the wrong mode risk falling behind in the relentless race to develop new technologies, designs, products, and services. All too often, firms jump into relationships without considering their structure and organizing principles – what we call the collaborative architecture.

To help senior managers make better decisions about the kinds of collaboration their companies adopt, we have developed a relatively simple framework. The product of our 20 years of research and consulting in this area focuses on two basic questions: Given your strategy,how open or closed should your firm’s network of collaborators be? And who should decide which problems the network will tackle and which solutions will be adopted? Collaboration networks differ significantly in the degree to which membership is open to anyone who wants to join. In totally open collaboration, or crowdsourcing, everyone (suppliers, customers, designers, research institutions, inventors, students, hobbyists, and even competitors) can participate. However, Pisano and Verganti differentiate four basic modes of collaborative innovation.

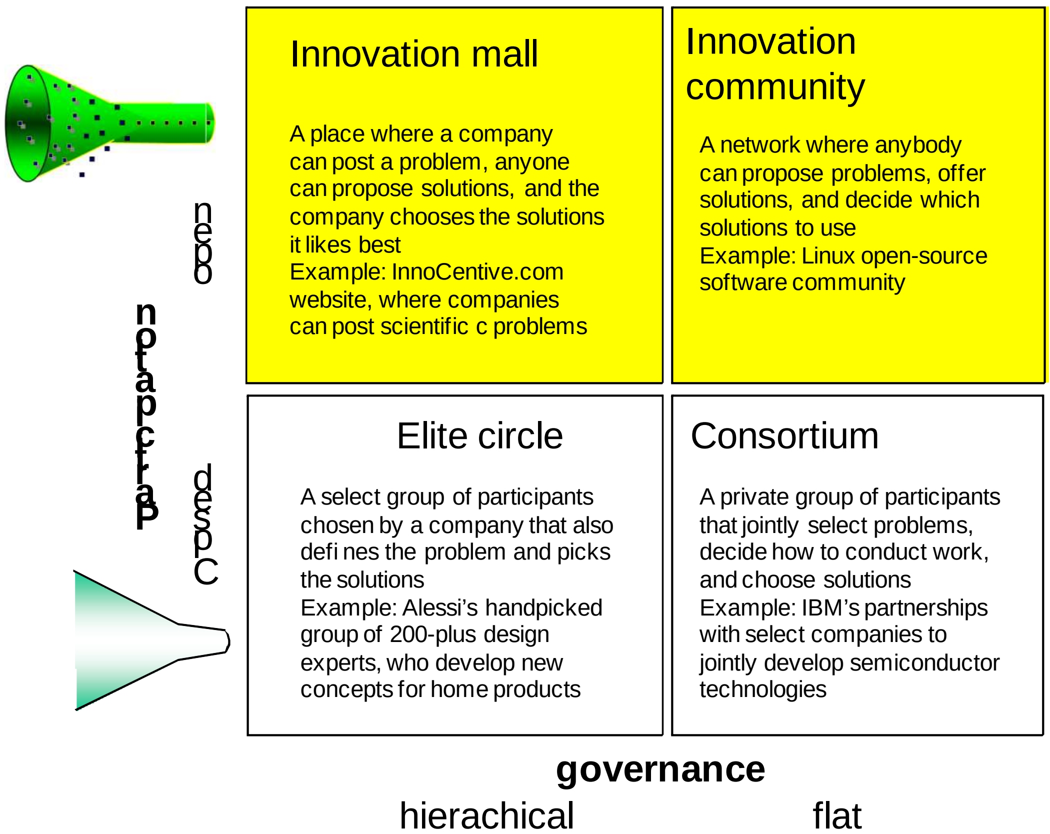


Figure 3. How to choose the best mode of collaboration (Gary P. Pisano and Roberto Verganti HBR 2008)

For a more detailed analysis some guidelines are shown in table 1.

| Mode of collaboration | When it is appropriate |
|---|---|
| Elite circle, in which one company selects the participants, defines the problem, and chooses thesolutions | » You know the knowledge domain from which the best solution to your problem is likely to emerge from.<br>» Having the best experts is important, and you have the capability to pick them.<br>» You can define the problem and evaluate the proposed solutions. |
| Innovation mall, where one company posts a problem, anyone can propose solutions, and the company chooses the solutions it likes best | » You need ideas from many parties, and the best ideas may come from unexpected sources.<br>» The consequences of missing a better solution from an elite player are limited.<br>» Participating in the network is easy.<br>» The problem is small or, if large, can be broken into modular parts.<br>» You can evaluate many proposed solutions cheaply. |
| Innovation community, where anybody can propose problems, offer solutions, and decide which solutions to use | » You need ideas from many parties, and the best ideas may come from unexpected sources.<br>» Because you don't know all possible user requirements, you want to share the costs and risks of innovation with outsiders.<br>» Participating in the network is easy.<br>» The problem is small or, if large, can be broken into modular parts.<br>» You don't need to own the intellectual property underlying the solution. |
| Consortium, which operates like a private club, with participants jointly selecting problems, deciding how to conduct work, and choosing solutions | » You know the knowledge domain from which the best solutions are likely to emerge.<br>» The problem is large and cannot be broken into modular parts.<br>» Having the best experts is important, and you have the capability to pick them.<br>» Contributors won't participate unless they share power.<br>» The expertise of all participants is needed.<br>» You can share the resulting intellectual property with the other participants. |

Table 1: Guidelines for collaborations (Verganti and Pisano 2008)

As one of the research backbones, we have looked for a model illustrating this conflicting situation. Pisano et al (2008) have developed a model which describes these basic ideas as shown in Figure 3. Basically, this framework can be used to better understand which mode of collaboration should be taken. There are two basic issues that executives should consider when deciding how to collaborate within a given innovation project: Should membership in a network be open or closed? Should the network's governance structure for selecting problems and solutions be flat or hierarchical?

In this paper we are mainly focussing on innovation communities. Especially in Europe the other three approaches have been tested very often but the issue of open and non-governed Living labs seem to be very promising. Such living labs have not been evaluated because the represent a new type. The basic assumption to be validated here is whether better innovation may be selected by applying the tools to the problem area. We believe that by using such living labs in an European innovation infrastructure, different types of organizations will be empowered with a better mechanism for the selection of innovative, marketable ideas. This should contribute to the general acceptance of Living Labs as a method in the innovation process.

### *3.2 Living labs as instrument for a European Innovation infrastructure*

Achieving a European innovation infrastructure is a major political goal. Consequently communities such as ENOLL provide an attempt for high level networking and integration. Basically Living Labs shall support the following tasks:

- Identifying, coordinating and sharing best practices supporting innovation management
- Establishing a coordinated European approach to Living Labs
- Defining a common suite of methods and tools for Living Labs
- Establishing a European Network
- Living Labs as the basis for a Single European Innovation System

Figure shows an overview about the conceptual framework of Living Labs. Here, the customer defines requirements which can be tested within a stakeholder infrastructure. Methods and tools are currently in development. These activities can be transformed into a set of results supporting the testing of innovations.

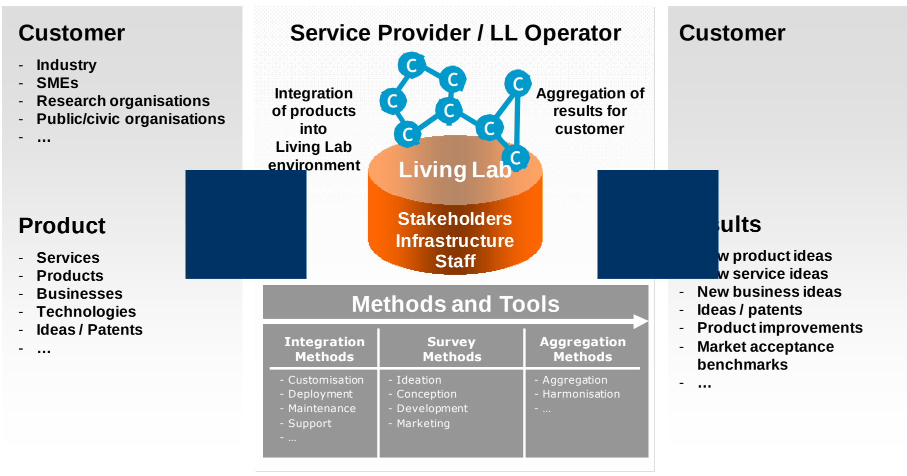


Figure 4. Living Labs as Innovation Service Providers

Living Labs can be seen as a method in the innovation process supporting different types of open and closed innovation. They can be used differently in the various business constellations.

The vision behind the Living Lab collaboration is that user involvement and user centricity are essential to a new, “service pull” model of innovation, where the role of the user is critical and has to be integrated and duly monitored throughout the whole innovation process. Living Lab research assumes an ecosystem perspective in the evaluation of the economic and societal potential and impact of open innovation approaches and assessment of the convergence of open innovation and the Living Labs approach in order to reinforce and create a European-based service industry for knowledge intensive sectors.

Over the past decade, Living Labs have become an established part of local and regional innovation systems, using a variety of methods and tools, and focusing on a wide array of domains and themes (Santoro 2010). However, the experimental, learning-by-doing set up of Living Labs within various application domains and the disconnection between individual Living Labs, has led to a wide variation of approaches, results and impacts of Living Lab activities. Therefore, as this innovation instrument matures, it is crucial to ensure that its main strength in terms of local embeddedness does not turn into a significant weakness in terms of the general applicability, validity and robustness of Living Lab test results. This implies that we need collaboration concepts that address these particular characteristics of innovation and change. Based on this evidence, we conclude that there is a need for an analytical approach enabling a case-by-case customization of the collaboration model for every innovative product, service or business model. Because we are focussing on Living LabLiving Labs, the authors can discuss experiences from the first four waves of ENOLL. With the help of these case examples, it can be demonstrated easily that different collaboration models may be selected.

## IV. Evaluation infrastructure

A small set of eligibility criteria will be applied. If an application is deemed non-compliant against an eligibility criterion, the application will be disapproved, regardless of its other qualities. The following criteria have proven to be important when running a sustainable Living Lab. The evaluation of applications is against these criteria. All criteria have not to be fulfilled before joining ENOLL, however it is expected that candidates fulfil at least 80% of the required categories. For checking this evaluators look instead the balance of criteria in comparison with the lifecycle phase of the Living Lab operations.

| No. | Description |
|---|---|
| 1 | Evidence of co-created values from research, development and innovation |
| 2 | Values/Services offered/provided to LL actors |
| 3 | Measures to involve users |
| 4 | Reality of usage contexts, where the LL runs its operations |
| 5 | User-centricity within the entire service process |
| 6 | Full product lifecycle support - capability & maturity |
| 7 | LL covers several entities within value-chain(s) |
| 8 | Quality of user-driven innovation methods and tools |
| 9 | Availability of required technology and/or test beds |
| 10 | Evidence of expertise gained from the Living Lab operations |
| 11 | Level of own commitment to open innovation process |
| 12 | IPR principles supporting capability and openness |
| 13 | Openness towards new partners & investors |
| 14 | Business-citizens-government partnership – strength & maturity |
| 15 | Organization of LL governance, management & operations |
| 16 | Business model for LL sustainability |
| 17 | Interest and capacity to be active in EU Innovation system |
| 18 | International networking experience and capability |
| 19 | Channels (web etc) supporting public visibility and interaction |
| 20 | People/Positions dedicated to LL management & operations |

Table 2: List of evaluation criteria

Finally the evaluation criteria have been structured into the groups services, results, management and resources.

## V. Conclusions

The management of innovations set organisation for a number of challenges. Many different types and categories of innovations show that a specific treatment for every innovation process is recommended. The new findings of collaboration modes illustrate that groups and communities can support completely different innovation strategies. In this paper we have highlighted the innovation communities. Such communities can be effectively be supported by living labs because a dynamic infrastructure is needed for the increasing complexity in product development. Consequently the living lab model has shown the different areas to work on. Finally an evaluation infrastructure has been conceptualised.

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# The "sustainable developers" experience in a telecom company reflections from a grounded experience in social innovation

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**Abstract:**
This case study is made from an action-research intervention in a very big multinational company of telecommunications. The objective of the project was to change the mind (attitudes, behavior and competences) of all these people who work in software development in the company (several thousands of persons). This intervention has been done during the 2009 year. The results of our work that we have capitalized and shared with the top managers of the company are interesting enough to be published in a scientific symposium like ERIMA.

The genesis of the project is first presented because it is central to understand the very nature of the complex process that has been developed. Then, the way we have organized and implemented our intervention will be explained. The idea of an insufficient preparation of the intervention (idea well shared by participants, managers, animators, researchers) will be discussed in the light of the results we have obtained.

After a capitalization step (done with the managers of the company), we think (and it has been written by the executives in charge of the project in the company) that the results we have obtained are interesting and that they constitute a good basis for a generalization of the change process.

**Key-words:** change, community, social networks, mental representations

## I. Introduction

This contribution is about a case study related to a long term intervention (2009) in a big multinational company of telecommunications ("E"). This intervention is about helping the company to make the attitudes and behaviours of all the professionals of software development *(largo sensu)* evolve, in order to make them more empowered, more involved, more responsible, more autonomous, more collaborative… Our intervention has been previously lengthily discussed (for months) with the company's staff and then realized by our team as a research action process. At the end of the preparation process, the starting of the project was extremely precipitated, due to an important pressure of the top management of the company who was considering that it was time to begin doing things rather than going on with discussions! An interesting sequence for us, researchers interested in complex project management. The research we have led in this intervention belongs to the category of action-research, which means that in such a case, the field intervention is the "raw material" from which we try to extract interesting outcomes from a research point of view.

That is why the whole life-cycle of the project is interesting in order to "catch" the fundamental features of such an innovation process. Particularly, the genesis of the project in its whole is very important in order to understand the deep nature of such a complex process which is beginning – and then lasting for months- with the preparation of this intervention (history is central in complex epistemologies). We will present what was at stake as far as the preparation period is concerned. In a following paragraph, we will describe the project specifications and then, we will successively focus, in two dedicated paragraphs, on both the modes of proceeding we have developed and the results we have obtained from this action-research.

## II. The genesis of the project

In the more recent period, for some years, the E group developed a tendency to consider that software development represents a cost more than an added value with a strategic character. Therefore, a logic of externalization (towards India particularly) had been developed. Nevertheless, two years ago, a strategic reflection stated that the unique common point of all the activities of the group (from TV production to smart buildings (domotics), including mobile phone and Internet, etc.) is the fact that all these activities are based on digital technologies. As a consequence, strategy was redefined, as it is understood that software-based products and services design, production and maintenance as well as their quality and relevance are central in such a strategy. Therefore, it is understood that the skills and competences related to these activities present a core strategic character for the group. Opening an ambitious reflection, the group’s top management staff develops the idea that the future of software development must be insured inside the company and that this change supposes the transformation of the professions related to the field of software development (all these professions which take a part in software development life-cycle, from analysis and design to code production and validation, passing by project management, quality management, customer service, etc.). Several thousands of persons are concerned in the whole group. The idea is to allow this professional community to evolve towards more responsibility, more self-management, more client orientation, to develop commitment and “agile” attitudes, behaviours and methods, to share knowledge, skills and tricks and to improve ability to communicate. Briefly, a deep change related to competences, attitudes and behaviours!

## III. The “sustainable developers” project

The project named “sustainable developers” was formalized as a consequence of this reflection. After having noticed that the previous discussions related to the project were lasting too much (several months of discussions about what we could do and how to do things), the top management decides to hurry up dramatically the implementation of the process. Action is needed at very short term. So that the real concrete preparation and implementation of our intervention will be done within a very short period of 3 weeks. It will be decided to organize the process per sessions of 15 persons groups, each session being organized on the basis of 15 days on a 3 months period (with the rhythm of four sessions a year).

We had defined a “program”, as usual in classical training sessions: technical innovative aspects (object orientation, frameworks, agile methods, etc.) and skills related to management, (“agile” project management, human resources management, skills, competences and learning, social networks, communities of practice, etc.). We defined six days of theoretical-practical presentation of these notions and five days dedicated to a work on the definition of a community of practice. Then two days were previewed for the evaluation of the session and two days more for the preparation of the next session. No more specification! We have to invent things walking! The evaluation of one session will be used for the design of the following one. This is to our convenience as far as we are conscious of the tight complexity we are facing and that we do not really know how to begin! We are in tune with the “agile philosophy” in which the specification is an ongoing co-construction! Now, we propose to describe the first session of the intervention.

## IV. Results

During the process, we decided to organize the « project sequence » (i.e. this part of the session dedicated to a concrete application project taken in charge by the group under the guidance of animators) in relation to the building and starting of the community of practice [1]. We had defined during the previous discussions such a community as the nucleus of the project (a new kind of organization able to trigger and favour improved relationships between developers). Our underpinned reflection was that by doing so (collectively working on the project of developing a community of practice), we were favouring the development of skills and competences linked to complex project management (*de facto* it is a very complex project) but that we are also contributing to make the reflection focus on, and give a form to, this really abstract concept of a ‘community of practice’, concept of which participants are not really aware.

[1] Etienne Wenger, communities of practice…, http://www.ewenger.com/theory/

The time dedicated to the functional reflection related to such a community will be very long as three days of very rich discussion between participants will be used. A lot more than what we had planned (we thought that we should be able to do that in one and a half day!). To our mind, it is fundamental that such a definition is the product of a collective work in order to favor the appropriation of unusual organizational modes and to allow the fact that this work becomes the embryo for a community (able to embrace thousands of people after a while). Therefore, it is also important that this reflection is tracked by a documental production in order to produce symbolic objects (text / power-point documents, etc.) as a basis for future involvement of people in such a community (for the next training sessions that we will have to animate, but also for this people who will enter the community in the future without participating to these sessions) and also as a foundation for the future “chart of developers” that the management would like to implement.

Participants are not familiar with functional specifications for such abstract and ‘virtual’ subjects like a ‘community of practice’. Therefore, session work is difficult to organize and manage. Any projection towards an “abstract” future is definitely far from the kind of systems they are conceptualizing currently in their profession. They are a lot more comfortable with concrete modes of ‘doing’ things (particularly in relation with *web*-based social networks, based on the single use of existing software tools like *Facebook* or *Hi5*) than with an abstract definition of things and the building of a proper concept, organization and environment. On the other hand, we understand perfectly that such a community-building should be more in the *web 2.0* philosophy and spirit if it was done on the basis of the concrete building of concrete services for concrete participants (doing things directly), that is to say using modalities based on an important self-organization and on individual-community highly interactive actions and relationships (by the means of the tool). But the way sessions are organized and the limited commitment and initiative ability of participants make it difficult.

Nevertheless, participants take progressively an interest to the game, even if the omnipresent participants’ “substantive doubt” (‘why are we doing all this work, if we know that top management will do nothing with it? As usual they are playing games with us, etc.’) re-enters the scene from time to time! They will finally take part intensively (the group members finish the sessions very tired!) and will try to answer the question: a community of developers: what for?

Animators lead the beginning of the reflection focusing on the types of services a community should propose to the developers (trying to be relatively concrete). The reason of this choice is that animators think that it is important to open the session with concrete reflections because participants are not used to manage abstract concepts and that at the beginning of the session it has been understood that they are not interested in abstract reflections. As they are relatively hostile or at least indifferent to the outcomes we pretend them to work out with these sessions, animators thought that it was important to propose them concrete challenges, with the idea that concentrating on “doing things” should counter-balance the relative hostile mind they have in relation to the purpose of the session. That is why animators did this choice. But after a half day work, surprisingly, the suggestion will come from the group itself: after a conversation between them, a member of the group takes the voice and suggests: “we should have to start our work from “a higher point” and consider and answer the question of developers’ fundamental needs. The group decides to stop momentarily working on the services that the community should propose and to begin a more abstract reflection about the fundamental needs of developers.

After a long and animated session, the group finally defined 5 classes of needs. The community must be seen as:

- A place for flourishing: allowing developers to realize and improve their personality by empowerment and initiative, eventually considering the possibility of developing projects not directly linked to professional subjects (*Google* model)
- A place for acknowledgement : allowing people to feel that the suggestions and the opinions they are able to formulate to the community are considered and useful (recognition)
- A place for developing competences: allowing people to improve and share their know-how and knowledge by the fact they are able to exchange regularly with the members of the community

- A place for contributions: allowing people to take initiative and to "propose" and "give" things to the community, on the professional side, but also on wider aspects
- A place for information exchange: allowing people to give and to obtain information from peers on the professional side of activity (for instance: how to do things, how to use a tool, how to solve a problem, etc.), but also on other aspects not so directly related to professional activity
- An attractive place: allowing people to have fun, to take pleasure in the exchanges they can have with the community, to be proud to be a member of this community.

It is also important to state that the group underlined the importance of a specific work on triggering conditions, critical mass and sustainability conditions for the community.

During the sequences of evaluation and preparation of the following sessions a presentation of the group's work will be done to the enlarged "pedagogic committee" (top management). The jury will be amazed and very satisfied by the quality and the density of the work made by the group. As a consequence, it is decided that the next session will be done using the same framework than the first one (with some minor adaptations).

## V. Discussion

One of the conclusions we can take from this experience is that organizers, animators and participants have developed an apprehension of organizational change and of its dynamics different from the ideas they had before[2]. It is a question of 'learning by doing', of 'capitalization'[3].

In order to deepen our reflection, we propose to mobilize some theoretical elements. The systemic approach we have adopted in order to realize this intervention is taken from the Palo Alto School concepts[4]. We will not enter into particulars of this approach but underline some points which are central for the understanding of the developers' experience. Following J.J. Wittezaele[5], "the essential characteristics of this approach are mainly related to the 'relational way' one has to consider living phenomenon and in the strategic manner to understand interventions related to change. It has its roots in systemic epistemology, as applied by Gregory Bateson[6] and in intervention strategy, initiated by Milton Erickson".

The Palo Alto School develops a constructivist approach of human mind. That means that "psychics is no more considered as a transcendental quality ('I think, then I am'), as a rational milestone allowing to understand the reality as it is and to act on one's environment […], but effectively as a quality emerging from the relationships between the individual and his environment (physical as well as social). We do not consider any more that there is a "one best way" to understand the world, THE reality, […] but that everybody is currently building 'HIS reality' which is nothing else than a point of view on the world. This allows facing (more or less successfully) the unavoidable difficulties of life"[7].

Two complementary characteristics of this approach consist in the fact that it stresses:

- Relationships more than individuals: "It is the relational context which allows giving a sense to individual conducts. Consequently we are not interested in understanding how a isolated person reacts but how she reacts in the frame of her relationships with the persons of her environment"[8]

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[2] Marie José Avenier (dir.), « Ingénierie des pratiques collectives. La cordée et le quatuor », Ingénium, l'Harmattan », Paris, 2000.
[3] Chris Argyris, Savoir pour agir. Surmonter les obstacles à l'apprentissage organisationnel, Dunod, 2003 (1993)
[4] Jean-Jacques Wittezaele, Teresa García, (2006), « A la recherche de l'école de Palo Alto », Seuil.
[5] Jean-Jacques Wittezaele, (1997), « Communication et résolution de problèmes à l'école. L'approche de Palo Alto », in Bulletin de Psychologie Scolaire et d'Orientation-n°2/1997, p. 53.
[6] G. Bateson, (1980), « Vers une écologie de l'esprit », Seuil Paris.
[7] Jean-Jacques Wittezaele, (1997), ibid, p. 55.
[8] Jean-Jacques Wittezaele, (1997), ibid, p. 54.

- Present more than passed: "We are interested in the past cause of a present conduct, but in the way this behaviour appears today and in the reactions which provoke and maintain it"[9].

Last, following Claude Duterme, "from the Palo Alto point of view, the particular way of working and the understanding of a system are determined by the nature of the interactions at work in it. The central point is therefore made of the interactions ('relationships') to be interpreted in function of the context in which they emerge. But this context itself is the result of interactions between individuals and groups with elements of an enlarged environment ('society', available technology, etc.). Relationships are seen as builders of the context as much as they are built by it and the whole constitutes the 'system'"[10]. In this approach, an organization, as any social whole, may be considered as a communication system". […] In fact, the difference is made by the fact of considering an organization as a communication system more than a system in which relationships are only considered as a part of the system […]"[11].

Following this approach, we have adopted a methodology centred on the day to day of participants and on what they were considering as 'making problem'. In the Palo Alto approach, a problem is characterized by three aspects:

- The difficulties the person is meeting are recurrent
- The solutions she currently implements do not permit to overtake these difficulties
- The person is suffering from this situation

Often, when a person is thinking that a situation is a problem, she is dealing with her emotions and focuses on what she considers as the best solutions. She explains she has tried any possibility and that there is no more solution. In this intervention, every participant expressed his rancour against the management: "we are not recognized in our work, they make promises, but then, nothing comes out, they are pulling our leg and we are no more confident".

It was important to overcome this 'bad' feeling in order to avoid the locking of the whole process and to be able to go on with the collective reflection. In a first step, we chose to let them express themselves freely and then we asked them to tell the facts which were leading them to pretend what they were pretending (because concrete examples are loud of signification).

After defining the problem, we worked with them on what kind of indicators should indicate that the evoked problem is solved, in its totality or even partially. In this perspective, we asked them to point out facts and not only fuzzy points like: "we will consider things go better when we will be recognized and valorised". Progressively, they expressed things in a more concrete way: "we will consider things go better when members of the top management will come and meet us during a training session". We, animators, were then in charge of organizing with them such a meeting. Very regularly all along this intervention, we managed moments dedicated to participants' expression in order to evoke the problems they were facing. We think that it has been a strong contribution to the collective building of the community.

## VI. Conclusion

Organic and eco-systemic approaches, emergence and self-organization, mental representations are central in the understanding of organizational dynamics. Understanding things by the means of social networks and communities has been omnipresent during this experience[12], among participants, but also among organizers and even researchers. The interest was so strong that the top management asked us to organize a seminar (2 days) on these approaches. After this experience, top managers are changing their mind about organizational innovation. Action-research is validated as an interesting method for accompanying socio-cognitive change[13], Edgar Morin's transdisciplinarity concept[14] (with the

[9] Jean-Jacques Wittezaele, (1997), ibid, p. 54.
[10] C. Duterme, (2002), « La communication interne en entreprise : L'approche de Palo Alto et l'analyse des organisations », Coll. Le management en pratique, De Boeck, p.69.
[11] C. Duterme, (2002), « La communication interne en entreprise : L'approche de Palo Alto et l'analyse des organisations », Coll. Le management en pratique, De Boeck, p.71.
[12] Edgar Morin, « La complexité humaine », Flammarion, Champs, Paris, 1994.
[13] Jean-Michel Larrasquet, Jean-Pierre Claveranne, Nimal Jayaratna et Luxio Ugarte, « Pourquoi cette revue ? », International Journal of Projectics, N°0, octobre 2008, De Boeck

participation of practitioners), tightly linking reflection and action, is also validated by this experience. The theories of Francisco Varela[15] about group constitution and cultural change in a group considering the building of interpersonal interfaces (individual – group) is also very interesting in order to understand how practice may change collective attitudes. Finally, the Palo Alto approach (mainly Gregory Bateson) was also extremely useful as we have underlined it above.

Innovation must be understood as a struggle between ambitions of change and resistances related to current practices, cognitive representations, existing management systems and power systems[16]. The management of complex projects related to socio-cognitive and behavioural transformations must be invented, considering particularly the “agile” philosophy[17] as a source of inspiration. In this experience, we have begun with an embryo of change. Top management must understand that from this first step, management systems and persons and teams evaluation systems also must be changed. The core question is about generating trust and commitment. The first priority to go ahead and to be able to develop a community of destiny (to our mind more than a community of practice), of which we have defined the first brick, is to develop trust in order to enlarge this basis and to trigger the first nucleus of the community, basis of new attitudes and behaviour.

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# The role of Technology Centres in the innovation process

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**Abstract:** The paper first introduces Technology Centres as key players providing intensive knowledge services and as a core component of Innovation System. Technology Centres are one such institution; dedicated to the production, dissemination and application of scientific and technological knowledge in any area of science and technology, with a multi-sector approach. They play roles in creating and marketing new products, processes and services, enabling collaboration between companies, and offering intensive knowledge services.

The aim of this paper is to analyse the innovation process of the Technology Centres according to Innovation Theory, Absorption capacity and stakeholders learning processes, in order to clarify the functions they are designed to play in the Basque Innovation System, and clear up critical routines to encourage innovation process.

**Keywords:** Technology Centre; Innovation System; Innovation model; Absorptive capacity; Knowledge base.

## I. Introduction

The goal of this research is to develop a framework to analysis the governance of knowledge processes driven by Technology centres, in an Innovation System, to ensure an effective knowledge management and an innovative performance. The proposed model integrates three components: (a) absorption capacity, (b) innovation and (c) learning processes. It proposes an framework linked to the interaction of these three concepts to explain the dynamics of innovation in Technology Centres.

## II. Technology Centres in the Basque Country

The overall infrastructure to support innovation is composed of entities whose mission is to provide services to foster and support companies in the innovation process. Technology Centres are one such institution; dedicated to the production, dissemination and application of scientific and technological knowledge in any area of science and technology, with a multi-sector approach. They play roles in creating and marketing new products, processes and services, enabling collaboration between companies, and offering intensive knowledge services.

One of the most comprehensive definitions of what Technology Centre is offered by Santamaría (2003): “Technology centres aim is to connect the long-term research in universities and public research centres with the most immediate needs of companies. Its role should be to create usable technologies from recent scientific advances and transfer efficiently to the companies so that they can innovate in their products/ processes. And all this must be done by providing assurance of the apropriability of the results, becoming a good connector between science and the market”

Nowadays Technology Centres are facing two challenges:  On the one hand, the linear model of basic research leading to applied research, and followed by market application, is no longer a realistic model. Research and product development have become an open activity with several interconnected stakeholders. And, on the other hand, there is a growing pressure on the research community to demonstrate that investments in research generate benefits for the sponsoring community.

The main questions this investigation is facing are: (a) what strategic frameworks are necessary to support effective knowledge transfer processes between science and industry environment? And, (b) how can knowledge and technology transfer activities run most effectively?

## III. Technology Centres innovation processes governance models

To answer this question would be necessary to analyze how Technology Centres access to external knowledge, how they learn both from academic and industry environment; and how this new knowledge is transmitted to the industry, where the latter fact, will be determined by the absorption capacity of the company. Therefore, the analysis of the absorptive capacity will allow us to identify the most suitable knowledge management in Technology Centres.

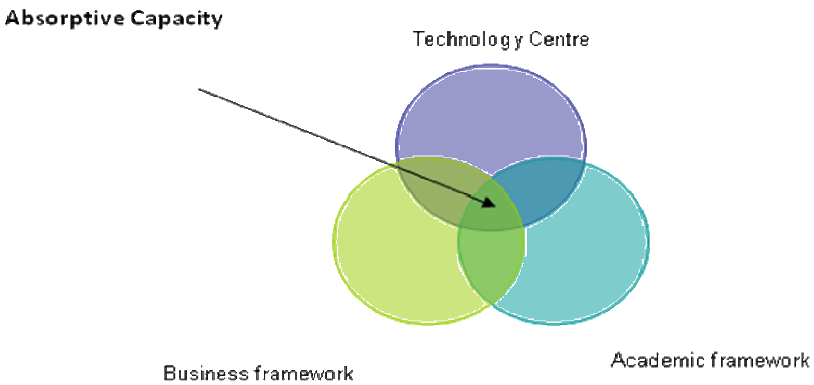


Figure 1. Technology Centre's learning processes

Absorptive capacity refers to a firm's ability to identify, assimilate and exploit knowledge from external sources (Cohen & Levinthal, 1990). There is a recursive relationship between the absorptive capacity and innovation processes, as the absorptive capacity helps the speed, frequency and magnitude of new and improved knowledge and that critical knowledge becomes part of the firm's absorptive capacity and contributes to the innovation development (Kim & Kogut, 1996).

Absorptive capacity models are built on the basis that internal and external sources of knowledge are complementary. They have to be combined to improve the innovative performance of companies. First, companies require internal R&D capabilities to recognize and monitor interesting technologies that are developed elsewhere. Second, internal research capabilities are indispensable to effectively exploit external know-how. External knowledge can only be recognized; accessed and assimilated when firms develop new routines and change their organizational structure and culture to facilitate open innovation processes (Dalander and Gann, 2007).

Cohen and Levinthal (1989) were the first identifying the term absorption capacity and to offer a three-dimensional model composed of identification, assimilation and exploitation of knowledge. Next table shows the results of the literature review to identify key dimensions of absorptive capacity and offer a reconceptualization of this construct.

| Dimensions | Identification | Assimilation | Transformation | Exploitation |
|---|---|---|---|---|
| Cohen and Levinthal (1989, 1990) | Recognize and evaluate new knowledge that is critical, and external | Assimilate external new knowledge | | Exploit new knowledge |
| Lane and Lubatkin (1998) | Recognize and evaluate new knowledge that is critical, and external | Assimilate external new knowledge | | Exploit and commercialize new knowledge |
| Zahra and George (2002) | Identify and acquire new knowledge | Routines and processes that allow companies to analyze, process, interpret and understand the information | Ability to develop and refine the routines that allow to combine existing and new knowledge | Ability to expand and create new knowledge through the incorporation of new knowledge |
| Lane et al. (2006) | It is a process determined by internal and external elements | It is a process that allow companies to internalize new knowledge | | The results of the absorption capacity must be measured by both the business result and the generation of new knowledge. |

Table 1. Technology Centre's learning processes. Source: Own elaboration

On these considerations, and from the undertaken literature review, we can conclude that absorptive capacity is composed of four dimensions: identification, assimilation, transformation and exploitation of the knowledge. In this research, we consider appropriate to include the transformation capacity separately from assimilation capacity, since each of these capabilities are based on different kinds of processes within the organization.

Furthermore, we identify the determinants of the Dimensions of the Absorptive Capacity.

a. Identification

The dimension of the identification refers to a company's ability to locate, evaluate and acquire knowledge that is critical to the category of activities of the company from external sources. The strategic nature of knowledge, characterised by its tacit and complex nature, is used as input in the learning process, and in the process of innovation, which implies a greater effort in the identification and acquisition dimension.

There are critical routines that contribute positively to the identification dimension of the absorptive capacity.

<u>Competitive Intelligence</u>: Competitive Intelligence is the action of gathering, analyzing, and applying information about products, domain constituents, customers, and competitors for the short term and long term planning needs of an organization. Consequently, we propose that "the availability of competitive intelligence systems in the organization contributes to the development of the identification dimension of the absorption capacity".

<u>Strategic Planning</u>: Strategic planning is an organization's process of defining its strategy, or direction, and making decisions on allocating its resources to pursue this strategy, including its capital and people. Consequently, when all the members of an organization share a common vision of what they want to achieve, how they can achieve and what is the information they are looking for, this common view fed the absorptive capacity and the objectives of the organization as a reflection on the strategy of it.

<u>Monitoring and evaluations Systems</u>: Evaluation is systematic determination of merit, worth, and significance of something or someone using criteria against a set of standards. In this research,

we propose that monitoring and evaluation systems are part of the learning ability of an organization as far as they provide useful information that allows the evaluation of the existing knowledge in the environment and the identification of new needs of knowledge.

b. Assimilation

The stage of assimilation of knowledge refers to those routines and processes that allow the company to analyze, process, interpret and understand the information obtained from external sources (Szulanski, 2000). If the organization achieves internalize and assimilate the critical knowledge from outside, will be able to implement, refine and therefore, to develop incremental innovations.

Knowledge Base and learning modes: In terms of the academic literature on learning and knowledge, the innovation process of firms depends on their specific knowledge base (Asheim, 1997). These different knowledge bases indicate different codification possibilities, required organizational structures and specific innovation challenges. Related to knowledge bases there are learning modes: STI mode learning and DUI learning mode. Learning STI is based on the codification and development of codes and general objectives, while the DUI learning tends to develop on the basis of implicit knowledge and local codes.

Empirical research conducted by Jensen, Johnson, Lorenz and Lundvall (2004) have show that organizations can benefit from using both types of learning, so that the organizations that employ learning STI so intense, the innovative results of organizations also depends on the learning mode DUI. Therefore, to promote a STI learning mode will be necessary to develop the use of formal information systems, while learning DUI learning mode needs to strengthen interpersonal relationships.

Knowledge conversion process: Nonaka and Takeuchi (1995) suggest that knowledge can not be managed in conventional terms, but what is possible is to promote and develop the process for creating knowledge in the organization. A Nonaka model describes a knowledge transfer model in a spiral process, based on two types of knowledge: tacit and explicit.

c. Transformation

The dimension of transformation of knowledge refers to the process to develop and refine the routines and activities that facilitate combining existing knowledge with new knowledge identified, acquired and assimilated.

d. Exploitation

The exploitation of acquired knowledge is the fourth dimension of absorptive capacity, and differentiates the absorptive capacity of knowledge management. The exploitation of the absorptive capacity focuses on the process that enables producing new knowledge and innovative developments, with the assimilated and transformed new knowledge.

## IV. Summary and future research lines

This paper presents a theoretical approach to develop a model that integrates three components: (a) absorption capacity, (b) innovation and (c) learning processes. This model aim is to analyse the actual roles that Technology Centres are assuming regarding their knowledge management activities and encouraging innovation. In future research, we will use a database from the annual questionnaire to Technology Centres, in addition to interviews and our own experience from working within the system.

Our analysis will therefore generate conclusions around the current challenges that Technology Centres are facing, and facilitate reflections on whether the functions and services that these centres are providing are desirable from a theoretical and policy perspective, and according to the Basque Innovation system.

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# Developing Standards for the IoT – A Collaborative Exercise?

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**Abstract:** The Internet of Things (IoT) has the potential to change our lives beyond recognition. Thus, this paper argues that the standardisation of the technologies that together will establish the IoT will have to be as open as possible to all stakeholders. In order to provide some recommendations on how this can be achieved the paper presents some theoretical analyses and reports on the findings of two empirical studies.

**Keywords:** Standardisation, Internet of Things, co-operation, users, SMEs

## I. Introduction

In some ways, the 'Internet of Things' (IoT) will represent a paradigm shift in communication: initially, communication occurred between living beings. With Information and Communication Technologies (ICT), this was complemented, and to some degree replaced, by communication between humans and machines (e.g., through word processing), by communication between humans enabled by machines (e.g., telephones or e-mail), and by machines communicating with each other (e.g., in B2B e-business). The next step will see communication between 'things' (e.g., the carpet with the hover, the cooker with the fridge, or the shopping cart with the till), again without any human intervention. To deploy these technologies beneficially for all stakeholders, internationally agreed standards will be a sine-qua-non.

These technologies will have an unprecedented impact on the environment within which they will have to function. The broad application of RFID technologies, and eventually the IoT, will change people's lives perhaps even more dramatically than ICT have done so far. We argue that the standards setting process will need to reflect this in some way. Against this background, this paper discusses two aspects

- ICT standardisation is a highly decentralised activity. How can the individual activities of the network of extremely heterogeneous standards setting bodies (SSBs) be co-ordinated?
- It will become essential to allow all interested stakeholders to participate in the standardisation process towards the IoT, and to voice their respective requirements and concerns. How can this be achieved?

## II. Standardisation and Innovation

Views on the nature of the relation between standardisation and innovation vary considerably. Indeed, and despite the fact that both processes have been discussed extensively, it seems that the true nature of their relation is still unclear.

Allen [1992] identified an innovation/standardisation cycle, where, after suitable experimentation, consensus is established about the (network) technology of choice. However, these cycles are distinct; standardisation is not seen as a contributor to innovation. Keeping this cycle model, Allen [2001] describes standardisation and innovation as 'Yin and Yang', "tensioned opposites containing seeds one of the other". Along similar lines, Branscomb & Kahin [1996] described the dual-faced nature of standards – they are critical to market development, but may threaten innovation and inhibit change once accepted by the market. A similar, albeit somewhat more 'optimistic' view has been discussed in [Mansell, 1995], who notes that standards- making is an important component of the innovation process. This view is corroborated by Swann [2000], who observes that standardisation enables innovation, and that it may also act as a barrier to undesirable outcomes (in the case of well-designed standards, that is). Likewise, [NSSF, 2003] reports that enterprises using standards as knowledge input are more likely to innovate than those who don't.

A rather different link between standards and innovation has been identified in [Blind et al., 1999]. They find that technical standards are also an appropriate indicator for the stock of results of research and development activities, and for the technological capability of an economy. In other words, not unlike patents standards may be used as an indicator of the ability to create innovations. These findings were re-enforced by a recent survey on the impact of ICT and e-business standards. One outcome of this survey was that standards structure markets by opening up new options for the development of innovations [No-Rest, 2006].

Along similar lines, we may observe that standards are a proven mechanism for technology transfer, fostering the diffusion and utilisation of technology [Interest, 2007]. They may, therefore, be considered the bridge between the technical domain and the economic, social and regulatory framework.

The development of new and improved standards requires high quality technical information. This creates a fundamental inter-dependency between the standardisation and research communities. Research can, and should, support the development of new and improved standards through the provision of objective technical information. Standards Setting Bodies (SSBs), in turn, need to effectively and efficiently deploy this information.

The need for a closer link from research to standardisation has also been recognised, for example, by the European Standards Organisations (ESOs):

> *"In the ICT domain, the link between R&D and standardization is of particular importance; standardization is in a position to leverage the consensus reached within an R&D project at the European and/or international level ….."* [ICT, 2005].

Figure 1 shows the relation between research and standardisation in technology transfer.

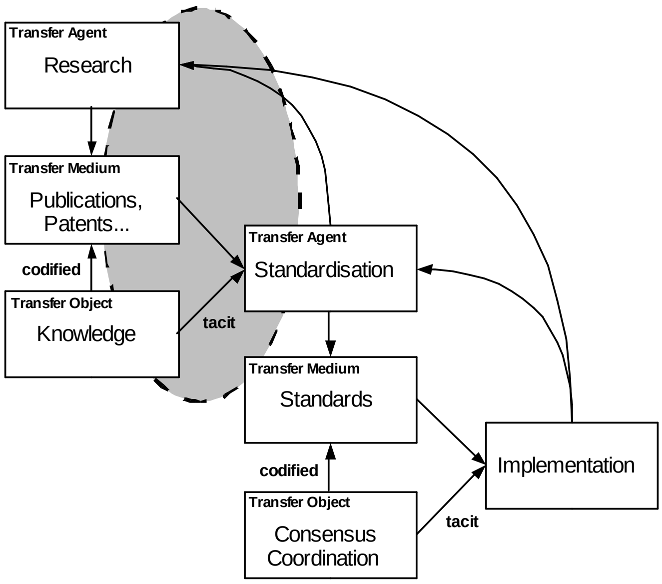


Figure 1. Research and Standardisation in a Simple Technology Transfer Model

The grey-shaded area represents the domain where the activities of R&D and standardisation meet. The figure also shows that the two representations of knowledge (i.e., codified and tacit) can be transferred from R&D to standards setting. In particular, the transfer of tacit knowledge requires involvement of researchers in standardisation.

The term 'innovation' is typically seen in a macro-economic context (as also exemplified by the above). Using a slightly broader notion of this term, Jakobs et al. [2001] compared and linked the processes of standardisation, innovation, and implementation. Both standardisation and implementation were found to be potential loci of innovations. This is largely due to the necessary co-operation between vendors and users (on whose sites the technology is to be implemented) during both processes. Along similar lines, Williams [1999] argues that only standards enable 'configurational' technologies (see, e.g., [Fleck, 1994] for a detailed discussion). The highly complex ICT systems of today are not monolithic, but created through a combination of simpler, standardised components, followed by a configuration of the overall system to meet an organisation's specific needs. This 'pick and mix' approach leads to local innovations, and would not be possible without agreed standards. That is, here as well standards are seen as an enabler of innovations.

## III. A Level Playing Field?

### 1. Background

The procedures adopted by the individual standards setting bodies suggest that the degree of control over, and influence on, the standards setting process is about equally distributed between the different stakeholders (including e.g. vendors, service providers, and users). One could, therefore, be tempted to assume that in this process interested parties meet, compile and review their needs and requirements, define the best technical approaches and mechanisms realistically feasible, and eventually come up with a standard that should survive in the market and should pretty much suit all needs. This – rather naive – situation is depicted in Figure 2.

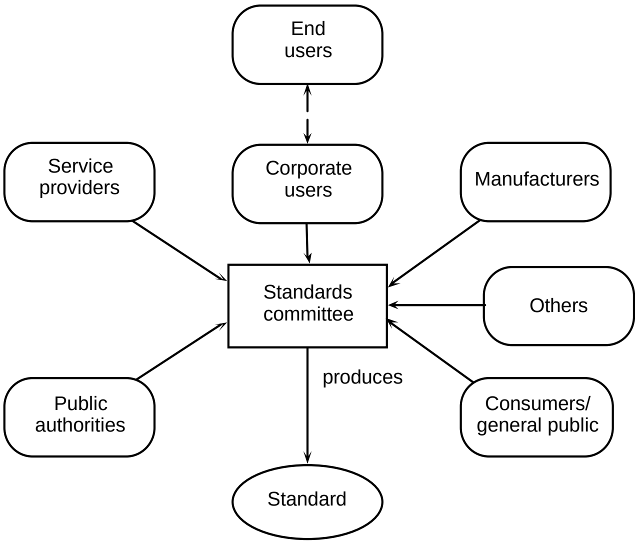


Figure 2. The naive idea of an ideal standards setting process

Unfortunately, this does not quite capture reality. Especially the assumption of an equal influence of all stakeholders appears to be flawed. In fact, it appears that so far development of IT standards has almost exclusively been technology driven; with standards produced solely reflecting providers' and implementers' priorities like, for example, manageability rather than usability. This can largely be attributed to the fact that relevant standardisation committees have typically been dominated by vendors and service providers (see also [Jakobs et al, 2009] for a more elaborate discussion). Accordingly, a more realistic model is called for.

Figure 3 depicts the actual situation more realistically. Deliberately or not, manufacturers and service providers act as a sort of 'buffer' between corporate users and standards committees. The figure also shows that some entities seem to form what you might call the 'Third Estate'[1] of standards setting. It comprises of the general public, consumer organisations and, most notably here, SME user companies. They are largely separate from the key players, with SME umbrella organisations (such as, e.g., NORMAPME in Europe) located somewhere in between. Although

[1] In pre-revolutionary France everyone that was neither clergy nor aristocracy (i.e., about 98% of the people) belonged to the Third Estate. They didn't have any say at all in state affairs. In standardization, the 'Third Estate' comprises primarily SMEs, users, and consumers.

they represent the vast majority of standard users these groups have extremely little say in the standards setting process.

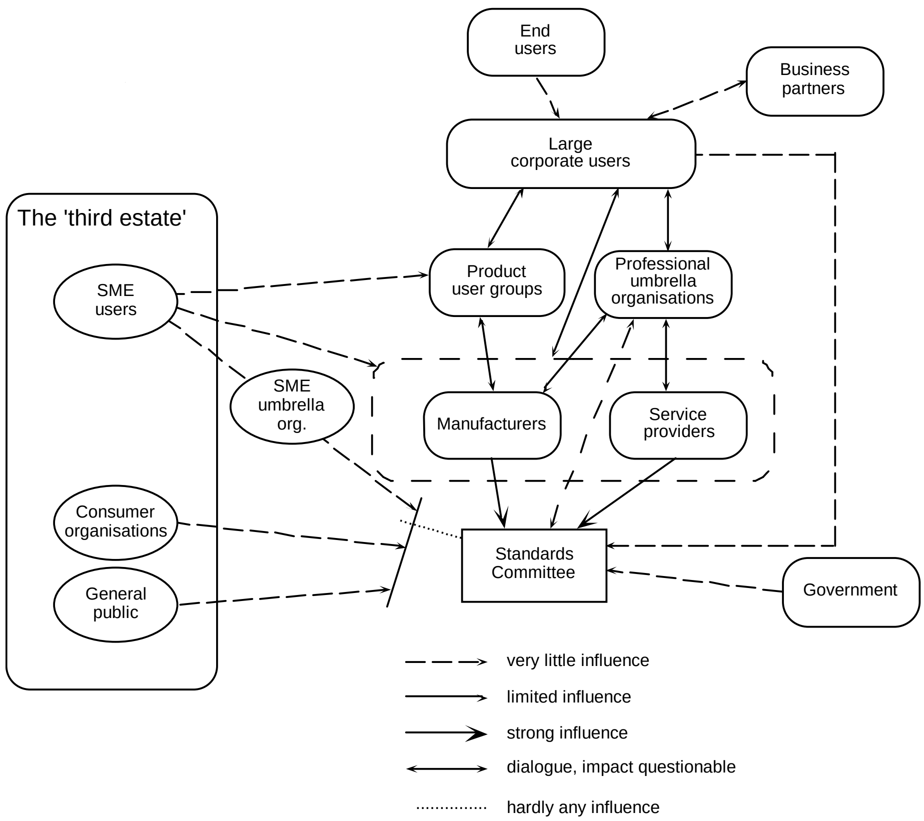


Figure 3. Relations between stakeholders in standardisation

## 2. Study Findings

Neither have all stakeholders in the standardisation of the IoT been created equal, nor do they exert an equal level of influence on the process. Specifically, members of the 'Third Estate' in standardisation rarely have the opportunity to make themselves heard. According to a recent study [Jakobs et al., 2010], large manufacturers and solution providers dominate the IoT standardisation process; participation of consumers and user SMEs seems to be negligible:

> *"Solution providers tend to be the most influential parties in ISO and ITU-T."*
>
> *"In my group, there is no participation from consumer or small user companies".*
>
> *"In RFID, [participation of consumers/SMEs] very low except through national bodies in the ISO realm".*

The case of EPCglobal, one of the major players, seems to be less straightforward as far as dominating stakeholders are concerned. A particularly long-standing standards setter (Respondent #9) states:

> *"In the case of EPC, both technology suppliers and users participate in the standards development process. … Technology suppliers have their favourite customers and together they form "blocks" of self interest and the stronger blocks tend to dominate."*

While none of the SSBs studied have erected any ‘formal’ barriers against participation of any groups of stakeholders, ‘informal‘ ones do exist, and they work. Lack of funding is the most important barrier here; lack of relevant knowledge also contributes.

> *“Smaller but perhaps technologically superior participants were forced to drop out due to the ongoing cost of participating in time and travel costs.”*

> *“Mostly the cost of participation. It is expensive to keep one or two experts full time on the standards development process. It is also very expensive to participate in working group meetings all over the world. It can cost hundreds of thousands of Euros a year to participate in a working group in a meaningful way. Part time participation does allow a participant to properly contribute to the work of the group.”*

Yet, there was wide agreement among study participants that consumers and SMEs should be represented (see Table 1).

| *SMEs* should be represented by JTC1 | | *Consumers* should be represented by JTC1 | |
|---|---|---|---|
| Yes | 9 | Yes | 12 |
| No | 3 | No | 2 |
| Don’t know | 8 | Don’t know | 6 |

Table 1. Views on desirability of SME/consumer participation in IoT standardisation

However, ‘representation’ is only a necessary condition, not a sufficient one. Those representing the ‘Third Estate’, and especially consumers, will need to gain the respect of their peers in the working groups. This is due to the fact that the technical, rhetoric and diplomatic abilities of any representative are important in order to be taken serious [Jakobs, 2009]. Likewise, taking over responsibilities (in the form of, for example, editor, WG chair, rapporteur, etc) is important.

> *“Technical: important. Rhetoric: you should be able to transfer the technical stuff in an elegant way. Diplomatic: most of the stuff was agreed over night.”*

> *“My scale for capabilities importance is: 1 – technical, 2 – rhetorical, 3 – diplomatic.”*

Unfortunately, (for the ‘Third Estate’), such capable individuals are typically to be found on the payrolls of large manufacturers and solution providers. Again, this is in line with findings of earlier studies (see, for example, [de Vries at al., 2009]).

## IV. Co-ordination in IoT Standardisation

Standards setting serves as a platform for co-operation between companies that are otherwise competitors. Yet, the increasingly complex structure of the web of SSBs suggests a considerable amount of fragmentation and overlap of standards setting activities.

Over the last decades a huge number of consortia and industry fora have entered the ICT standards setting arena. As a result, companies are today faced with an almost impenetrable web of standards setting bodies (SSBs), with complex inter-relations. Each of these bodies has its own membership, works within its own environment, and has defined its own set of rules. The resulting fragmentation of the standards-setting arena, and considerable overlap of the activities of individual SSBs, means that interoperability between standards from different sources cannot necessarily be assumed. While standardisation itself is basically a co-ordination mechanism, improving co-ordination in ICT standards setting between SSBs has become a major issue.

Such co-ordination is important for two reasons. For the SSBs, they are a co-ordination mechanism, to help ensure that no work is duplicated, and that no contradicting or potentially competing standards are being developed. For those who actively want to push a specification towards a standard, such links may offer a welcome 'detour'. For example, EPCglobal is widely considered as being largely driven by users . On the other hand, users are not normally well represented in most, if not all, other SSBs. Thus, a user company is more likely to successfully push a proposal in EPCglobal than in, for example, ISO. Utilising the link that exists from EPCglobal to ISO, they may therefore be able to influence the process within ISO by submitting their proposal via EPCglobal, as opposed to a direct contribution to the ISO process.

Figure 4 shows the major SSBs currently involved in IoT standardisation. The most important pair wise links that exist between them will then be briefly discussed.

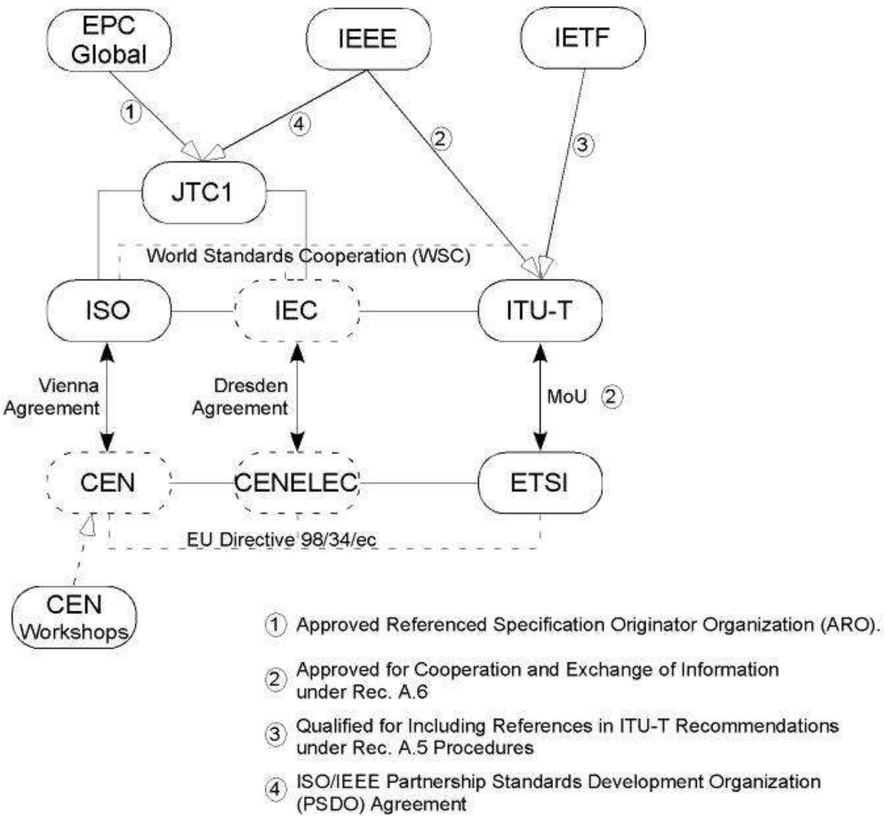


Figure 4. Links between discussed SSBs

- EPCglobal ↔ JTC1
  EPCglobal is an 'Approved Referenced Specifications Originator Organization' of JTC1. Also, they are successfully submitting some of their specifications for transposition into, or inclusion in, ISO standards. EPCglobal is open only to 'subscribers', whereas participation in JTC1 is open to all (through the respective national bodies). The former could represent a problem for some (although the subscription fee is moderate, especially for users). On the other hand, EPCglobal has a fairly obvious focus on users.

- IEEE ↔ JTC1
  IEEE and ISO have signed an 'ISO/IEEE Partnership Standards Development Organization (PSDO) Agreement'. Under the regulations laid out in this agreement, "*IEEE may propose that an existing IEEE standard, within the scope of the ISO technical committees covered in this agreement, be submitted as a final draft International Standard (FDIS)*". Both organisations highlight their 'individual participation'. That is, delegates are supposed to act in an individual capacity, as opposed to company or national representatives. Whether or not this is the case in reality is a different issue. IEEE's 'corporate programme' is based on a 'one company, one vote' principle, which probably makes it attractive for some.

- IEEE ↔ ITU-T
  This co-operation is governed by ITU-T Recommendation A.6. IEEE being 'A.6 qualified', it is possible for ITU-T to re-use (parts of) IEEE standards in their own Recommendations (and vice versa). However, thus far, this has never happened. Only ITU-T member states may vote on Recommendations. Other organisations may participate in the technical work, but without the right to vote. This is in stark contrast to both IEEE standards development programmes ('one vote per individual' or 'one company, one vote').

- ETSI ↔ ITU-T
  In addition to ETSI being 'A.6 qualified' (see above), a separate MoU defines the level of co-operation between these SSBs. The provisions of the MoU also address mutual participation of experts and exchange of policy information. The processes adopted by the two SDOs are very different. For example, ETSI's procedures favour large companies, whereas the same companies don't even have the right to vote in ITU-T.

- IETF ↔ ITU-T
  This co-operation is governed by ITU-T Recommendation A.5. This document describes the criteria a specification needs to meet in order to be included in ITU-T Recommendations as a normative reference. IETF standards may be referenced by ITU-T Recommendations. IETF's 'individualistic' approach is very different form the one adopted by ITU-T. This aspect should not be under-estimated, whether for the IETF or other SSBs; see e.g. [Jakobs, 2009].

In addition, less formal and perhaps even more important, the many individuals that are members in several relevant SSB serve as agents of co-operation. This holds specifically, albeit not exclusively, for co-operation between ISO and EPCglobal and IEEE, respectively.

## V. Conclusions

Apparently, today's standards setting processes may be considered as largely adequate overall. This holds despite a wide agreement that consumers and SME users should be represented in the process, but not necessarily are, and that the process is (inevitably) dominated by large manufacturers/solution providers.

There are, however, a number of caveats. For one, the 'Third Estate' is far from being adequately represented in the standardisation process towards the IoT. That is, (small) user companies and, particularly, consumers are hardly, if at all, represented in the standards working groups that are currently developing standards for RFID technology and applications, the likely initial core technology of the IoT. This finding is pretty much in line with those of earlier studies in the ICT sector. In this case, however, the fact that especially consumers are not (adequately) represented is a major problem, as they are likely to be even more affected by the IoT than by 'traditional' ICT systems.

Along similar lines we note that informal barriers exist that keep members of the 'Third Estate', and most notably consumer representatives, away from active participation in standards setting. The foremost obstacle is an apparent lack of resources, with respect to:

- Funding. Standards setting is a costly business; at least one full-time employee (better more) will be required for any serious participation. This is money that small companies and consumer organisations will hardly be able to get together.
- Human resources. There is an observable trend of experienced, and respected, standards setters gravitating from small(ish) companies or from the research realm towards large vendors and service providers. This further corroborates the inequality of influence in standardisation.
- Knowledge. Small companies, let alone consumers, typically only posses an inadequate knowledge about the – fairly complex – IoT/ICT standardisation environment. Likewise, little

is typically known about the importance of standards, and about the difference active participation in the process may make (in terms of, for example, expanded knowledge, competitive advantage to be gained, new markets to be identified).

## VI. Some Initial Recommendations

Some initial recommendations on how the above issues can be addressed, and how IoT standardisation can generally be made more credible (in the sense that really all stakeholders are actively involved; that also any informal barriers to such involvement are removed), might include:

- Provide funding to have small users and consumers be represented throughout the process by dedicated, knowledgeable champions.
  This representation needs to be 'dynamic', i.e., continuous throughout the process. That is, technically savvy champions are needed who adopt the users'/consumers' point of view; they don't necessarily need to actually be users/consumers. Such representation would require external funding.

- Educational initiatives targeting the Third Estate should be initiated.
  This would at least enable them to get a better understanding of the complex nuts and bolts of IoT/ICT standardisation. Such educational measures should also cover aspects like how to act in a working group, as well as rhetoric.

- Create a 'hierarchical' representation of (small) indirect stakeholders.
  We can identify a whole range of stakeholders, many of whom do not necessarily catch your eye. It would be less than practical to have them all directly represented in standards setting. Here, a more indirect approach will be needed.

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# Managing Organizational Learning in Small & Medium Enterprises in India

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**Abstract:** The importance and contribution of the Small & Medium Enterprises (SME) sector to the economic growth and prosperity of India is well established. Their role in terms of employment creation, upholding the entrepreneurial spirit and innovation has been crucial in fostering competitiveness in the economy. Government's policy initiatives in India like enactment of the new Micro, Small and Medium Enterprises Development Act, 2006 are encouraging steps towards boosting entrepreneurship, investment and growth. However, though a lot of incentives and support is provided to this sector, it is felt that SMEs pay very little focus on leveraging organizational learning. The SMEs focus on running the business on a day-to-day basis and find no time to manage the knowledge which is perceived as an 'overhead'. SMEs experience a rapid rate of change as they move through their organizational life cycles. This paper attempts to understand the perception of SMEs in India in managing knowledge in the organizational life cycle in terms of acquisition, sharing and utilization and identify a framework for managing organizational learning.

**Key Words:** small & medium enterprises, organisational learning, acquisition, sharing, utilisation.

## I. Introduction

In India, the Small and Medium Enterprises (SME) sector now includes the micro enterprises and is referred to as Micro, Small and Medium Enterprises (MSME). This sector which constitutes nearly two-third of businesses across the globe is widely accepted as the engine of economic growth. The SMEs are credited with generating the highest rates of employment and growth and account for a major share of industrial production and growth (GOI, 2006). As per the data available, the Micro, Small & Medium Enterprises (MSME) sector employs an estimated 59.7 million persons spread across 26.1 million enterprises. (4th Census of MSME Sector). The sector accounts for about 45% of the manufacturing and around 40 % of the total export of the country. The performance of the sector has a direct multiplier effect on the economy of the country (Table1).

| Country | Share of Total Establishments (in %) | Share of Output (in %) | Share of Employment (in %) | Share of Exports (in %) | Criteria for Recognition |
|---|---|---|---|---|---|
| India | 95 | 40 | 45 | 35 | Fixed assets |
| USA | 98 | n.a | 53 | n.a | Employment |
| Japan | 99 | 52 | 72 | 13 | Employment |
| Taiwan | 97 | 81 | 79 | 48 | Paid up capital assets & sales |
| Singapore | 97 | 32 | 58 | 16 | Fixed assets & employment |
| Korea | 90 | 33 | 51 | 40 | Employment |
| Malaysia | 92 | 13 | 17 | 15 | Shareholder funds & employment |
| Indonesia | 99 | 36 | 45 | 11 | Employment |

Table 1. Contribution of SMEs Across Countries

*Source: Pandey & Shiveesh. (2007). Pp.4*

The MSME sector comprises of a wide and divergent spectrum of establishments, from micro and rural enterprises to modern industrial units using sophisticated technologies. Such enterprises exist in the form of factories, workshops, trading and service organizations (Pandey & Shivesh 2007). SMEs have been defined in different ways in different countries. Most countries have adopted the benchmark of employment. Some define them in terms of assets, a few in terms of sales and yet others, in terms of shareholders fund (Pandey & Shivesh, 2007). In India, under the new MSMED Act 2006, the Government classifies industries based on the investment in plant and machinery. Though the definitions vary from country to country, they have one thing in common- the vast majority of SMEs are relatively small and over 95% of SMEs in Asia employ less than 100 people.

The contribution of the sector in India is 7 per cent of India's GDP. The performance of the sector after liberalization in terms of economic parameters such as number of units, production, employment and export has been phenomenal (Table 2).

| Year | No. Of Units ( in Million) | Production (Billion Rs at current prices) | Employment ( in Million) | Export ( in Billion Rs at current prices) |
|---|---|---|---|---|
| 1993-94 | 2.38 | 2416.48 | 13.93 | 253.07 |
| 1994-95 | 2.57 | 2998.86 | 14.65 | 290.68 |
| 1995-96 | 2.65 | 3636.56 | 15.26 | 360.74 |
| 1996-97 | 2.80 | 4118.58 | 16.00 | 392.48 |
| 1997-98 | 2.94 | 4626.41 | 16.72 | 444.42 |
| 1998-99 | 3.08 | 5206.50 | 17.15 | 489.79 |
| 1999-2000 | 3.21 | 5728.87 | 17.85 | 542.00 |
| 2000-01 | 3.37 | 6454.96 | 18.56 | 599.78 |
| 2001-02 | 3.46 | 6905.22 | 19.22 | 712.44 |
| 2002-03 | 3.67 | 8243.63 | 20.07 | 861.03 |
| 2003-04 | 3.83 | 9323.54 | 20.90 | N.A |
| 2004-05 | 4.00 | 10600.87 | 21.78 | N.A |
| 2005-06 | 4.18 | 1213.80 | 22.78 | N.A |
| 2006-07 | 4.37 | 14019.39 | 22.17 | N.A |
| 2007-08 | 4.08 | | | |

Table 2. Performance of SMEs in India: 1993- 2007

*Source: GOI, ministry of MSME (2009). Annual Report (2008-09), pp. 10-11*

## II. Characteristics of a SME

To understand the perception of the SMEs in managing organizational learning it is important to look at the characteristics of SMEs in general. Pandey & Shivesh (2007) have characterised SMEs in India as organisations which have

- Started out of individual initiatives and skill;
- Greater operational flexibility;
- Low cost of production;
- High propensity to adapt technology;
- High capacity to innovate and export;
- High employment orientation;
- Utilize locally available human and material resources and
- Helps in reduction regional imbalances.

SMEs generally focus on running the business on a day-to-day basis and find no time to harness experiential knowledge. Formal management of organizational learning is therefore not a common terminology that one uses in SMEs and is perceived by the sector as an 'overhead'. The reasons for the same have been attributed to several factors in the study by Kumta (2008) as listed below:

- Focus is on running the organization on a daily basis and therefore finds little time to analyse it and retain learning. Their focus is on 'getting the job done' now.

- The sector already has a large enough informal network to enable people to get the job done. It is generally felt management of organizational learning is required only when there are a large number of employees.
- Planning for risk of separation of the key employees is not perceived as a big threat due to the informal network and the embedding of knowledge in the products and services.

Knowledge management has received increased attention, recognition and importance in the business world. Research on knowledge management (Toffler, 1990; Nonaka, 1991; Barney, 1991; Barlett & Ghosal, 1993; Drucker, 1993; Stewart, 1997; Pillania, 2008a) has shown that it has emerged as the most important strategic resource for organizations. The need for knowledge management is critical for the SME sector (Pillania, 2006 b; Martin, Martin & Mabbett, 2002). The SMEs in India are also trying to identify the most important knowledge and are trying to leverage it (Pillania, 2007a). However, the study by Pillania (2008) on the SMEs of automotive components reveals that Indian and international automotive components manufacturers pay little credence to the knowledge available through government institutions and industry associations.
The SMEs have unique characteristics that impact how they strategically manage knowledge. The sector experiences a rapid rate of change as they move through their organizational life cycles. Each stage in the life cycle requires a different approach and emphasis on managing knowledge (Kumta, 2008).

## III. Methodology

The study adopted a survey research method for the research design. The sample consisted of 41 SMEs in the service, trading and manufacturing sector located in various industrial zones in Mumbai, Maharashtra. The data was collected using a questionnaire comprising of both, closed and open-ended questions which was specifically designed for the study. To substantiate the quantitative data, the researchers also collected qualitative data through various discussion forums organised for the purpose of the study.

## IV. Findings and Analysis

The data with regard to the type of organization reveals that 56% of the SMEs are in the manufacturing sector followed by the service sector (26%).Venturing into the manufacturing sector can be attributed to trade liberalization and structural reforms brought about by the government to promote SMEs. Fifty one percent of the SMEs in the study were more than 15 years old and about 46% of them employed less than 500 people.
The data also reveals that SMEs had functional departments similar to any professionally managed organizations but did not have specific support functions like IT or Knowledge Management. This can be attributed to the SME characteristic where knowledge generated is immediately put into practice, rather than being stored in an electronic repository.

### 4.1 Organizational Information Sharing

SMEs have unique characteristics that impact how they strategically share and manage knowledge as they move through their organizational life cycles. Each life cycle requires a different approach and emphasis on managing information sharing. Research has shown that (Kogut & Zander, 1992; Nelson & Winter, 1982; Calvert & March, 1963) organizational learning is built on the current information and ways of doing things.
The study shows that 51 per cent of the SMEs feel that sharing of information within the organization is important for achieving the organizational goals. Respondents indicated that information sharing within the organization is necessary for transparency and creating an environment for growth. The other reasons for information sharing are depicted in Figure 1.

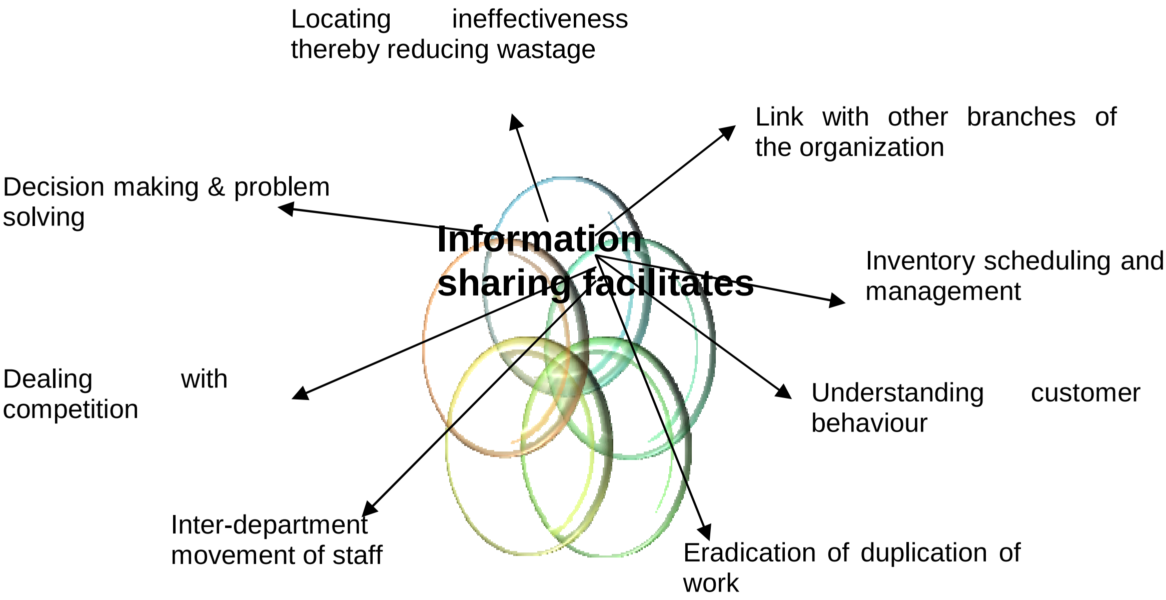


Figure 1. Importance of Information Sharing among SMBs

Around 5 per cent of the respondents feel that information sharing is not important for achieving organizational goals. The respondents feel that secrecy is important to sustain the business and handle competition.

### 4.2 Retention & Management of Organizational Learning

SMEs need to use knowledge at two levels, (a) in day-to-day operations; and (b) at strategic level to define organizational goals. According to Kumta (2008) SMEs in order to grow to the next stage of the life cycle need to broaden their customer base, add new products/services, penetrate the domestic market and strive for overseas expansion. All these will require retention and management of organizational learning (Figure 2).

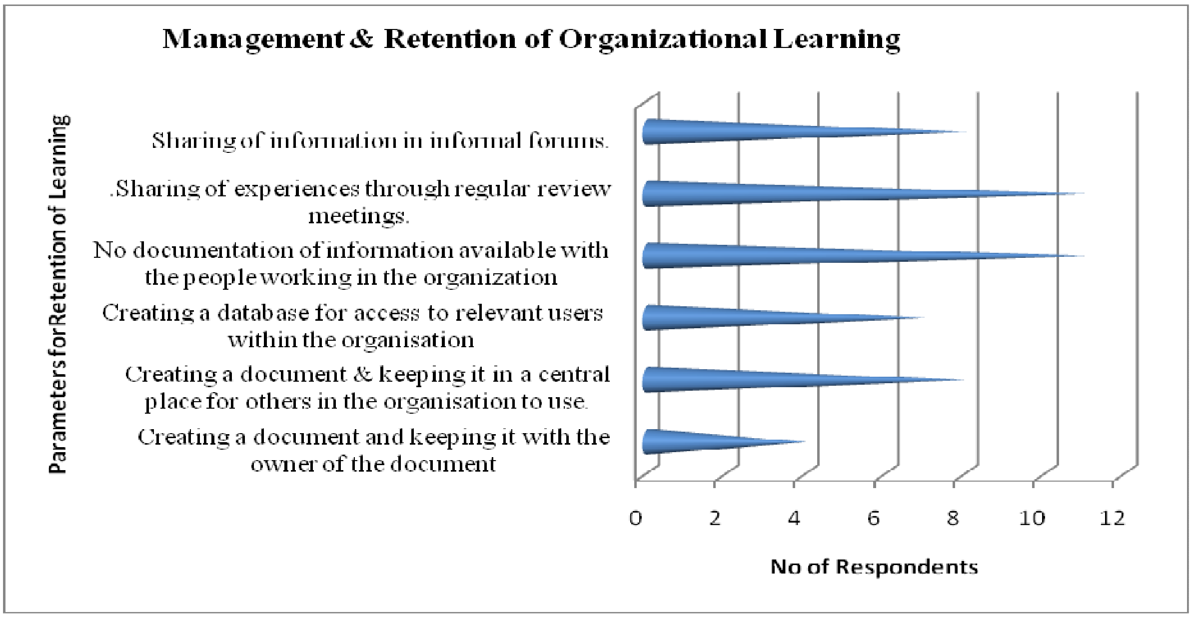


Figure 2. Management & Retention of Organizational Learning

The data shows that innovative practices in knowledge management have not made in roads into SMEs in India. The reasons for the same can be attributed to high cost of technology and lack of qualified manpower. The data in Figure 2 shows that around 27 per cent of the SMEs have knowledge management practices of sharing experiences through regular review meetings. Twenty per cent of the SMEs create documents for use which is kept at a central place for others to use in the organization while 27 per cent of the SMEs felt that this was not necessary. According to Awazu and De' Souza (2004) SMEs had a deliberate mechanism in place to prevent knowledge loss from becoming a problem. Knowledge in SMEs is normally created, shared, transferred, and applied through people based approaches such as face-to-face meetings, mentoring, observations, apprenticeship, etc.

### 4.3 Government Interventions in India

As the SMEs do not have adequate skills and resources, they require Government intervention to support them in order to acquire external knowledge. The new MSMED Act 2006 in India can do more by providing SMEs with a powerful tool of providing regional information, data and value-added knowledge in order to leverage external knowledge. It is a wonderful opportunity to create a region-wise database of micro, small and medium enterprises which can be used for analysis, environmental details and sharing of best practices.

Most MSMEs suffer from sub-optimal scale of operations, technological obsolescence, supply chain inefficiencies and/or fund shortages. MSMEs need professional expertise in several areas (http://www.msmementor.in/). It is, however, very difficult for them to find professionals easily; horizon being limited to personal contacts or through word-of-mouth.

Small Industries Development Bank of India (SIDBI), India's premier institution for the development of the MSME sector and NSE- India's largest stock exchange have therefore launched a portal which is aimed at utilizing the vast idle professionals' national skills resource for a useful purpose. It is an online platform, for professionals to submit their profiles in a simple format and for MSMEs to identify and reach experts they need, through a refined search mechanism. SIDBI, with its nationwide network and relationships with a very large number of MSMEs will be actively involved in ensuring that the MSMEs, all over India, access and utilize this vital resource.

## V. A framework for managing organizational learning.

Organizational knowledge can be defined as all the tacit and explicit knowledge that individuals possess about products, processes and services. This includes explicit knowledge codified in manuals, databases and information systems as well as tacit knowledge that is shared collectively in the form of routines, culture and know-how (Nahapiet & Ghoshal, 1998; Grant, 1996; Nonaka & Takeuchi, 1995).

In most SMEs, the potential of the ideas that the founders have in their heads are the most valuable assets they possess. The entrepreneurial perspective suggests that we examine the processes that lead to the discovery, evaluation and exploitation of entrepreneurial opportunities. According to Jack Welch Chairman, General Electric, an organisation's ability to learn and transfer that learning into action rapidly is the ultimate competitive advantage.

KM is therefore about people learning faster, deeper, continuously, collaborating and being creative all the time. Knowledge Management should therefore provide the capability to apply the learning for the benefit of the organization. It therefore involves two important aspects of connection and collaboration. .

- **Connection:** *People to 'actionable' information ------- People to business*
- **Collaboration:** *People to people -------- People to communities*

The Knowledge Management Framework can therefore be described as follows:

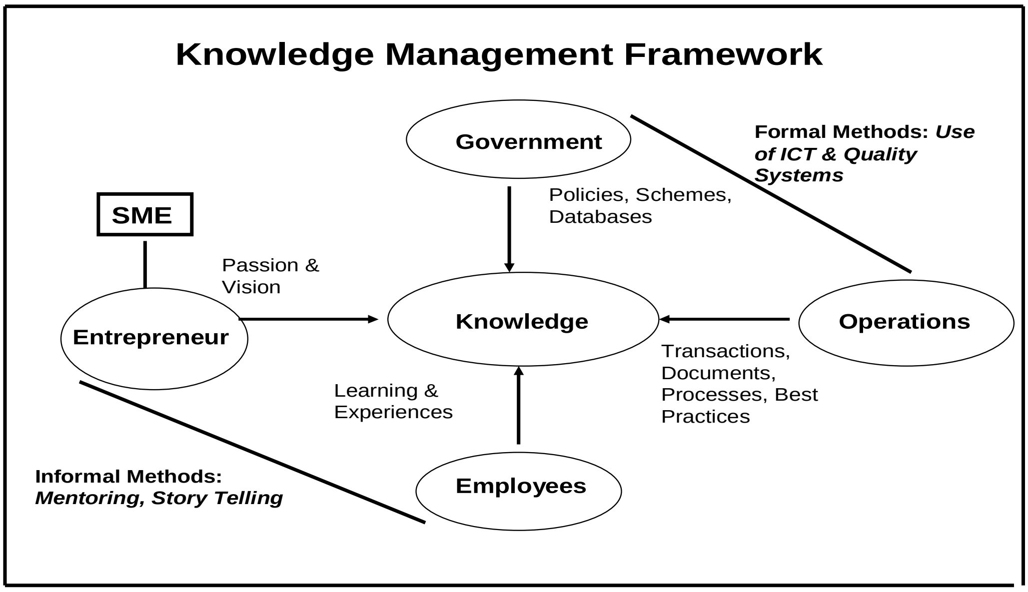


Figure 3. Knowledge Management Framework

## VI. Conclusion

A very critical phenomenon in today's competitive environment is innovation and management of changing strategies. The SME sector, which is an important contributor to the economic growth and prosperity of India has significant growth potential but has tremendous inherent risks. They are faced with challenges to remain competitive in a highly dynamic environment, manage attrition as they are unable to compete with the larger organisations in terms of compensation and retain organisational knowledge which is not captured.,

A knowledge management strategy that helps solve business issues, accelerate innovation to cash on opportunities and improve customer service is very essential for SMEs. Though a lot of incentives and support is provided to this sector, it is felt that SMEs pay very little attention to leveraging organizational learning as the emphasis is on executing certain regular orders and find no time to consolidate their position though they are aware that actionable information is most essential.

Knowledge management is a continuous process, which should be sustained through a suitable set-up to coordinate, control and renew knowledge. It is therefore necessary to create an environment for generating, using and sharing knowledge as part of the work flows and also embed it in the products and services. Knowledge Management is more a people issue than a technology solution and has to be built around the way people work. Sharing knowledge requires a different kind of environment – a unique combination of human and information systems to reduce the 'knowing–doing' gap. It is a movement from a 'knowledge hoarding' mind set to a 'knowledge sharing' culture.

Knowledge sharing requires a mind set which appreciates that knowledge does not belong to an individual; it belongs to communities. It moves from one generation to the next through professional communities and new knowledge gets created at the boundary of the existing knowledge. (McDermott, 1999). A successful knowledge management project must begin with the existing knowledge, deliver initial results and then continue to expand.

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# Multi-Project Management: a way of managing today's Innovation

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**Abstract:** In this paper, we suggest Multi-Project Management, MPM, is a way of dealing with some new challenges in innovation today: multiplicity of varied innovation projects, open innovation, sustainable development and increase of external financings. The reflection is based on both conceptual and empirical research works we did last years. We will particularly present the results of a research that we conducted inside an aeronautical firm located in south west of France: Liebherr Aerospace Toulouse (LTS).

**Keywords**: Innovation Management, Multi-Project Management, Open innovation, Cooperative projects, Sustainable development.

## I. Introduction: New challenges in today's Innovation management

There is a consensus about strategic importance of innovation for firms, and, consequently, for nation growth. Innovation is viewed as a way of anticipating, of avoiding technical obsolescence of products and services, of competing more efficiently. It also permits to modify the firm's strategic area by internationalisation and relied diversification. It is a mean to differentiate products and services in response to more and more differentiated customers and clients needs.

For this reason, firms must continuously innovate and not punctually as before. Innovation projects management has been becoming a recurrent activity of firms. We define an innovation project as a "project aiming to develop new offers (product, service), processes, or technologies. An innovation project can also aim to improve existing offers, processes or technologies (Fernez-Walch, Romon, 2008)".

At the end of the 1980's and at the beginning of the 1990's, a lot of firms belonging to different industries implemented project management to manage innovation projects. Project management tools and principle (project team, project manager, etc.) were applied to develop new products and new processes.

During the 1990's, firms had to deal with a new challenge: a significant increase of the number and of the diversity of innovation projects. Firms could not only to manage each project taken separately; they had to take into account a lot of projects together. Innovation projects differ by their objectives, the business market they target and the results they provide. They also differ by the strategic importance they present for the firm, their level of risk and their deadline. For example, risked breakthrough technological projects, aiming to create a new market for the firm, compete with small product development projects launched to animate existing markets. At the same time, those projects can be interdependent. They compete for resource allocation: financial resources, skilled people and components. They also share the same knowledge or technologies. Before the 2000's, innovation projects were usually conducted inside the firm. But since a couple of years, the innovation context has been changing.

- Open innovation has been becoming a dominant paradigm in a lot of industries (Chesbrough, 2003).

- Since some years, the part of external funding, which can be private or public such as venture capital, research tax credit, European research programs, has been becoming more and more significant. Firms have to ask for external funding if they want to finance all innovation projects they want to launch. To obtain external funding, they must prove that they are able to take into account their environment and have to belong to networks, clusters, etc.
Therefore, we have noticed that the number of cooperative projects has been increasing significantly. Those cooperative projects gather varied types of participants: firms belonging to different strategic business units, competitors, customers and suppliers, public research public organisms, etc. There are a lot of differences between the participants: size, capital or legal status of the organization, corporate culture, nationality. Moreover, participants having an economic based culture have to negotiate with some other participants having a more scientific oriented background.

- Another issue is sustainable development. Innovation Managers have more and more to take into account, such as new standards and regulation, as well as social factors. It constraints the product and process design and the choice of the innovation projects to launch. Not only do they have to successfully reduce the lead-time to launch new products, but also they have to meet the users' demand for long-term performance.

In this context, new management strategic and operational problems appear, which are, for the moment, not solved: what kind of governance inside a project? How to define appropriate information systems to manage virtual project teams belonging to different organisms and firms? How to choose the appropriate project managers? How to manage knowledge, which is created inside a project? How to coordinate various interdependent projects according to the firm strategy? Usual management of innovation by projects is no longer effective. Firms can no more manage Innovation by the same manner as in the nineties. They have to find new ways of managing Innovation. We define innovation management as following: "actions and decisions made by a firm to make emerge and manage new innovation projects (Fernez-Walch et Romon, 2008).

We suggest that Multi-Project Management, MPM, could be an appropriate way of dealing with the new challenges of the innovation. According to Fernez-Walch and Triomphe (2004a), MPM is a global way to manage a set of projects, accounting for interdependences between the projects of the set.

Consequently, this paper aims to explain how MPM can be used to the take up the new challenges of Innovation: multiplicity of various innovation projects, open innovation, sustainable development and increase of external financings. The reflection is based on both conceptual and empirical research works we made last years. We will particularly present the operational results of a research we have conducted inside an aeronautical firm of south west of France and belonging to a family capital German group: Liebherr Aerospace Toulouse (LTS). It consisted in implementing innovation projects portfolios but differently of usually projects portfolio management.

In the second part of this paper, we will explain research methodology and theoretical background of MPM. In the third part of this paper, we will show the particularities of LTS MPM. In the last part, we will propose some ideas about the way of using this out of ordinary type of MPM to take up the new challenges of today's Innovation. We will explain this idea in light of the results of a qualitative research that we conducted inside Liebherr Aerospace Toulouse.

## II. A significant multi-project management implementation: Liebherr Aerospace Toulouse (LTS)

### 1. Research methodology

When the research began, Liebherr-Aerospace Toulouse SAS (LTS) was one of Europe's leading manufacturers of air systems for aircrafts. It supplied air management, flight control and actuation systems, hydraulic systems and landing gears for customers such as Bombardier, Airbus, etc. The systems were on board many civil and military aircraft programs: commercial transport aircraft, commuter and regional aircraft, business jets, fighters, military transport and trainer aircrafts as well as civil and combat helicopters. It was the third largest business in its industry. This company employed no less than 800 people, the vast majority of them having a very high level of technical know how.
The goal of the research program was to design an appropriate model of Projects Portfolio Management. This Projects Portfolio Management had to be consistent with both the Innovation and R&D Strategy of the firm and with the management of the projects taken separately.
For three years, the researcher led a group composed of the R&D manager, the technological development manager and the marketing manager. This group developed a specific model of project portfolios management. It created innovation projects portfolios according to the firm's strategy. It formalized new organizational processes of multi-project management. It provided a global organisational approach of multi-project management, linking innovation strategic management and operational project management, for the convenience of the firm.

## 2. Theoretical background about MPM

Fernez-Walch and Triomphe (2004a) proposed one typology of MPM practices. This typology was used by Midler and Silberzahn (2008), as a theoretical framework to "explore the question of managing start-up development in a high-tech context, through multi-project learning".
They identified three MPM approaches: portfolio approach, platform approach and lineage approach.

- The portfolio approach aims to handle projects sets, called projects portfolios, by optimizing the process of resource allocation to the portfolio, taking into consideration constraints of delay, quality and cost. The projects portfolios management was implemented in firms in the 1980's. According to some authors, (Maïer et al, 1994, Cooper et al, 1998), Projects Portfolio management refers to instrumental solutions, particularly under constrains optimisation methods to manage one unique projects portfolio. The term "portfolio" came from the financial world (as in a portfolio of stocks and shares). All the projects inside a portfolio competed to obtain resources. The goal was to increase the efficiency of innovation processes by improving projects selection and arbitration mechanisms inside a portfolio. One tried to maximise one aspect (for example, profits) with the constraint of resources (financial, human resources). This attempted to define, for each project, attributes that were used as indicators to compare the different projects belonging to a same portfolio. Only the "best" projects were selected or prioritised, the others were dropped or given up.

During the 1990's the increase in the number of projects and the limited research and development budgets obligated companies to rationalise their portfolio. Models of portfolios were created so that managers could discuss and make pertinent decisions in terms of ranking projects, allocating resources and developing long-term strategies. Bonhomme and Midler (1999) put forward the porous funnel model, which is an "open" portfolio allowing for the sale of projects. The managers gathered the projects of the same nature inside one portfolio. They created either Information Technology portfolios, R&D projects portfolios or new product development projects portfolios.

More recently, Cooper et al (1998) proposed to create portfolios by gathering new product development projects dedicated to a specific business unit. Fernez-Walch (2004) argued that firms build not one portfolio or one portfolio per business unit, but various portfolios using criteria, which are defined according the strategic goals of the firm. For example, Fernez-Walch proposed that to prevent firms from choosing short term profitability over long term profitability, they must create two portfolios: one portfolio of technological development projects and one portfolio of new product and process development projects. Firms can decide what amount to dedicate to each portfolio according to it strategic objectives. Consequently development projects and technological projects do not compete anymore.

- The platform approach consists of the management of a family of projects. The projects of a same family aim to conceive and realize products, which can share common components, sub-systems and systems.
Platforms management has been studied by Meyer and Lehnerd (1997). Meyer and Lehnerd describe such practices in firms such as Toyota and Hewlett Packard. The idea is to imagine common components that are used in differentiated products, which are designated to the customers of various kinds of market units. The common component can be a simple product, a sub system or a complex system. This complex system is called platform, referring to production platforms. The goal is to increase the efficiency of the product development by standardizing one part of the product. This part is not noticeable for the customer. At the same time, one other part of the product is differentiated in response to customer needs. Consequently, the firm has to manage sets of projects that we call a “projects family”. Inside a family, there are different kinds of projects (Fernez-Walch and Triomphe, 2004b, Clark et Wheelwright, 1995):

- Projects aiming to create a platform; those projects use the technologies developed in technological breakthrough projects of the firm;
- Projects aiming to improve the platform;
- Projects aiming to develop common components and sub-systems of several products;
- Projects aiming to develop new products; those projects are launched when new customers needs emerge; they use the platform and other common components.

- The trajectory approach aims to manage families of projects that are launched constantly to conceive and launch new products that share the same knowledge and technologies. The knowledge and technologies that are created and used inside a project will be used, in the future, to launch new projects according to the strategy of the firm.
Two types of publications have emphasized the third approach of MPM. Researchers working about the new product development emphasized product family management with strategic tools like roadmapping. French researchers emphasized trajectories management. Ben Mahmoud-Jouini (2004) defined an innovation trajectory as “a set of new product development projects which are coordinated according to the knowledge they use or they create”.
She distinguished two types of trajectories: improving trajectory and what she called “pivot of diversification”. The projects of an improving trajectory use and create knowledge of the same type: market knowledge or technical knowledge. To explain what is a pivot of diversification, Ben Mahmoud-Ben Mahmoud-Jouini reused the example of Chapel (1997) that took place in a firm of home appliances. This firm used one technology (stamping and teflon) to focus on the market unit of the housewives. It used that knowledge about this market to develop new offers that satisfy others customers needs. It developed for example a frying pan including a cooking scale, acquiring technologies like electronic, electromagnetism. Those new technologies, when they were well known, allowed to develop others offers on a new market unit: nursery. In this way, the firm could introduce the knowledge of a project into other projects, and consequently made a profit on the investments.

The trajectory approach aims to capitalize and share knowledge between a lot of projects that are launched in a flow. This flow is determined by a strategic logic linked to the markets, the technologies and the know how of the firm: “the strategic advantage is based on trajectories that introduce breakdown of the identity of products, markets and technologies “(Lenfle et Midler, 2003).

According to Fernez-Walch and Triomphe (2004), the three approaches, apparently different, in fact belong to the same category of management practice: MPM. MPM differs from the management of a big project (often called program). A program is composed of several sub-projects. The sub-projects can’t exist without each other. They are a part of the same whole. The objective of the program is decomposed in sub-objectives. Even if sub-projects are executed by distinct people or firms, they have to be integrated at the end of the programme. On the opposite, with MPM, the projects of a set exist, or could exist, independently.

MPM is distinctly different from management by projects, a concept that emerged since the beginning of the 1990s. Management by projects, as MPM, is an organizational response to the evolutions of an environment that is increasingly complex and troublesome: dynamics of work, evolution of macro-environments, changing values (decentralization, participation), technological developments, network cooperation, etc. This situation demands to manage, not only the projects separately, but also the environment of the projects. This means implementing tools and organizational solutions (cross organization) to make the projects more efficient. But the risks associated with management by projects are important: interdependencies of the projects were not taken into account; people that proposed to implement management by projects tended to believe that all the activities of a firm (recurrent and non recurrent processes) must only be managed with project methodology, project teams, and so one…

In the 1990's, some authors have shown it is better to reserve project management to non recurrent activities and that it is necessary to combine the functional and the project dimension. Today, matrix organizations are implemented even in SSII which have be created on the project dimension basis. Contrary to management by projects, MPM proposes tools, methods to manage a new unit: a set of interdependent projects, taking into account the firm organization system. It is based on the idea of managing the interdependencies between projects not on a case by case basis but globally.

## III. Empirical research results: LTS MPM as a new way of managing projects portfolios

In former research works, we had proposed a new way of managing projects portfolios. The projects portfolios management doesn't only aim to maximise one aspect (for example, return on investment or lead-time to market) with the constraint of resources (financial, human resources), it also aims to manage the portfolio itself as a whole (Fernez-Walch et al, 2006). We have shown that firms build not one portfolio nor one portfolio per business unit, but various portfolios using criteria, which are defined according the strategic goals of the firm (Fernez-Walch and al. 2003, 2006). We also explored two other innovation projects approaches such as the lineage approach and the platform approach, based on the reuse of knowledge in others projects, which has been created inside a previous project (Fernez-Walch & Triomphe, 2004a).

We tested those ideas in LTS. The multi-project management we implemented is out of the ordinary for the two following reasons. It is a project-portfolios approach but:
- There are several portfolios, not a single portfolio. The criteria being used to identify the portfolios was not the business unit criteria (Cooper et al, 1998). In effect, five projects portfolios have been identified, by using strategic criteria, which had never been described in previous research works.
- It takes into account the knowledge sharing, which represents the main background of the lineage approach and the platform approach.

### 1. Organizing the process innovation according to strategic criteria

At the beginning of the research, new product development projects were essentially conducted in the R&D department. There were two projects portfolios. The first portfolio gathered new product and new process projects in response to the customers needs (market pull). The second portfolio gathered applied research projects. The projects of both portfolios competed for resources and the researchers of the firm were often asked to hold "market pull" projects back. The applied research portfolio was not managed as a whole.

- Thanks to the first criterion, varied, skilled people will be gathered at all the stages of the innovation process. It also gave more importance to the proposals in regard to product development projects.

- The second criterion was chosen according to the research work of Fernez-Walch (2004). She proposed that, in order to prevent the firm from choosing short-term profitability over long-term profitability, it has to create one portfolio of technological development projects and one portfolio of new product and process development projects. The R&D budget is no longer allocated among all the projects but among the portfolios. The budgets are allocated to each portfolio (and not to each project), according to the part of profit the firm decides to dedicate to knowledge and technology renewal.

- The third criterion allows for the expression of experts creativity in the early design phases. The firm can manage efficiently the forward phases of innovation processes.

### 2. Creating five projects portfolios

Five portfolios were identified: ideas portfolio, technological development projects portfolio, prospects portfolio, proposals portfolio and customers projects portfolios.
- The ideas portfolio consists of ideas. One idea is a theme possible for a technological development or a commercial action (partnership, prospecting, offer, etc.). This portfolio management aims to merge and formalize, without censuring, the ideas of projects.
- The technological development projects portfolio consists of technological development projects. One technological development project is a project that allows for the creation of new internal knowledge. The portfolio management aims to arbitrate between the projects of the portfolio. It also aims to coordinate the projects according to knowledge that has been created in them.
- The prospects portfolio contains prospects. One prospect is a new offer for a new or existing customer for LTS. The product can be at any stage of its development (technological concept, prototype, etc.). The prospects portfolio management aims to express the creativity of skilled people. It also facilitates the selection of the “best” prospects.
- In the proposals portfolio, prospects are transformed into proposals. Its management aims to optimize budget, schedule and human resources allocation.
- The customer projects portfolio gathers product and process development projects. Its management aims to optimize the resource allocation by using projects competition. It also coordinates projects by knowledge management.

One management process has been defined for each portfolio. One new level of management between strategic level and portfolio level has been defined: multi-portfolio management. The goal was to coordinate the knowledge of the portfolios and to optimize budget allocation to each portfolio. Structural mechanisms and management tools have been identified for all the processes: portfolios management processes, multi-portfolio management processes. We noticed that the term “project” was used with a different meaning than the usual one. In effect, although it was a non-recurrent process, and effectively included a starting and ending date, it was not necessarily managed with a project management methodology.

## IV. Conceptual research results

Thanks to this research, we have shown it was possible, and appropriate for a firm to implement a new management multi-project approach, linking the main principles of the three kinds of MPM: portfolio approach, platform approach and lineage approach. We suggest this approach could be used to deal with new challenges in today’s Innovation.

### 1. Linking the main principles of the three kinds of MPM: competition and knowledge management

The MPM, which has been implemented in LTS, is at first a portfolio approach. In effect, the main goal is to optimize the financial resource allocation. For this reason, it takes into account the main principle of the projects portfolio approach: competition between projects. But, it also takes into account the principle of the lineage approach and of the platform approach: coordination of projects by knowledge management. The projects of a portfolio are coordinated using knowledge management. Portfolios also are coordinated using knowledge management. The platform approach was eliminated because of the impossibility to standardize interfaces between aircraft’s components and systems. Maybe, it will be possible in the future to do this standardization thanks to the system engineering method; but not today even if some research programs are conducted about this subject in the aeronautical industry.

### 2. Dealing with new challenges in today’s Innovation with the LTS MPM model

The LTS model of Multi-Project Management is an effective way of managing a high number of interdependent and varied innovation projects. We suggest it could also be a way, for a firm, to manage the constraints linked to open innovation, external funding and sustainable development. We will explain this idea in the case of cooperative projects.

When firms are involved in cooperative projects, they have to share knowledge. According to Chesbrough and Schwartz (2007), this knowledge is divided in two categories: key assets, contextual capabilities. The key assets are linked to the core competences of the firm. They represent the principle source of the firm's differentiation. Contextual capabilities are necessary for the entire product but do not constitute the company's core competences. Core competences have to be closely handled and cautiously shared whereas contextual capabilities can be more easily shared. When firms work with partners that they already know, they can easily define with them rules of knowledge appropriation and exploitation conditions of the results of the project. It is more difficult when firms work with organizations or people who they did not previously know. For example, it is difficult for firms to have informal partnerships, spontaneous discussions with experts or academic partners, cooperation with specialists or user communities via the Web. The result is that firms agree to share their core competences with known partners, but not with unknown partners.

We argue that a MPM approach would be a more secure and profitable way for a firm to work with external partners. We suggest for instance to create two portfolios: one portfolio gathering projects based on the core competences of the firm; and the other portfolio gathering the projects based on contextual capabilities. The formalization of legal sharing of intellectual property with the partners will be stronger for the first portfolio.

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Norme ISO 14040:2006 Management environnemental -- Analyse du cycle de vie -- Principes et cadre.

# Environment for generation of ideas to TRIZ´s implementation: case in business incubator in Autonomous University of Puebla, Mexico

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**Abstract:** The challenge for incubators at the university level is to make its operation viable through sophisticated tools of innovation, where it enters the project achieves high profile component of innovation and technology that support the financial and human effort that represent an area of development of its kind in the universities.

A criticism of many models prevalent in incubators in Latin America, is the excessive focus on developing a business plan and the relatively little effort to focus the support in finding routes in case of disruptive technology projects. Equally little is done by supporting projects in the pursuit of innovation in business model.

The paper presents the experience of technology-based incubator of the Autonomous University of Puebla, where he designed a space called Idea Lab contributes to the generation of innovation ideas with high impact and high efficiency.

It proved equally novel, integrating TRIZ methodology in the process of generating ideas to improve high-tech prototype, obtaining very accurate results for developers and high efficiency in the implementation of TRIZ solution to this problem.

**Keywords:** TRIZ, entrepreneurship, prototypes, ideal system.

## I. Introduction

In a highly competitive world, there is a rapid shift towards value creation intensive factors driven by innovation, technology and knowledge. The entrepreneurs of the XXI century, are the most promising emerging factor to generate new spaces for the growth of a modern and competitive economy.

It is, then, to watch the development with strategic sense and belief that on the basis of the advantages of natural resources, the task to advance development requires building new dynamic benefits, injecting knowledge and innovation to products still insufficiently developed but also strengthening existing capacities and vocation related to natural resources and moving toward knowledge-intensive sectors. Entrepreneurs are in the XXI Century, key players in this new economic revolution.

From the view of the Knowledge Economy, Education for the XXI century have four pillars: learning to know "," learning to do, learning to be "and" learning to live together. " To these, it is considered necessary to add the "Learning to entreprenuership" to promote the development of a proactive attitude, which from the do, with knowledge and awareness, enables people to set goals, make proposals and take initiatives with intelligence, innovation and creativity, seizing opportunities and overcoming the threats that are presented in the current scenario.

In Mexico, some universities are still discussing the relevance of this type of training for entrepreneurship, a situation that is accentuated in public universities. In which a proposal has been consolidating entrepreneurial manifests however, a tendency to simplify the training with knowledge related to the development of Business Plans.

## II. Research background

Idea generation is a way to discover, learn and refine some design concepts, solve problems and even group learning. Participation in this type of scenario helps to broaden and deepen perspectives on a variety of considerations that sometimes go unnoticed for the developer of a project.

In any process of generating ideas to innovate, the starting point is the definition of the problem, you have to devote sufficient time to determine what the problem is being addressed.

A wide range of methodologies for the projection of ideas in terms of solving a problem or project, including Brainstorming (brainstorming), projected thought Kinetics, Methods of Speed, Futurism, elegance, practicality voltage, TRIZ.

**Brainstorming**: This consists of throwing between members of the team a lot of ideas to solve the problem. All ideas are written, regardless of their quality. Good ideas come out towards the end when they have consumed all. Do not criticize the ideas of others. This method works when the problems are too complex to solve or want to conventional solutions.

**Projected Thought**: It consists in putting to work individually with members of the team. Each is giving their ideas. That is the time to criticize others' ideas and to be evidenced. The criticism the more out of place, the better. They are being written all the ideas that emerge.

**Synectics**: Once you've determined the problem, start brainstorming for analogy of similar problems in different situations or products. In this way one forgets the initial problem and the problem can be resolved through an analogy.

**Methods of speed**: On an individual basis is, stopwatch in hand and a sheet of paper, daily exercise the mental muscle around the same problem. Every day we shall be going more and higher quality ideas.

**Futurism**: Thinking about how to solve the problem today if there were technologies, materials, processes that do not exist today. In short it suggests a future solution. Think about how you would do today and what prevents it. For example, how we wish that was a bike? Light, MP3, Folding autocandado, to climb the hills alone, very safe, and so on.

**Voltage elegance-convenience**: Make two versions of the same problem or in this case a single product, the refined version and easy version.

**TRIZ**: So very briefly, accurately describes a system and its environment, determines the useful effects (desired) and adverse effects (undesirable), define the ideal system to use as reference. After determining the contradictions that "Tatar" or situations to innovate, apply TRIZ tools most appropriate and to the extent that solves the problem or the product innovates the system becomes more productive and business in general more competitive. This is the only tool that takes the art of "trial and error" in any systematic or levels of sophistication.

TRIZ (pronounced /tri:z/) is the acronym for Russian: Теория решения изобретательских задач (Teoriya Resheniya Izobretatelskikh Zadatch) meaning "The theory of solving inventor's problems" or "The theory of inventor's problem solving". It was developed by a Soviet engineer and researcher Genrich Altshuller and his colleagues starting in 1946. It has been evolving ever since.

Today, TRIZ is a methodology, tool set, knowledge base, and model-based technology for generating innovative ideas and solutions for problem solving. TRIZ provides tools and methods for use in problem formulation, system analysis, failure analysis, and patterns of system evolution (both 'as-is' and 'could be'). TRIZ, in contrast to techniques such as brainstorming (which is based on random idea generation), aims to create an algorithmic approach to the invention of new systems, and the refinement of old systems (see figure)

Some TRIZ is in the public domain. Some TRIZ resides in knowledge bases held by commercial consulting organizations. A complete and open TRIZ development process is not yet evident. Various camps vie for control of TRIZ and interpretation of its findings and applications.

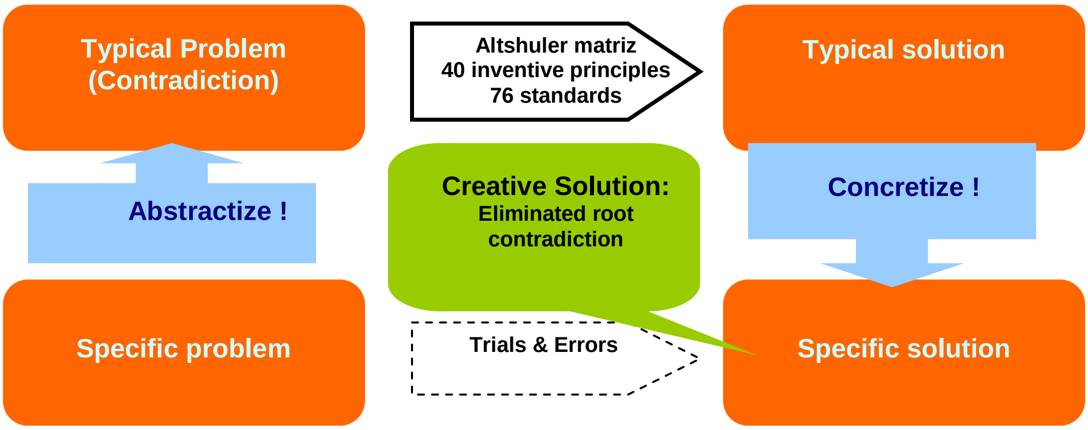


Figure1. The TRIZ Model

These and other methodologies contribute significantly to the generation of ideas, however, to consider the person in the center of the process, your application may be conceptually relevant, but virtually inoperable in the case of complex projects involving several actors , where the asymmetries of mental models, training and culture, can make extremely long sessions with the resulting wear.

**IDEALAB: Thinking Space Technology**

In devising the Laboratory of Idea, as the core of the proposal of the Business Incubator of Technology-Based BUAP, we start to conceptualize as an interactive space where people succeed in transforming a group interaction in a smart meeting, technology-supported collaborative work in local digital and virtual environments

We leave for their design, from studies at Stanford University in conjunction with the full learning and productivity in idea generation. New tools are needed to support informal learning activities, in particular, the processes associated with the development of concepts. A collaborative study team from Stanford University showed that the newest ideas in a group were generated during informal activities and far fewer ideas are generated in formal activities.

On the other hand, were able, during the discussions of collaboration, people focus on one piece of information, a construct that represents the smallest part of a coherent idea, for an average of approximately six seconds.

The effectiveness of the environment is demonstrated under the following operating principles:

- Members focus their expertise on a common objective shared.
- Each member contributes to the discussion and it is "heard" the same level
- The ideas are freely expressed.
- It addresses issues multi-dimensionally.
- No member requires leadership or decision making in the discussion
- Members present their views in a frank and concrete.

- Members participate in a creative and open to new ideas.
- Analysis and discussion of profound issues without an effort is made evident and appropriate times.
- Avoid the inconvenience of psychological inertia or self-censorship to a highly creative opinion but frankly subversive or revolutionary.

These operating principles, allow:

- Savings of up to 5 times of meeting time
- With a slight training can facilitate a discussion.
- The group generates hundreds of useful ideas in an hour.
- The group is involved in the discussion and really experience a pleasant feeling.
- Disorganized groups become high-performance teams.
- The new knowledge created is highly reliable.
- People converge to shared conclusions despite initial radical positions.
- The group is committed to action more easily.

In the Incubator Technology-based Space, we hypothesized that the TRIZ methodology could increase its efficiency significantly in the analysis of technological improvement path in high technology prototypes, which could work experts from various disciplines in a relatively short time .

TRIZ experts, raise the problem that occurs when using the methodology involves several knowledgeable of this tool, especially if there is a large domain.

Under these assumptions, it is proposed to work under a methodology learning by doing (learning by doing), where several experts were invited to take a short workshop on TRIZ and under the guidance of an expert, apply the principles of TRIZ to pathway analysis improves of a prototype high-tech.

The paper shows an analytical comparison of the process. Tables are shown the process performed and calculate the intellectual productivity achieved in the process of analysis of technological prototype using TRIZ analyzed in the Laboratory of Ideas.

## III. From the Business Plan to Business Model and Innovation

The term comes from french venture "Entreprenur", referring to "the determination to do something like a conquest." It is defined as "the ability of a person to make an extra effort to reach a goal or objective, being used also to refer to the person who started a new company or project."

The entrepreneurial approach of competition should be a crosscutting principle that integrates the educational proposals of the different systems, levels and training cycles. Ultimately, success will depend in particular on what the students "learn by doing" in real situations, while strengthening their ability to learn, innovate, cooperate and live together.

The capacity for entrepreneurship, find sustenance in attitudes and values associated with creative and innovative behavior. It is therefore appropriate to adopt a strategy for the venture, focused to drive and talent to engage and innovate.

It is a project that synthesizes the entrepreneurial capacity and the project is about where they should turn the repertoire of tools with which business incubators, as an area of development of innovation capabilities of the project, must converge to achieve university projects high value-added and knowledge incorporated.

## IV. Structure of the Business Incubation System. BUAP

**Vision:** Integrate a state-wide network of Support Productive Projects and Innovation in Social Enterprise, which impacts directly on economic and social development of the state of Puebla and each of their regions of influence, through the generation of dynamic integrated supply chains and value networks of the regional productive vocations

**Mission:** Build capacity and exploit areas of opportunity for members of the university community and stakeholders in the institution, to the promotion of entrepreneurship and successful productive projects, with capacity to strengthen the export sector, attract investments and reduce the development gap between countryside and city, incorporating knowledge and technology to the regional productive vocations through a planning process (pre-incubation stage), operation (incubation stage) and consolidation (post-incubation stage) companies.

Figure 2. Building of Business Incubator. Cultural Complex of the Autonomous University of Puebla

## V. Experience developed

**The object of study**: a prototype optical analyzer that is designed as an evolved system keyboard or mouse to allow an invention of the third or fourth level, even that may be suitable for users of computer equipment, with some kind of disability or incapacity.

**Objective:** To know the TRIZ methodology to implement the prototype analysis, developments and innovations in High Technology
Duration: 16 hours. Location: Laboratory of Ideas IDEALAB.

**Topics presented**

Case Presentation: Prototype Optical Analyzer
Introduction to TRIZ
TRIZ´s tools
Using IDEALAB
Application of TRIZ to the functional analysis of a prototype high-tech in IDEALAB

**Participants:** 7 experts and 3 entrepreneurs

The questions raised in the environment to facilitate this process were:

1. If you had to choose a formal name for the system, what would you propose?
2. From the demonstration of the prototype, what you think is the Primary Useful Function (PUF)?
3. In addition to the PUF, what other useful features can be identified?
4. What features identify harmful?
5. How do you feel should be the ideal system?
6. What resources identified in the current system? (Pre-prototype development)
7. What you consider that additional resources are required?
8. What kind of contradictions identify?
9. What are the limitations of the current system?
10. Are there any similar systems to ours?

## VI. Results

In the 6 hours of work, the following results were obtained in number of input and ideas:

**Ideas generated**

| Question detonating | For Participant | For Hours |
|---|---|---|
| Project Name | 35 | 5 |
| Primary Useful Function | 21 | 4 |
| Additional Functions | 41 | 12 |
| Harmful Functions | 49 | 10 |
| System Ideality | 47 | 13 |
| Resources involved | 58 | 14 |
| Additional Resources | 44 | 12 |
| Contradictions identified | 48 | 12 |
| System Limitations | 67 | 14 |
| Analogy with other system | 22 | 6 |

**Relative Productivity Ideas Proposals**

| Question detonating | For Participant | For Hours |
|---|---|---|
| Project Name | 3.5 | 5.8 |
| Primary Useful Function | 2.1 | 3.5 |
| Additional Functions | 4.1 | 6.8 |
| Harmful Functions | 4.9 | 8.2 |
| System Ideality | 4.7 | 7.8 |
| Resources involved | 5.8 | 9.7 |
| Additional Resources | 4.4 | 7.3 |
| Contradictions identified | 4.8 | 8.0 |
| System Limitations | 6.7 | 11.2 |
| Analogy with other system | 2.2 | 3.7 |
| **Total** | **43.2** | **72.0** |

**Agreed Relative Productivity Ideas**

| Question detonating | For Participant | For Hours |
|---|---|---|
| Project Name | 0.5 | 0.8 |
| Primary Useful Function | 0.4 | 0.7 |
| Additional Functions | 1.2 | 2.0 |
| Harmful Functions | 1 | 1.7 |
| System Ideality | 1.3 | 2.2 |
| Resources involved | 1.4 | 2.3 |
| Additional Resources | 1.2 | 2.0 |
| Contradictions identified | 1.2 | 2.0 |
| System Limitations | 1.4 | 2.3 |
| Analogy with other system | 0.6 | 1.0 |
| **Total** | **10.2** | **17.0** |

According to empirical experience, the application of TRIZ in an intense session of 6 hours of a group of 10 experts, swiftly led to the discovery of a universe of different contributions in terms of key concepts to facilitate the innovation process, such as primary useful function of the system, though seemingly trivial, is often not easy to determine, the same for the useful and harmful functions of the system to prosecute efforts to increase the degree of ideality.

Defining the ideal system that will serve as reference framework to facilitate the innovation process and the contradictions to which is subject to the system to identify those who most affect or will not let her evolve.

Definitely the union of these two powerful analysis tools (TRIZ and IDEALAB) represented a novelty for those involved in this process, both experts and entrepreneurs said that was achieved in a short time what otherwise would have taken several weeks or perhaps months.

The most significant achievement of this experience was the discovery of a technique to further increase the efficiency and effectiveness of TRIZ as a formal methodology for systematic innovation, using a digital collaborative environment as IDELAB, which seeks to optimize the analysis process to the generation of ideas. TRIZ is a systematic procedure for innovation and a whole philosophy to design new paradigms and more quickly achieve human welfare, and IDEALAB has been proclaimed as the most efficient, sophisticated and innovative "trial and error" combining the best of all previous steps to it.

In this particular case the participating entrepreneurs took many excellent ideas and even a clear concept of what the system can be built. It would be unusual in this year, they are able to achieve an innovative product, advanced, high technology, economic and that he can be marketed successfully.

## VII. Conclusions

The application of TRIZ in a collaborative digital environment, tested the hypothesis that the analysis path of technological upgrading in high-tech prototypes, it could work under TRIZ experts from various disciplines in a relatively short time.

Derived from this case, has designed a Technology Innovation TRIZ Consulting, which make use of Idealab, a part of the Service Catalog the Business Incubator of the technological basis BUAP, provides academic and business sector of State of Puebla in Mexico.

It is recommended that institutions that promote the use of TRIZ, incorporating collaborative solutions such as Zing Technologies with the goal of operating under criteria of efficiency and effectiveness in systematic innovation processes based on TRIZ. Similarly, the case study and the conclusions presented, enabling business incubators in Institutions of Higher Education, optimize its portfolio of services with high productivity tools aimed at improving levels of innovation of the projects assisted.

## Acknowledgement

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# Product Development for the Creative Customer

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**Abstract:** Experience Value and Creativity are attracting wide attention these days. But most of these discussion focus on users or on designers. It is often forgotten that our customers are very active and creative. And if we look at engineering, the current approach is one way from the producer to the customer and the customers are regarded just as consumers. But if customers can be involved in product development, they can enjoy their experience not only as users but as product developers. And at the same time it will satisfy our customers' desire for creativity. This paper describes how we could change our design and manufacturing so that we can get our customers involved and develop experience value together with our creative customers.

**Keywords:** Experience Value, Creativity, Creative Customer, Product Development Experience

## I. Introduction

Most discussions on experience value and creativity regard customers as consumers. But as the word "customers" implies, they would like to customize our products to their own tastes and needs. We have forgotten that they are very active and creative. Traditionally our product development has been one way from the producer to the customer with primary emphasis on developing final products with high sophisticated functions. Although experience value is emphasized these days, experiences discussed there are mostly at the stage of use. And the importance of creativity is also emphasized to respond to the quickly increasing diversification, but most creativity discussions are about designers' creativity.

This paper points out that our customers are very active and creative. Therefore, to satisfy their expectations, we have to change our style of product development. Then, customers will be no more just passive recipients of our products. They will be our partners in developing values.

We have regarded value in terms of the performance of final products up to now. i.e., our traditional value has been nothing but product value and it is nothing else than producer's profit. But if we can get customers involved in our product development, the experience of developing a product itself will yield value. Product development processes are no more just cost increasing factors. They are creating values in addition to the performance of a final product. 20th century was an age of product value, but 21st century will be an age of product and process values with increasing importance of experience.

## II. The Creative Customer

As the fact that the word "customer" originates from "customize" implies, our customers are very active and creative and they customize our products to their own needs and to their own tastes. Children, for example, children invent new different ways of slipping down the slide (Figure 1).


Figure 1. Children slipping down the slide

Youngsters create new fashions. They introduce holes into their jeans (Figure 2). This is probably because they are very well aware that jeans are working clothes with stories. They would like to invent their stories.

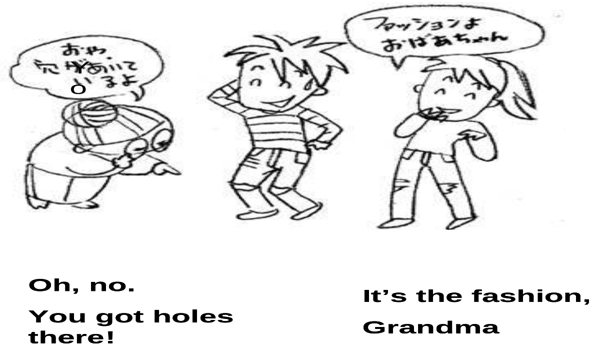


Figure 2. Jeans with holes

Design creativity is getting wide attention these days to respond to the rapidly increasing diversification, but most of them discuss designer's creativity in the current framework of producer-centric and product-oriented design and manufacturing. We often forget that our customers are not mere consumers, who just accept what we offer and appreciate our products, but they would like to be creative themselves. We should develop products and services that will satisfy their desire for creativity.

Customer involvement is a prerequisite for a user-centric design. But what should be remembered when we discuss this is to consider how we can satisfy their desire for creativity. Customer involvement does not mean just a team work between the producer and the customer for product realization. It is something more than that. We have to satisfy our customer's expectations and to let them exhibit their creativity.

## III. Process Values

### 1. Experience Value

Behaviour economics are getting wide attention these days and they emphasize the importance of value of customers' experience in using our products. The more satisfying experience they have, the higher they evaluate our products. But these economics discussions focus only on customer's experience after our product is delivered. But it should be noted that we can provide our customers with enjoyable experience even when we are developing a product. i.e., we can create experience value throughout the whole product lifecycle, not only at the time of use.

Current product development is very much producer-centric and product-oriented and the value producers are paying attention to is only final product performance. But processes also yield value. Our customers can enjoy the processes if they could get involved in design and manufacturing. User-centric design discusses their participation, but again their discussion is for the benefits of producers and is focused upon how we can respond to the diversifying requirements of our customers. What should be stressed here is that we should consider their participation in design and manufacturing from the standpoint of creating experience value..

In the traditional value theory (Miles 1972), value is define by

$$\text{Value} = \text{Performance}/\text{Cost}$$

But performance here has long been interpreted as the functions of a final product. Weber-Fechner law (Weber and Fechner) teaches us that the better and better quality becomes, the more and more it becomes difficult for our customers to perceive its improvement. That is why cost reduction is encouraged in most industries. Cost is easier to estimate. And value here is nothing other than profit to the producer. It does not necessarily is associated with customer's value. In an age when products were lacking, our customers were very happy to have products. But these days our customers are looking more for emotional satisfaction.

### 2. Emotion

Emotion is often interpreted in the passive sense. Most of the discussions about emotions in product design focus upon the issue what emotion a customer would have toward a product. This is very similar to the concept of Affordance (Gibson 1987). To put its idea simply, the outer world provides some stimulus to a human being and it stirs up emotions. Thus, most discussions of emotion focus on product value. They basically regard our customers as mere consumers who are very passive and accept what they produce.

Emotion is not passive at all. In fact, it is very active. The word “emotion” comes from the Latin word “E=out” and “Motion=Movere”. Emotion, therefore, means “move out”. Emotion is not something you receive from your product. But it is something that is generated as a result of your action. And it should also be added that the word “motivation” also comes from the Latin word “movere” (Fukuda 2010). How can we motivate our customers is a great challenge in our future design.

Therefore, emotion is very interactive. Action is involved there. So just adding something would not really satisfy our customers emotionally. To appeal to their emotions, some actions on the part of our customers are needed beyond just product impressions. In other words, we should focus our attention more toward how we can bring our customers into design and manufacturing and let them have creative experience.

Even in design alone, we can take in our customers’ creativities so that we can produce a product what would work for a variety of usage if we can really get our customers involved. Slide, as mentioned earlier, is one example. It is very simple, but provides an opportunity to create new ways of using it. We have to develop such a very adaptive product with our customers.

## 3. MANUFACTURING VALUE

Customer involvement in design is often discussed in such a way as participatory design, but we should remember the importance of manufacturing. Until now, manufacturing has been considered nothing other than a cost increasing factor. So to increase value in the traditional product development, time and expenditure reductions were considered very important.

But manufacturing is performance. Why human is called Homo Faber? Why human has to develop a tool? If just to use a tool, even animals can do it. Humans challenged to develop a tool because they would like to have their own tastes and their own needs satisfied. In fact, it is an activity of self actualization and challenge. As Maslow (Maslow 1987) pointed out in his hierarchy of human needs (Figure 3), self actualization is the most important and highest human need.

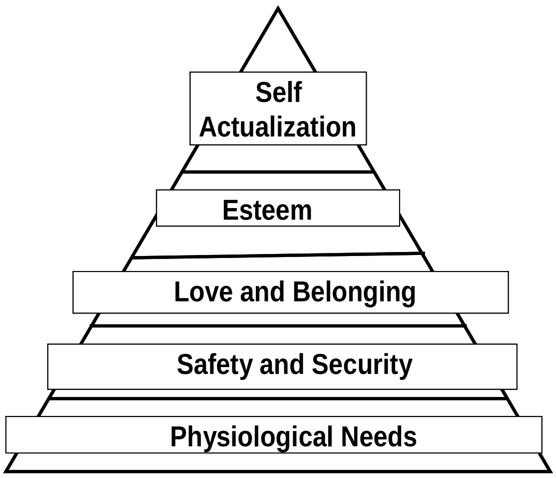


Figure 3. Maslow’s hierarchy of human needs

Why artists never give up their arts, although most of them do not get rich while they are living is because they are actualizing themselves. Challenge is the core and mainspring of all human activities. If our customers can get involved in the manufacturing processes, they can satisfy the highest human need of self actualization and challenge.

Welding, for example, provides a good example. We have a problem of shortage of welders on one hand. But on the other hand, many artists are learning welding because outdoor sculptures need welding. Why? Because welders do welding for work, but these artists do that for joy. If we can turn our work to joy, it will become performance. And value for our customer will certainly increase.

To let our customers enjoy the process of manufacturing, we have to change our design in that direction. The concept of user manufacturability should be introduced. Today's discussion in design for manufacturability focuses attention on better quality and higher functions with less time and less expense. These are experts' jobs.

User-involved manufacturing is something that goes in the opposite direction. We should discuss what would be the bottom or acceptable level for our customers to produce a product, rather that how we can achieve the top level with the highest expertise. User manufacturability must attach great importance to enjoyment and designers must design a product which allows our customers' participation in manufacturing..

## 4. Repair Value

We also should note that maintenance or to be more exact repair can be turned into enjoyable experience. Software can grow endlessly as will be discussed later. But hardware is physical so their degradation is inevitable. But we could design our system so that our customers can enjoy repair. The word "repair" means to prepare. So it is nothing other than "preparing" or customizing products to the needs and to the tastes of our customers. In fact, customers develop attachment after they use our products for a long time. It is another value of experience. And repair will satisfy their need for self actualization or challenge. It should be noted that a degrading curve is nothing other than a learning curve turned upside down. So the more they learn how to repair and to put their product in better working conditions, they feel more confident and happy.

Traditional maintenance is, as the word "maintenance" indicates, the activity to restore the degrading functions back to its original level of designed functions. But customers do not necessary prefer new ones. Our customers feel very much satisfied with our products after some lapse of time when machines are well adapted to their situations and to their needs. They would not like such well adapted machines to be back to the original design state.

To let the machine work best in the present situation is "repair". Maintenance does not consider adaptation, but repair does. In fact, not a small number of our customers enjoy repairing our products to keep them in the state they wish them to be. So how we can make our repair more creative and enjoyable to our customers is also a great challenge in a user-centric design. PHM (Prognostics and Health Management) will serve for this purpose.

## 5. Product value and Process value

We have been making great efforts to improve the quality of our products. Higher and wider varieties of functions were added. But the more the performance of our final product is improved, the more difficult it becomes for our customers to realize how much it is improved as is pointed out by Weber-Fechner's law. They need more increment to realize improvement as quality level becomes higher. Therefore, it will be increasingly difficult to satisfy our customers just by improving or adding functions. Indeed, if we note that our customers are very creative even when they use our products, it certainly is one way to add value to consider use experience for adding value. But this experience value is still within the realm of product value.

Then, what will happen if we get our customers involved in product development? Although Toffler (Toffler 1984) proposed a prosumer system where the producer and the consumer work together and Prahalad and Ramaswamy (Prahalad and Ramaswamy 2004) proposed value co-creation, they are basically discussing the issue from the standpoint of the producer. Their emphasis is how we can develop a product faster and better or how we can respond to the diversifying requirements of customers more flexibly. They are discussing how good product we can develop if we get our customers involved.

Figure 4 shows asymmetry of information. Asymmetry of information used to exist between the producer and the customer . So if we produced a product that filled up this water level difference, we could satisfy our customers and we could make profits. But our society is now becoming information-rich, so it is not rare our customers know more. In addition, their requirements are diversifying so quickly and extensively that producer-centric design does not work any more.

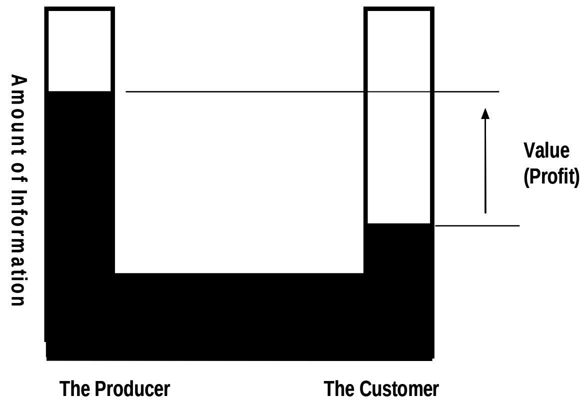


Figure 4. Asymmetry of information

To solve this problem, C. K. Prahalad and Venkat Ramaswamy proposed value co-creation [This can be illustrated as Figure 5, if we use a water level model. The producer and the customer work to raise the water level together. The rise of water level will be value (profit) to the producer and value to the customer. Value in the traditional value engineering meant nothing other than profit to the producer, but this value means true value to the customer.

They emphasize the importance of value co-creation as it is a team work of the producer and the customer, because it is easier for such a team than otherwise to realize a product that would satisfy the diversifying customers' requirements. Their approach is very unique, because other team-based design approaches focus on producers' teamwork,. However, their view is still producer-centric and product-oriented.

Their arguments are certainly different from listening to the voice of customers. Listening to the voice of customers' means that you have already defined your problem and you would like to solve it better with advices from your customers. It is problem-solving.

They are different in that they insist on the importance of formulating a problem. Unless we cannot formulate a problem with our customers, we cannot produce a product that would satisfy them. That is their message. In a very quickly diversifying world, what products we should produce becomes more important than how we can produce our products better. Now is the time for problem formulation. Their arguments stress the importance of problem formulation.

Therefore, value co-creation is a team based design i.e., a team of producers and customers. Team-based design is getting wide attention these days. But most of these researches discuss how we can form a best design team with members from different areas and/or with different personalities are discussed. They focus only on producers. And their discussions are very much product-oriented. Indeed, to cope with the diversifying requirements, we need more heads from different areas to solve a problem. So this is problem-solving. What is needed in such an open world as today is problem formulation. We have to identify what our customers expect to realize their dreams. We have to find out what product we should produce before we start to design.

Thus, our customers are major players in our design team. User-centric design is not a user-focused design. This team has to formulate the problem and solve it flexibly and adaptively in response to the changes in time and space. This will satisfy the desire for creativity of our customers and provide them with rich experience of self actualization and challenge.

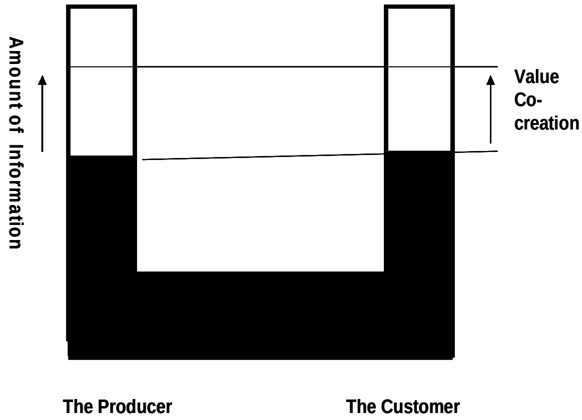


Figure 5. Value co-creation

But if we note that the wall between the producer and the customer is disappearing very quickly today, as Web 2.0 demonstrates, 21st century is the age of a festival, How we can enjoy together becomes very important. If we get our customers involved in such a way, then they would enjoy developing a product and this process itself creates rich value.

## IV. Software and hardware developments

To consider the problem of product value and process value, let us compare software development and hardware development.

If we look at software development, it gives us a hint as to how we could change our product development toward this goal. Software used to be developed in the same manner as hardware (Figure 6).

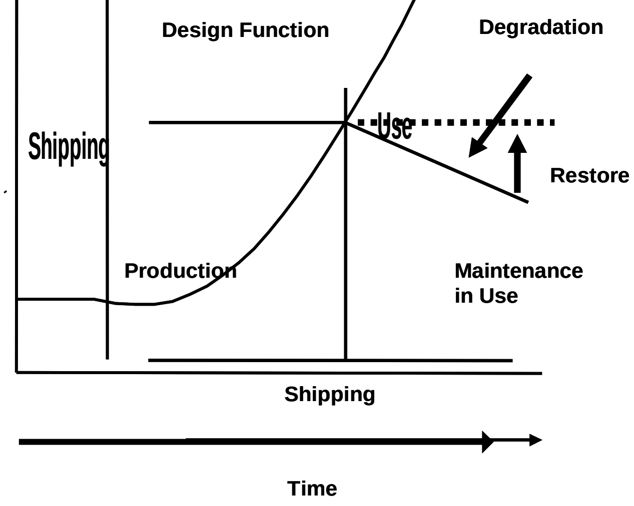


Figure 6. Hardware product development

But AI (Artificial Intelligence) introduced continual prototyping and changed software development style as shown in Figure 7.

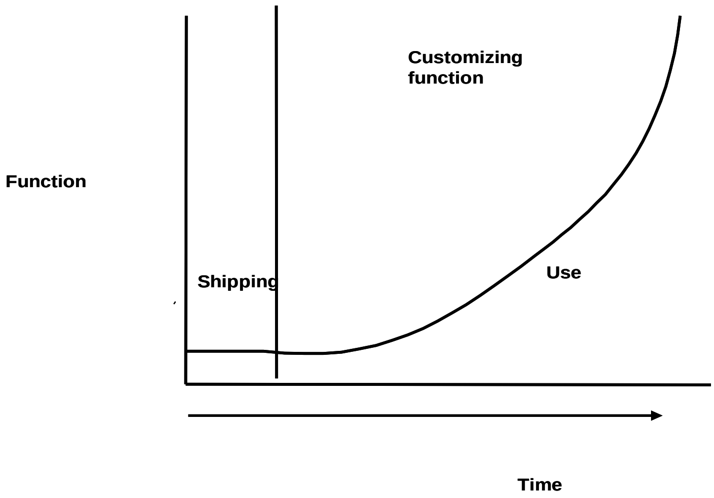


Figure 7. Software development

Hardware is physical but software is non-physical. So software development is none other than service development. If it is goods or physical products, win-lose relationship will develop. But if it is service, we can establish win-win relationship easily as is demonstrated by Web 2.0.

What are important in continual prototyping style software development are,

(1) Functions grow step by step in response to users' requirements. First very basic functions are provided. By the time users get accustomed to them and feel confident, they will know what functions they need for the next step. The functions provided at the next step are to respond to such users' requests so they know very well what will be offered. So they can learn very easily and gain confidence in a very short time. This cycle goes on repeatedly. Software development is, therefore, very much reflective. It is no more one way as is done in hardware.

(2) A growing (evolving) function curve in software development is similar to a learning curve. As we learn more, we gain more confidence and we develop our ability to adapt and to evolve. And as we accumulate our confidence, we put more trust in the system. It is interesting to note that in the German language, Vertrauen means confidence and trust at the same time. Software development is in fact a producer-user team work. It not only provides enjoyable experience to users, but also it helps to grow confidence and trust. If we become more confident, we can turn many experiences into happy events. And if we feel the system is very much trustworthy, then we evaluate it very high. Continual prototyping serves not only for generating process values but also for increasing product values. It should be noted that in Maslow's hierarchy of human needs, security and safety are 2$^{nd}$ from the bottom basic needs. Thus, trust is very important for our customers when they evaluate our products. .

## V. Product development continual prototyping style

Continual prototyping style product development has many benefits as described above. But it is not so easy to introduce it to hardware development. One reason is that hardware is physical and has life as an individual, while software issues are those of species. But if we introduce Virtual Reality technology for example, we could get users involved more in product development and such continual prototyping can be introduced.

Another way is to develop products by combining simple modules. Combining simple modules together into complicated systems are already done. But to achieve the goal mentioned here, simple modules must be simple enough in the eyes of users. Norman (Norman 2004) pointed out that people used to trust machines because they were simple and behaved as they expected. But today machines become too much complicated and they do not behave as users expect them to do. So people are losing trust and their uneasiness increases quickly. We have to design and develop modules which would respond to users' expectations. And step by step, we add modules to make the system complex. This way, we may be able to introduce continual prototyping approach into hardware development, too.

Such continual prototyping is a history of hardware development. We started from very simple machines and developed them into machines with high functions. Thus, to achieve the current goal, how we can repeat this history in a short time is the problem. And it should be noted that such continual prototyping product development would serve to develop workforce as well. In fact, there will be no distinction between the producer and the customer so the workforce is none other than our customers from a different perspective.

## VI. Conclusion

Our traditional product development has been one way from the producer to the customers. But if we note our customers are very active and creative, we should get them involved in product development and provide them with the joy of creation and satisfy the highest human needs of self actualization in Maslow's hierarchy of human needs.

Then we can create not only product values but also process values as well. Continual prototyping product development as is being done in software gives us a hint how we can change our product development toward that goal.

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# The use of Structure-conduct performance allied with Business Process Management and Learning Management Mechanisms to improve the adaptability of a company

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**Abstract:** This paper presents a model that aim to improve the adaptability of a company in industries with high potential for innovation. The model proposes an integrated use of structure-conduct-performance (SCP) paradigm, combined with the view of a Business Process Management (BPM) allied with learning management mechanisms. These elements, working together, can identify the changes in the environment and also reconfigure their internal processes, in accordance with the new relevant Key Performance Indicators (KPI). None of the less, by using these methods it is possible to maximize the use of tacit knowledge of those involved. Given this framework, it is possible to comprehend the enhancement allowed by the use of SCP, BPM and the learning management mechanisms. For that, it is illustrated in a case study of a Brazilian computer's industry.

**Keywords:** Structure-conduct-performance, Business Process Management, Key Performance Indicators, Knowledge, Learning mechanisms.

## I. Introduction

Nowadays, one of the mainly characteristics from the competitive scenario is the ephemerally from one configuration. Factors as the globalization, the technological innovations, each day more frequents, are generating a big number of dimensions that need to be considered for the representation of maps, that each time, imposed by the volatility of the environment, becomes quickly surrealist images, from something that few moments ago was a precisely image.

These changes are consequences from the Knowledge use, which acquires characteristics from a prominent economic resource, in some cases more important than the usual basic inputs; occasionally, even more important than the money.

Variables such as the globalization and technological innovations each day more frequently are changing the competitive scenario each day more dynamic and cruel for the organizations that do not have the ability to recognize the critical dimensions and therefore re-set the characteristic´s operation.

When Michelangelo painted the Sistine chapel he had to conceive a great number of scenes from the Old Testament, among them the creation of man. He took over four years (1508-1512) to complete his work. These days, the organizations do not possess Michelangelo's geniality; also do not have the guidelines from what is fundamental in a map construction. As it was, in Michelangelo's case, the Old Testament. Even worst, many times there is no available time, like he had, to deliver the piece!

In the given model the SCP generates a screen where it's possible to understand the behavior of an industry. The construction of the processes that support this new scenario is made by the BPM combined with the learning organization assistance. The essence of this work is to create a mechanism that enables the quick configuration of the processes of an organization which is inserted in a high degree of changes environment.

## II. The Structure Industry Analysis and the Model SCP

According to Mason and Bain (Porter, 1983), on the SCP, the proposal is to analyze the competitive environment where an industry is inserted by the dimensions: structure, conduct and performance. The structure is seen as a set of attributes that define the role of the market, as an example, the use of high or down level of integration in the chain. The conduct is characterized by the way that an agent acts on the market in terms of the politics adopted and the way his strategies impact on variables, as price, production level and service level available to the market. The performance evaluates the results of market structure and conduct of the agents. A crucial point is that the orientation of SCP can be in two ways, in other words, a company can shift the structure of the industry Mckinsey (2008) or their own, and therefore SCP model can be considered as a dynamic system.

By (Porter, 1986) the strategy's essence is connect one company to its environment. Although, the relevant environment is from a broader perspective, containing social forces as well as economics, the mainly aspect from the organizational environment is the industry. The forces outside an industry are mainly significant in the relative meaning, once that they usually affect all of the companies in the industry. Therefore the basic point is founded on the different responses given by an organization, which by it´s time is based in the organization abilities in deal with this forces.

Nowadays, the level of competitiveness in most industries already imposes the price as a market condition, in other words, there are rare cases where a company inside an industry still has conditions to stipulate the prices. In this way, the primary concern about the effects of oligopolies today takes a dimension somewhat distinct from the economic view.

The industry evolution is strategically important since this role, brings with it changes in the structural source from the competitiveness. Once diagnosed the forces that affects the competitiveness in an industry an it´s basic causes, the organization is in position to identify its weaknesses and strong points in its field of action. Still accordingly to (Porter, 1986) from the strategic point of view, the crucial conditions are the organizational positioning concerning the basic causes from each competitive force.

An effective competitive strategy takes over an offensive or defensive role, in order to create a protective position against the five competitive forces. In broader concept, this comprehends many possible approaches, like following:

- Placement of the company in a way that its capabilities provide a better defence against the existent set of competitiveness forces;

- Influence the balance of forces through the strategic movements and therefore improve the relative organizational positioning; or,

- Anticipate the changes in the basic forces factors and answer to them, exploring this way, the change through the choice of an appropriate strategy to the new competitiveness balance before the rivals identify it.

The structural analysis focus broadly on the competition beyond the existent rivals, it should reduce the need of debates about where to establish the industry limits. Any definition about an industry is essentially a choice about where to establish a line between the existent competitors and the substitute products, the existent companies and the ones that may have come to enter in this industry and also between the existent companies and the suppliers and buyers.

In the model proposed in this study, the scope of action from the SCP model will be enlarged in terms of giving support to the understanding of mechanisms, which would support the comprehension of the industry role and even further, the way that the changes from this role would suffer or would impact in the action from different agents in this industry. In a posterior phase, this model proposes how an enterprise may reconfigure their management process. For the reconfiguration of the management process the model use the view of BPM – Business Process Management.

## III. Business Process Management

For (Varvakis et al., 1997) process management is the definition, analysis and continued improvements in process, with the objective to fulfill the client´s needs and expectations.

According to (Harrington, 1993, p. ix) "truly advanced organizations realize that we no longer can survive by pouring more resources into our business process in an effort to overpower the competition". Even further the author emphasizes the need of change in the management´s thinking.

The discussions about the need of a process´ view are not recent. Mary Parker Follett in the first's decades from the last century already had discussed about the need of a company´s overview. (Grahan, 1997)

If we look at process as assets, core processes and process we may find that they can generate greater value for the customers. This way it should be managed in a careful way. Besides being a consistent value to customer, if well managed it can also be a foundation for future improvements. None of the less, Business Process Management entails the following tasks according to (Chang, 2006, p. 32) "measuring, monitoring, controlling and analyzing business process".

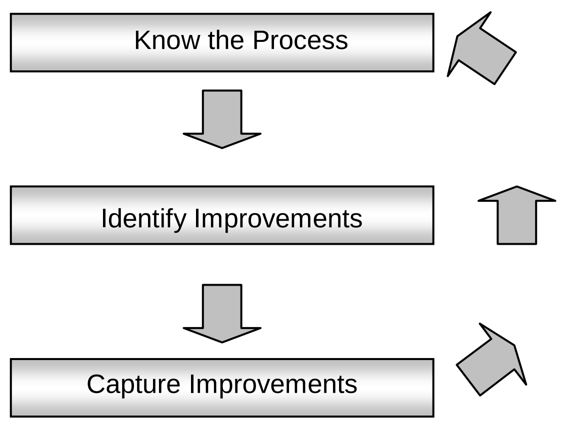


Figure 1. Scheme representation of Process Management

Considering a continuum from a simple kaizen in a manufacturing process until a drastic business reengineering, the process view aim to understand the process and align them to the new performance patterns. These patterns are many times not previously known.

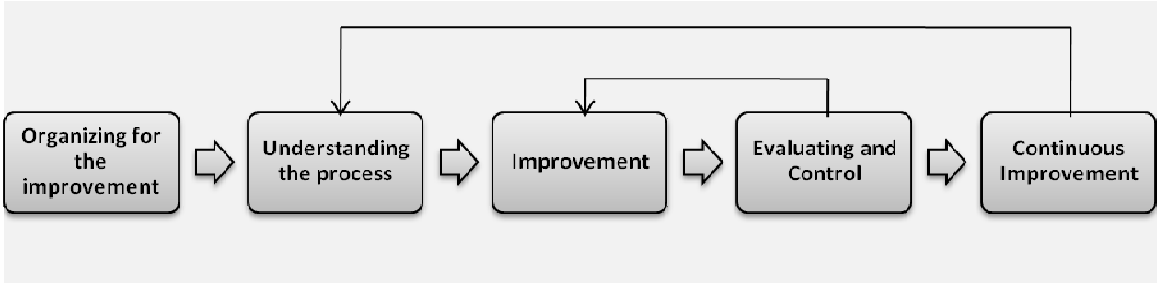


Figure 2. Scheme of Process Management
(Harrington, 1993, p. 27)

Each organization has a specific set of process, which aim to create value for their clients and produce financial results. According to (Lobato et al., 2006, p. 116) "it is possible to testify that one generic value chain may serve as model for an organization to build an internal perspective for their process".

In this case, enable an innovation process, involved with the needs research and also with the operation process. That verifies since the creation of value until the efficient, regular and punctual delivery of its products or services and at last comprehends also the after-sales process, which includes the assistance after the purchasing of a product or service.

For (Harrington, 1993) one of the key elements from the quality revolution on the 80´s, it was the evidences that the process, and not the people, are the key to an unflawed performance. Although, the question that remains is, are not the people the ones who define a process?

## IV. Learning Organization

In a fast moving world concept, innovations, new events and changes come up at an incredible speed. Despite a world that few years ago was seen as moving towards an integrated world society, nowadays it is already seen as more and more differentiated and complex.

In this context, enterprise productivity may be influenced by external conditions, which are from a broader perspective. According to (Milkovich and Boudreau, 2000), maybe the most important influence, might be considered the competitive pressure, in all levels locally and globally, and also the dramatic technology development. These facts are distressing the organizations, imposing them to changes. In this sense, (Rocha-Pinto et al., 2007) say that the differentiation that has happened between the traditional companies and the new organizations are the response that are given to the changes in the organizational macro-environment.

This way, is possible to see that leaders of organizations are consistently looking for better and reliable ways to improve performance and results. According to (Probst et al., 2002), in the innovative organization the leader emphasizes the special role that knowledge will perform in shape the enterprise's future. In order to survive and be competitive in the knowledge society, the enterprises should learn how to manage its intellectual assets.

Other consideration consonant to (Nonaka and Takeuchi, 1997) concerns the knowledge focused on action, besides the needs in supply an analysis matrix with a proven tool. It is also important, in order to measure the results, develop criterions to measure the success; for that, it is needed that the enterprise acts in a compatible way with the existing systems to integrate the methods and find solutions. At last, it is also important that language be formulated in a comprehensible way, and could be used in the daily enterprise´s activities.

From the approach of (Nonaka and Takeuchi, 1197) there are four modes of knowledge conversion. The first one is socialization, situation where there is an interaction through the experience exchange. In this case, the person shares his/her tacit knowledge directly with another; it might be per language, observation, reproduction or practice. The externalization mode is when someone shares his/her tacit knowledge with the others and not by a direct way. By its time the blend and share between explicit knowledge produce the combination. At last, in the internalization happens the sharing in a straight formal way, in which the person in receiving the explicit knowledge transform it in implicit knowledge.

In this scenario where there is a considerable speed in the information flow and the changes are evident, the knowledge denotes in power. This way, the organizations need to adapt themselves internally to compete in a scenario with a fast moving world. Therefore, in order to establish a foundation that support its competitive advantage and develop its assets, the adoption of a learning culture provides support to the constant changes and the dynamic lived by an enterprise.

For (Sveiby, 1998) the only true agents in the organizational environment are the people, for the author, every other assets and structures whether are tangible or not, are resultant from the human action. People can create also an external structure as well as internal to express themselves. The first one is accomplished when managements from one organization direct their personal efforts to inside of the company; in this case it will be created intangible internal structures, through process improvements or new products. Meanwhile, the second one is due to the attention shuttle to the external environment through the production of new tangible assets and like benefit of this external intangible structure there is the relationship with the client, for example.

## V. Key Performance Indicator

The Science in Administration has been experiencing a path with different stages over its history. It is possible to say that since Taylor and Fayol many organizational systems had appeared in order to fulfil the organization´s need. With the industry´s development and working relationships, managers have been called to suit their management way to be in accordance with the approaches in vogue in their time, by creating methods, models and patterns to deal with materials, economics and human resources; and align them with the global company´s objectives.

The use of indicator is one way of evaluating and estimating the product´s quality, process and clients; nonetheless with them is possible also to apply the same approach focusing on the external organization´s environment, in this case to the industry scenario. The performance measurements apply an important role in the organization´s life, since it represents a self critical process and constantly follow-up from activities, actions and decisions that are taken during its execution.

It is common sense that it is not possible to manage what you cannot measure or what you do not know how to measure. In this way, it is possible to observe the importance in adopting an indicator system, which allows a structuring in the database collecting, processing and analysis and also in the results usage.

By using indicators it is offered to an organization guidelines that will orient the course of action that is taken, in a way to lead the company to a better performance. It would also enable the opportunity of a company to create and sustain a competitive advantage (Porter, 1998).

In this context the Key Performance Indicators helps a company comprehend how well they are performing in relation to their strategic goals and objectives. In a broader sense, a KPI provides valuable performance information that allows an organization to understand whether it is acting properly, or not.

The following scheme offers a view about the use of KPIs.

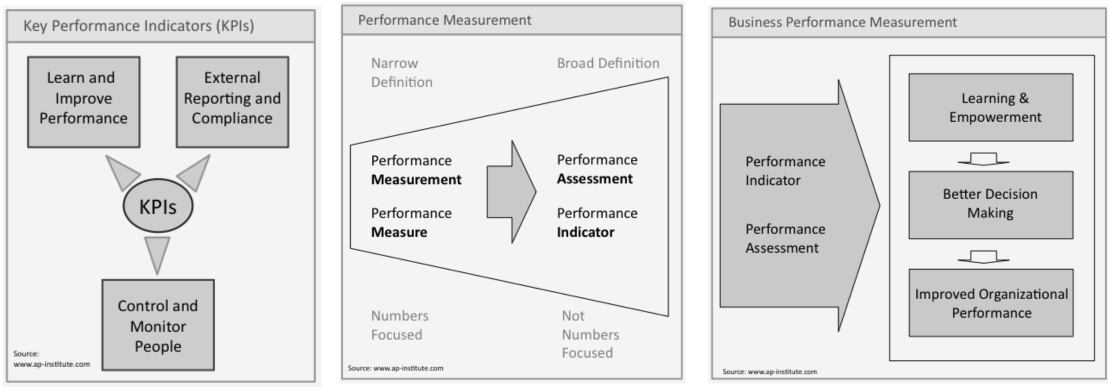


Figure 3. KPIs, Measuring Performance and Business Performance Measurement
Advanced Performance Institute (2010)

Therefore, (Kaplan and Norton, 1997), a balanced system of measurement should translate the trade mission and strategy for a business unit into objectives and tangible goals. These directions will show the balance between the external indicators connected with stakeholders and the internal indicators from critical business process, innovation, learning capability and growth. Consequently, there is a balance with the KPI´s – the consequences and past efforts – and the indicator that shows the future performance.

## VI. The propose model – Case The Personal Computer Industry in Brazil

The following figure presents the functioning of the propose model.

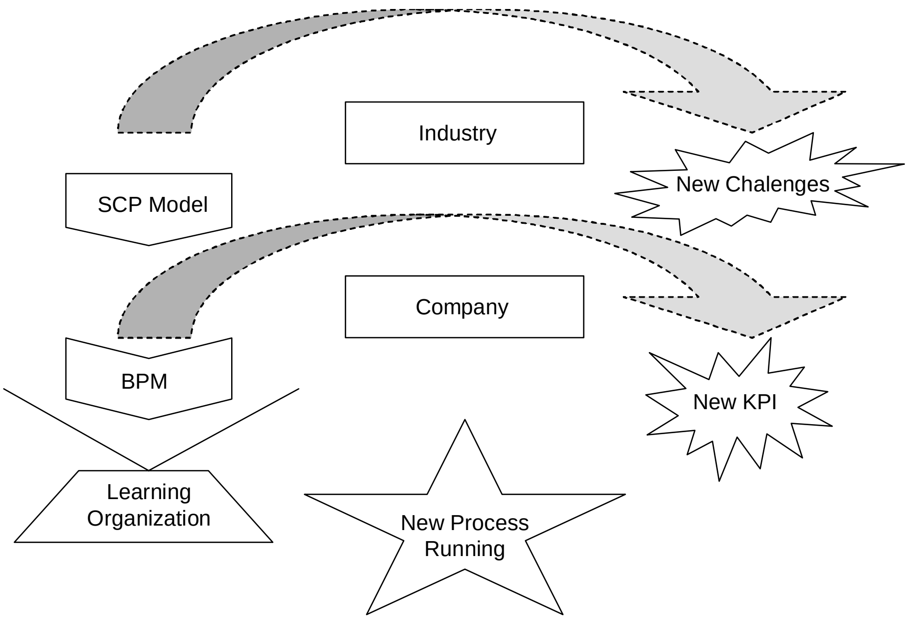


Figure 4. Scheme representation of the propose model (The use of SCP allied with BPM and Learning Management Mechanisms to improve the adaptability of a company)

The former topics already discussed the model´s elements proposed in an isolated treatment. Here is presented the model functioning in an integrated way trough a suggestion for an enterprise that belongs to the Brazilian computer´s industry. The period of time is comprehended of September 2008 to March 2009.

Until August, 2008 the Brazilian computer´s industry showed extreme level of growth. For the desktop segment the growth level was nearly 30% and for Notebooks' it reached scary level of 100%. On that period appeared two new groups of computer companies. The first one was composed by small companies that offered low cost of products. The second group was the big global players of electronics segment, such as Philips and Samsung.

From September, 2008 with the international crisis the industry structure begins to suffer drastic changes. The Brazilian computer´s industry acquires almost the totality from raw material from external sources, mainly from Asia. With the crisis the credit for purchase raw material was reduced in a significant way, and not less critical, exchange depreciation brought some strong impacts in a chain that is highly depended on dollar.

This is the start point, from where it will be discussed the model here proposed. Until August, 2008 the structure industry follows a pattern dictated by the leaders brands, which possess high market share in all the market. There were new entrants ranked in third or fourth place, or even with smaller shares. The enterprise conduct in this period followed a single path that was to look for market growth while maintaining margins in accordance with their brand positioning, in other words, it was a scenario where there was a market for all and the percentage in the chain were satisfactory. It may say that there was a satisfactory performance.

In this scenario, many organizations started to change their conduct, above all in prices terms. This lead the performance from all the industry to suffer a significant drop in the efficiency. Looking from an organizational perspective, what would be the impact of this new industry configuration? And what would be the new KPIs and process to support this new configuration?

Before the crisis the goal was growth with almost guaranteed margins. After the crisis, in a scenario with a low demand and credit, what was left to the enterprises was re-allocate the operations in order to warrant more liquidity to the operation. Therefore, the organization´s priority was to guarantee cash flow.

In a simplified business view, process so far were relegated to a second plan, characterized like supportive, but now became the focus of the company. To illustrate this situation, in the beginning of the financial crisis a purchase team needed to focus more in search for credit solution, then find a way to lower the costs. In other words, the purchase perspective is focused now in finance.

## VII. Conclusion

To integrate what so far has been discussed.

1) SCP: the industry structure has changed. The need of search comes for new performance levels, above all what comes to the liquidity.

2) BPM: there is the need of re-configure the critical process. The new KPI´s will have a strong orientation to the financial perspective.

The final component from this model aims to use some mechanisms from Learning Organizations. Because the knowledge management will enhance and sustain innovations, more adjusted process, flexibility in the response to the market and also competitive advantage.

In the present case, from the Brazilian Computer´s Industry this model would fit properly, since this industry is having many changes in the business scenario, with some new entrants that have forced an adaptation on the performance levels. If a company applies this model, with an SCP analysis and BPM supported by the procedures of learning organizations, very certainly this enterprise would have an efficient and innovative management suitable with the knowledge economy.

By embedding these procedures from learning organization with the contributions driven by the new KPIs, it is possible to evidence the mechanisms that can retain knowledge and action in benefit to the performance level, which would support the business operation from a company in the future.

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# Initiatives in benchmarking Innovation Management in small high-technology firms: A case study in the Brazilian digital communications manufacturing sector

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**Abstract:** The Brazilian government has been promoting innovation initiatives for small, medium and big-sized companies for the past years. Among its initiatives, a benchmarking program - developed by the Euvaldo Lodi Institute in Santa Catarina State, Brazil – was started, aiming that assessing the current performance and practice levels, regarding innovation in Brazilian SME and at comparing them against an international database containing data from more than a thousand firms from 32 countries. In this paper, we report how a small firm faced the challenges imposed by this benchmarking initiative. The firm in study was selected for the pilot project in the State of Santa Catarina, along with four other firms, due to their technology and product development-oriented strategies and for being awarded several times, state and nation-wide, for their R&D and innovation practices. We report the challenges imposed by the benchmarking program the firm needed to overcome and how the company achieved this objective, through bibliographical surveys and on-site visits to the company during the period 2006-2010 and we outline how the firm evolved since then and their current challenges for the forthcoming years. We conclude by assessing the gains of the firm in relation to their innovation management programme.

**Keywords:** Innovation Management, Benchmarking, SME, Performance Indicators, Practice Indicators**.**

## I. Introduction

Innovation activities have become essential for all industries and markets. It is commonly accepted to say that innovative companies are more competitive and often do better in financial terms. For instance, a study made by the European Commission found out that, innovative firms in the EU displayed higher percentages of sold goods and/or services on international markets (Eurostat, 2008).

In Brazil, the growing support of the government in the last decades has been recognized as one of the major reasons for the country to gain importance as an emergent economy (Russo, 2009). Over the last years, Brazil has seen an improvement in their university-industry relationship, with approximately 80% of their research projects being developed in public universities and research institutes (Bound, 2008), while their private sector is one of the strongest in the world.

The support of Brazilian Federal and State funding agencies to small and medium-sized (SME) companies has also being growing in the last years, and specially in the promotion of innovation initiatives. The Euvaldo Lodi Institute of Santa Catarina (IEL/SC) is the entity responsible for the orchestration between the industrial sector, development agencies and research and education institutions1 in the State of Santa Catarina, Brazil. In 2006, a study conducted by IEL/SC aimed at benchmarking small companies against a database of European firms in relation to their management of innovation.

One of the chosen firms for the pilot project was a digital communications solutions manufacturer, due to their technology and product development-oriented strategies and for being awarded several times, state and nation-wide, for their R&D and innovation practices.

[1] http://www.ielsc.org.br/

After the assessment programme was completed in 2006, the firm's broader view of their maturity level in relation to innovation management helped to identify their strengths and specially their weaknesses.

In this paper we report the challenges imposed by the assessment programme that needed to be overcome and how the company achieved this objective, through bibliographical surveys, starting in 2006 and on-site visits to the company during the period 2006-2010. The visits enabled a greater understanding of the innovation management model developed by the firm as well as to better contrast it with prior findings.

Semi-structured interviews were conducted with several employees of the firm. Interviewees were drawn from different hierarchical levels of the firm, including senior management levels.

The paper has six sections. The first section is this introduction. The second one introduces some details regarding the creation and development of the Benchstar methodology. The third section brings the methodology used for data collection. The fourth one brings the case of the firm in study. The fifth section concludes the work.

## II. How the Benchstar methodology came to be

The Diagnosing/Benchmarking phase was developed in 2006 by the Euvaldo Lodi Institute of Santa Catarina (IEL/SC), through the participation of a project financed by FINEP. The objective of the project was to develop a Brazilian benchmarking methodology for innovation management in small companies, namely the Benchstar Methodology.

The origin of the Benchstar Methodology (BM) was the "Made-in-Europe" program for benchmarking best practices in European companies in the mid 90's. Since 1997, IEL/SC worked in the acquisition and adaptation of this knowledge, finally producing the "Made in Brazil" methodology (Seibel, 2004).

The "Made in Brazil" methodology consists in a rapid and effective diagnose for medium and big-sized enterprises, covering all the key areas in the company, allowing the comparison of its results with the indexes stored in an international database, containing more than a thousand companies from 32 different countries (Gariba, 2005).

The Benchstar methodology then, was adapted from the MIB, for suiting the SME's characteristics and needs, seeking to disseminate modern management techniques, and to communicate what the market leaders, contained in the database, are doing to secure their leadership position (Mazo, 2003). The application of this tool allows a complete analysis of the firm's management practices and performance and its competitiveness compared to others in the same sector or region.

The Benchstar methodology aims at: disseminating modern techniques of business management, and report what the leaders contained on an international Database are doing to ensure its leadership position.

It is composed of six phases, which are:

- Survey
- Visit to the company
- Measurement discussion and fitting
- Measured data processing

- Presentation of the results to the company
- Client satisfaction measurement

**Practice and Performance Index**

The methodology uses two concepts for the establishment of comparison parameters, the Practice index and the Performance Index. The practice index is related to the management and technological tools and techniques in the productive system and the performance index measures the company's performance through the practices implemented (Mazo, 2003). It uses two types of graphs to present the results, the first one is the Radar Graph, and the second one is the X-Y Plot, called the Practice and Performance Graph.

The radar graph is composed by five axis, each one with a scale from 0-100%, the position of the company in a specific aspect is represented with a point, linking them with a line, forming a closed polygon of five faces, the corners of the polygon represent the aspects that were measured: Innovation, Innovation Organization, Competitive Intelligence (CI), Monitoring and New Product Development (NPD).

The second graph uses a boxing analogy (Hanson and Voss, 1995, Mazo, 2003). The basic test of validity of the model is to correlate the use of Best Practice versus Performance, the designated areas in the graph are:

- *World class*: Those with both practice and performance higher than 80%.
- *Innovatives*: Those with practice and performance higher than 60%.
- *Contenders*: Those with both practice and performance higher than 50%.
- *Promising*: Those with 50% or more of the practice but had yet to enjoy the performance benefits to the same level.
- *Vulnerables*: Those with 50% or more of the performance scores but without having the enduring best practice to the same level.
- *Reactives*: Those with practice and performance below 50%.

The Benchstar measures four key Practice Processes: Organization for Innovation, Competitive Intelligence, Product Development and Monitoring.

Finally, the variables that measure performance are organized in a separate group, called Innovation Activities which include: Cycle Time – From product release to market availability, Cycle Time – From product design to product release, Market share, Quality of new product in relation to specifications, Introduction of new products (last 2 years), ROI Time, New product/process release time, Innovative Capacity, Workers satisfaction, Functional product performance and Customer Satisfaction.

## III. Research Methodology

This study was undertaken within a small digital communication solutions manufacturer in Brazil, which was identified by the authors as a benchmark in innovation practices, confirmed by several prizes awarded to the company state and nation-wide by science and technology agencies.

The methodology had two phases, first, a deep bibliographical survey on several Cianet's documents; and second, multiple on-site visit to the company from June/2006 to April/2010. The timing of the visit enabled a greater understanding of the innovation model developed and used by Cianet as well as a better contrast with prior documentation and findings.

Semi-structured interviews were conducted with several employees from Cianet. Interviewees were drawn from different levels of Cianet, including senior management, mid management, and operational area.

The CEO and some operational employees were interviewed on multiple occasions, allowing examination of several aspects of the process over time.

### Company Background

Cianet Networking[1] provides digital communication solutions for several markets around the globe, by developing and incorporating technologies in a convergent and flexible way. With 15 years of market and based in Florianopolis, Cianet Networking is an industry that has as its goal to provide solutions in digital communications for the global market by developing and adding technologies and services in a convergent and flexible way.

The technologies developed by the company allow users to reduce costs in the implementation of market-oriented systems for data, voice / data and quad-play, based plug & play equipment, enabling integration with existing systems without complex configuration. The solutions are fully compliant with current platforms, also allowing the transparent implementation of VoIP, IPTV and VoD (video on demand).

The use of federal tax benefits, at state and municipal levels, allowed the company to face Asian competitors in the Brazilian market. In this sense, Cianet Networking reported a 40% increase in revenues in 2009 compared to the previous year. Moreover, the number of employees increased 10% over the same period.

The innovative and entrepreneurial nature of the firm are visible through the various awards they received: FINEP[2] Award in 2005 and 2008 - was second placed in the regional South in the Product category and third in the SME segment, respectively; Excellence Award in R&D for the Yearbook Informatics Today in 2005 and 2007 (winner); Expression of Technological Excellence Award 2007, SME category; Best apprenticeships practices Trophy by FIESC/IEL 2006; Innovation featured firm in 2007 and also in 2008 by FIESC[3].

## IV. The Cianet Case

### 1 - The assessment phase

The assessment programme on innovation management was developed by the Instituto Euvaldo Lodi in Santa Catarina State (IEL/SC) and funded by the Brazilian Agency for Project Funding (FINEP). The programme methodology was adapted from a European benchmarking tool, namely 'Made in Europe', which aimed at benchmarking best practices in European companies in the mid 90's.

[1] http://www.cianet.ind.br
[2] Brazilian Agency for Project Funding (FINEP)
[3] Santa Catarina State Industry Federation (FIESC)

After adapting the ‘Made in Europe’ methodology to the Brazilian context, the IEL/SC started applying it in big-sized enterprises allowing the comparison of the results against data stored in an international database, containing more than a thousand companies from 32 different countries (Gariba, 2005).

Later, the methodology was adapted again in order to comply with the needs and requirements of Brazilian SME’s aimed at seeking to disseminate modern management techniques in use by European firms (Mazo, 2003).

IEL/SC selected five SMEs in the State of Santa Catarina for the pilot study. This paper will study the implications of the assessment programme on one of the chosen firms. The assessment tool was applied in 2006 and produced as final result two graphs summarizing the data collected.

Figure 2 shows the positioning of the case study in relation to the World leaders in the electro-electronic sector based on the measurement of Innovation Practice (61.60%) and Innovation Performance (52.73%), boxing the firm in study inside the ‘Contenders’ area in the graph, according to Hanson and Voss’ boxing classification (Hanson and Voss, 1995, Voss et al., 1997).

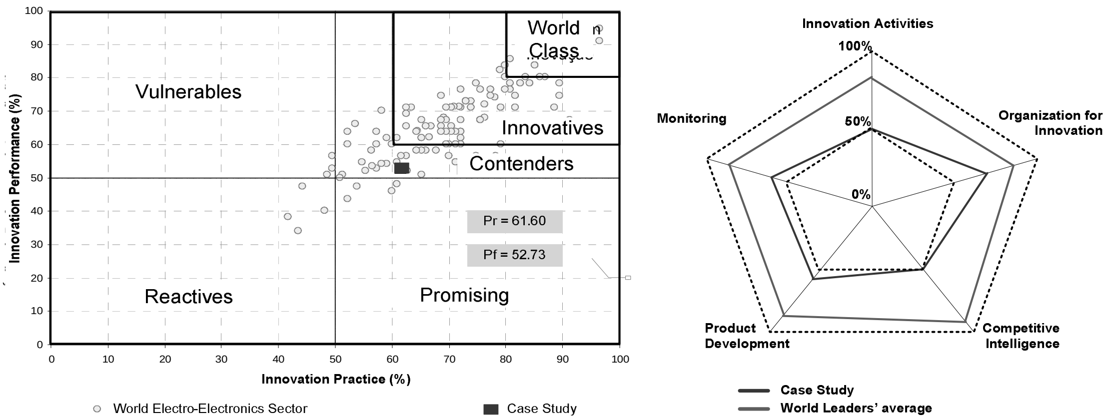


Figure 1. Results of the assessment programme

The ‘Contenders’ area holds firms which have shown practice and performance indices higher than 50% but, despite its efforts have not positioned themselves as ‘innovatives’ nor ‘world class’ companies yet, which means that the collection of management routines used by the firm is not sufficient yet to achieve sustained competitive advantages.

## 2 - The post-assessment phase

After the presentation of the final report by IEL/SC in 2006 to the firm’s managers and a meeting held in August 2007, some aspects were discussed and analysed, in order to identify some of the causes that contributed to obtain those values in Practice and Performance indexes.

First of all, it was determined that the methodology didn’t consider explicitly the environmental context of the companies studied in Brazil, in the sense that some of the weaknesses identified by the assessment tool were known to the firm’s managers, however because of the unavailability of more own financial resources, lack of supporting public policies, etc., these actions (e.g. specialized equipment for product testing, ERP system, extra staff for quality management, etc.) weren’t executed.

These characteristics could inevitably affect the performance and practice indexes, since benchmarking companies of different contexts, like the Latin American SME's and European world class companies, present exogenous variables, that sometimes are determinant factors for producing biased values.

Afterwards, an improvement plan was designed. The firm adopted an strategy-driven approach, by focusing on a top-down management, working over Strategic Planning concepts, in order to analyse internal and external aspects of the company (Jeston and Nellis, 2008). Some models were used in order to establish an innovation- driven strategy, among them, SWOT analysis, competitive forces and environmental aspects as well as core competencies (Porter, 1980, Hamel and Prahalad, 1994).

Until April, 2010, the implementation process was still in execution. The firm is positioned now on four pillars: Diagnosing, Internal Technology Analysis, Project Management and Competitive Intelligence.

Periodically, new diagnosing activities are made internally, which seek to evaluate and identify performance gaps in the innovation process. The internal technology analysis is supported by the SWOT model, aiding to understand the current technological positioning of the company. The activities for project development are supported now in tools and techniques of Project Management.

And, finally competitive intelligence systems were implemented. The results after four years of implementation have shown an improved control over current and new projects, a better alignment with innovation for employees, more qualitative and quantitative information processing improving decision making and a stronger market focus. The implications of these changes have led to a greater number of projects being developed by the firm, and also, a greater number of new products going to the market.

## V. Conclusion

Innovation initiatives have been increasing its importance for Brazil. The positive outcomes of those initiatives were caused by 1) government support, 2) university research and 3) firms and industry qualification and improvement.

This paper has proven that Innovation Management benchmarking is an effective initiative for improving organizational performance. This paper presented the challenges a small high-technology firm faced when implementing an innovation management and measurement system, through their first three phases: diagnosing/benchmarking, action plan proposal and implementation.

The experiences gained by Cianet Inc. in the process, as showed in this paper, facilitated the identification of the causes that were preventing the company to reach higher performance levels and the establishment of actions aiming to eliminate or at least reduce those causes.

These experiences also showed to be positive for the implementation of a continuous innovation management cycle inside the company, incorporating periodic meetings with the IEL/SC staff in order to measure the changes perceived by Cianet.

Another relevant fact that was learned from the Benchstar application in the case study company was that some of the weaknesses of the methodology were identified, especially regarding to contextual or situational variables, that impact directly on the indicators measurement and analysis, creating a feedback process for the IEL/SC Institute in order to improve the BM.

The results after three years of implementation corroborate the success of the model, when reached a better visualization and control over project development, improved qualitative and quantitative information processing and specially, a greater number of new developed projects and with market insertion. As one of the corporate managers suggested “it has been a positive experience with a clear and visible development of the company with a sharper focus on innovation”.

The need for companies to focus on innovation and to design, implement and manage innovation activities as a core competency inside the firm. Second, the need for a process of organizational change, which enhance drastically the performance of such initiatives.

The next step for Cianet Networking is to continue with the implementation process, and to start a new innovation practice and performance measurement in order to visualize the qualitative and quantitative changes experienced in the process.

## Acknowledgments

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# Management of a virtual technology development enterprise

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**Abstract:** For a large variety of technology development tasks, a company-external network is increasingly becoming the solution of choice. However, the laborious and time-consuming build-up of specific networks, the high complexity of network management, the lack of a single external access point and the often uncertain quality of results turn this option into a dead-end situation from the point of view of many companies. To resolve this dilemma, an innovative solution is suggested: The so-called 'Virtual Technology Development Enterprise' enables the advantages of a well-kept network of partners via a structure similar to the 'Virtual Factory'. A central coordinator, being the sole visible counterpart for the customer, leads case-specific networks for each technology development, with the participants being recruited from a managed pool of potential partners. The challenge in enabling this specific set-up, which has not been in the focus of research until now, is to define the roles, the cycle of activities and the cooperation within the network. For example, this involves the specific steps of steering a development project or in the controlling and revision of the available partners. In this contribution to the ERIMA 2010 proceedings, the new methodology will be explained and mirrored on already existing networks.

**Keywords:** technology development, cooperation, network, management, virtual organization

## I. Technology development is increasingly becoming a networked process

Due to the increasing speed of technological change, the importance of interdisciplinary technologies or complex technological systems from various technology fields is growing constantly (Ermisch 2008). This and specific properties of technology development in contrast to product development (Voegele 1999), like for example the uncertainty of results, the required degree of individual freedom in science or the interdisciplinarity lead to challenges. Because single companies do not possess all the required personnel and technical resources for such technology development tasks in-house (Gassmann and Gaso 2004), they need cooperations with external partners. Therefore, the insight of sciencists and practitioners is that technology developments and innovations will in the future almost always require a network. Especially rare topics that will not return often are suitable for an external technology development in a network (Zentes 2005), because networks help to benefit from available solutions from different areas (Gassmann and Gaso 2004). Such a network cannot simply be realised by simple bilateral, cross-institutional cooperations, but will require more complex network structures with a larger number of participants and the capability to transfer knowledge and to adapt constantly. Recently, technology development in networks is becoming more and more widespread in industry and is accepted as a fact by innovation and organizational research (Håkansson et al. 2009).

## II. Case study: An European technology development network

Because the fact is well known that challenges in the management of networks still prevail, a number of technology development networks were analyzed from the coordinator's perspective. One of these networks is an European Union-funded project which develops a high precision, resource-effective replicative manufacturing process in the area of high precision optics production. The need for this technology development stems from the constant trend towards the miniaturization of products together with an increase in their performance that requires the integration of more and more functions in today's everyday technical items. Cell phones that simultaneously act as high resolution digital cameras and modern motor vehicles that use a range of highly integrated microsensors to provide increased driving comfort and safety are nowadays common (Nollau 2009). Central to a large part of such applications are extremely demanding optical glass components. For the manufacturing of such high-end optical components, European industry needs an advanced replicative production technology. However, the development of such technologies is highly interdisciplinary and very complex and therefore requires a large development network with a large number and variety of partners. Additionally, such a project would be much too large and the required efforts surmount the capabilities of single industrial companies in the precision optics market, which is mostly dominated by knowledge-intensive SMEs.

The project advances the development of the technology and makes precision glass moulding for optical products accessible to European business. With a consortium of 23 industrial and research partners, the network is covering the entire process chain of the replicative optics production technology, from the manufacturing of the tool to the assembly of the final product. For the whole process chain with various interdisciplinary topics, like coatings or machine controls, the network benefits from experiences from different areas, that are accessible via the numerous partners and their variety of know-how. Additionally, the technology development task is characterized by a strong interlinkage of the single work packages. The different steps of the process chain as well as the partners that are working on these can be seen in Figure 1.

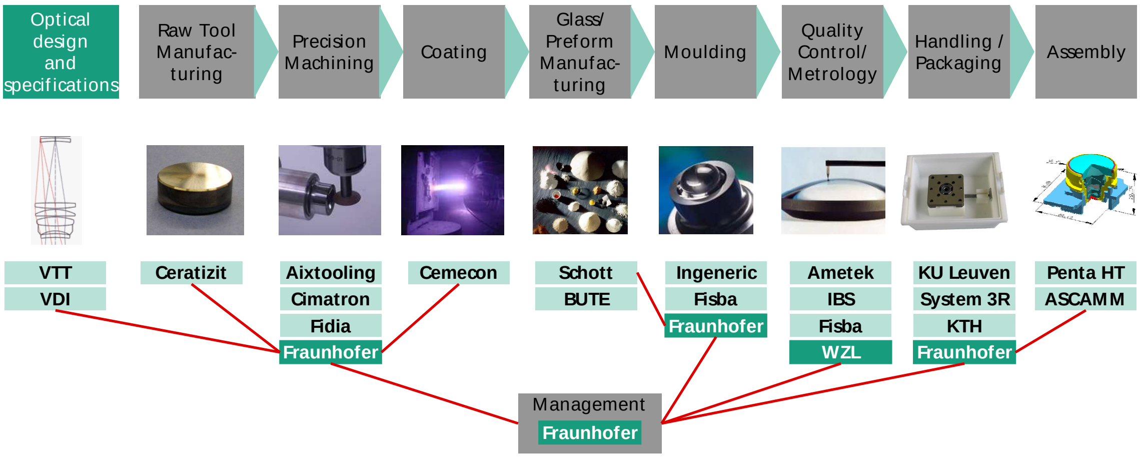


Figure 1. Process chain that is being developed in the case study network, including responsible partners for the single steps

As is shown in the schematic drawing of the process chain, the management of the network is based on a strong involvement of Fraunhofer IPT as the central coordinator. Both for the coordinator and the involved partners, the characteristics of the technology development task lead to various challenges in the management of the technology development network.

## III. Challenges in the management of technology development networks require innovative management practices

The main advantages of a technology development in a network are the improved flexibility regarding the availability of competencies and capacities (Gassmann and Gaso 2004) and the potential for an increase in efficiency (Kloyer 2005). As in the case of the studied network, rare (Zentes 2005) and interdisciplinary (Ermisch 2008) topics can be accessed and experiences from different industries can be profited from with the help of the network partners (Gassmann and Gaso 2004). Unfortunately, a conflict exists between the required scientific independence and the lack of formal power relationships in the network on one hand and the quality and efficiency goals on the other hand. This conflict of goals between autonomy and control is able to paralyse the cooperation (Sydow 2006). In detail, it leads for example to unclear modalities in the assessment and payment of partners, the distribution of intellectual property rights, the assignment of tasks and responsibilities and the process of the technology development project (Kloyer 2005).

A central coordinator manages the network project and has initially assembled the group of partners out of companies and institutions that had been known from previous cooperations. Thanks to large experiences in managing networks and to the employment of known partners, the network is successful. However, this network requires a strong involvement of the coordinator not only in the administration and coordination but also in the research itself. In general, the handling of technology development networks is commonly considered a challenge and even a risk for the coordinator (Gerybadze 2005). To distribute efforts and responsibilities more evenly, formal management roles like the leadership of single work packages are taken over by qualified partners in the studied network. On an underlying layer, there is a strong network of personal communication between scientists from all partners – this network is used for informal communication and quick scientific exchange. However, the first set-up of the network was very time consuming. After the start of the project, it still took long until the functioning of the project was guaranteed not only by the formal relations but also by such informal structures. It is a known fact that not only the operation, but also the build-up of technology development networks, especially for new topics, consume often more time and budget than originally planned (Ermisch 2008). This can be accepted in the studied project because it is one of the main goals of the European Commission’s funding to establish these informal relations, too. However, this is not the case for industrial projects, that have other criteria for success. Additionally, the difficulties grow if, unlike in the case of the studied network, no pool of known partners is available because the capabilities and competencies of unknown potential network partners are hard to estimate. With unknown partners, also the quality of the results of a technology development project is insecure (Camarinha-Matos 2005).

In the worst case, the technology development in a network can fail because of organisational and efficiency problems (Gerybadze 2005). In practice, this leads to a demonstrably high rate of failures for technology development networks which increases with the number of participants. For bilateral cooperations, which are commonly considered as the smallest possible network, this rate of failure is already at 30% (Ermisch 2008). In order to avoid a failure and reach the desired results, an elaborate network management needs to be done, which requires experienced managers and ties down valuable personnel for a long time (Sydow 2006). These raised management efforts lead to higher transaction costs for the whole technology development network – not only for the network manager but for all participants (Zentes 2005). Because technology development networks can only be attractive if they have lower transaction costs than other options for technology development, their attractiveness is currently still limited because of the mentioned problems (Voegele 1999). Therefore, innovative new management practices are needed to support the industrial application of technology development networks.

## IV. Existing solutions

It can be learned from both the studied case and the existing research on the topic that the management of technology development networks is a challenge and that a specific solution to help resolve the problems is needed. While solutions are existing for single parts of the problem, and while approaches can be found for similar topics like collaborations for product development, there is no sufficient solution for the problem addressed in this paper. Especially, a research gap can be diagnosed in the subtopics with the highest relevance: the case-specific set-up of networks and efficient network structures[1].

[1] This is verified by KOLLER, LANGMANN and UNTIEDT in an analysis of the state of the art on the management of innovation networks (which are, in fact, subject to much more research than technolgoy development networks): “t shows …, that still many questions regarding the specific configuration – especially on the organization and the leadership, but also on the distribution of tasks and results – are left unanswered.” Koller et al. 2006

Research is approaching the technology development in networks from two perspectives. On one hand, factors for the motivation of the cooperation and its success, properties of existing networks and the like are assessed empirically. For example, HAKANSSON[1] pointed out the importance of networks for innovation (Håkansson et al. 2009), without giving further instructions on how they must be structured, ROTERING analysed success factors empirically (Rotering 1990) and HAGEDOORN has done empirical analyses of different modes of cooperation and sectoral differences (Hagedoorn 1993). In practice, all these empirical works can only serve as the basis for a further development, as they offer no sufficient solutions in themselves.

On the other hand, scientists are working on approaches to structure networks methodically and to support their build-up and management. An overview of existing research on technology-related alliances and cooperations was given by GERYBADZE, who has also worked on the restructuring of cooperative projects for more effective management (Gerybadze 2005). In the 1990ies, the 'virtual corporation' was invented by DAVIDOW and MALONE (Winand et al. 1998). A specific subtype of this is the 'virtual factory' (Schuh et al. 1998). The experiences with this concept, which is so far not specifically adapted for technology development, serve as a basis for the development of an innovative solution that is presented as follows.

## V. An innovative approach: the virtual technology development enterprise

An innovative management approach has been developed, which helps to eliminate the existing deficits and to take advantage of the full potential for transaction cost savings of technology development in networks. With this methodology, the technology development is based on a network, without the typical challenges of a network affecting a customer. Because the customer is able to handle this development just as if he was cooperating with a single enterprise, the methodology is named "virtual technology development enterprise"[2]. The developed method enables complex and elaborate technology developments, exceeding the competencies and capacities of a single contractor, to be executed in a network without creating large management efforts for the customer. For this, the typical disadvantages of a network are avoided and the advantages are strengthened. A complex network management and a sensible distribution of powers and responsibilities is needed for this. It has been concluded that an adequate means to realize an efficient management is a focal instance (Schuh and Wegehaupt 2004), which also interfaces between customers and network. Because this central coordinator is able to configure case-specific networks, it is possible for him to offer various technological topics to his customers. For such a large variety of topics, the central coordinator[3] must be able to configure quickly and easily a case-adapted team of network partners (Winand et al. 1998). These partners are recruited from a so-called „pool"[4] of known companies with evaluated capabilities. Thus, as can be seen in Figure 2, companies can participate in the virtual technology development in three different levels: they can present their capabilities[5] in a pool of potential partners, take part in a technology development project network or even be the central coordinator.

[1] For example with his work „Industrial technological development: a network approach"

[2] This name is chosen in accordance with the "virtual factory" (Schuh et al. 1998) and represents a different interpretation of the term "virtual" than is common for example in connection with "virtual reality". Therefore, a clear boundary is drawn between the virtual technology development enterprise and the "virtual engineering", which takes advantage of techniques of virtual reality, simulation and CAD. Consequently, the virtual technology development enterprise is a subtype of the virtual organisation with the purpose of technology development.

[3] The central coordinator is a type of development service provider that is specially enabled to manage a technolgoy development network and can also be called "focal instance", "central enterprise", "coordinator" or "broker" Winand et al. 1998

[4] In literature, similar concepts are also named "Virtual Organization Breeding Environments"

[5] With the profile of requirements for the capabilities given by the central coordinator.

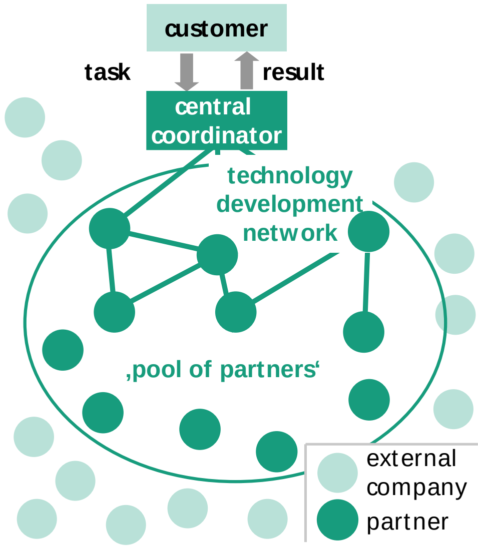


Figure 2. Schematic representation of the structure of the virtual technology development enterprise

To enter the pool of potential partners, aspirant companies must first be evaluated by the central coordinator. If a customer requests a technology development, the central coordinator chooses suitable partners for the task from the pool. These partners form a case-specific network which executes the technology development with the management of the coordinator and is disassembled after the end of the project. The configuration of the case-specific network as well as the network-internal distribution of responsibilities and subtasks is also in the hands of the coordinator. The work of the central coordinator is supported by the methodology that is being developed. For this, first the challenges that are associated with cooperating in a technology development network are analyzed. Then, a structure and a process of the virtual technology development enterprise are set up. Finally, a method for configuring the collaboration and for distributing responsibilities and subtasks among partners in accordance with the characteristics of a technology development task is defined. The general structure of this method is shown in Figure 3 and its most prominent elements will be explained in the following chapters.

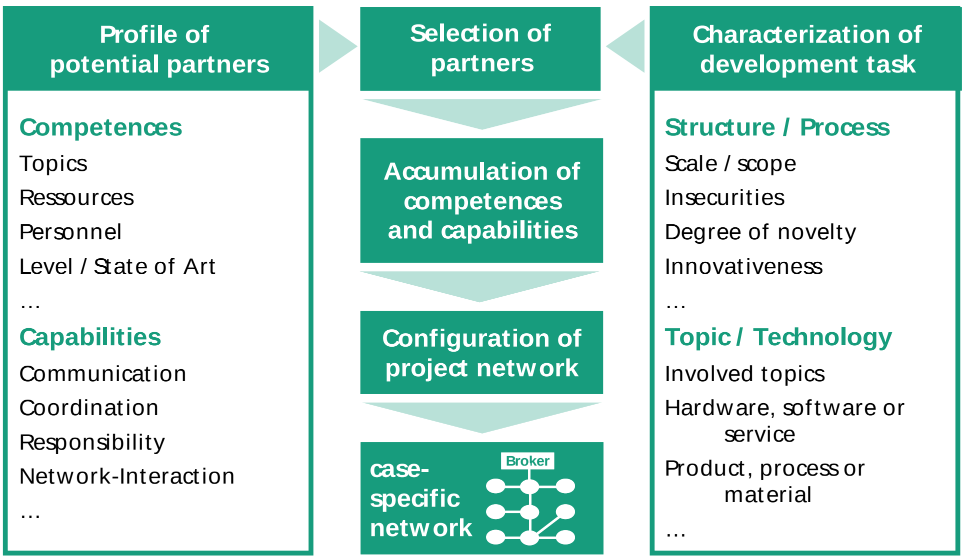


Figure 3. Method for the configuration of case-specific technology development networks

As was seen in the studied case and explained above relating to the process and roles of the virtual technology development enterprise, the configuration of the network and the selection of partners plays a vital role for the success of the technology development.

## VI. Characterization of technology development tasks

The configuration is based on a sound characterization of the technology development task. For example, if the technology development task contains a full process chain with various steps belonging to different scientific disciplines as in the case studied above, a larger number of project partners from different areas might be required. Furthermore, for such a partition into separate steps it might be beneficial to have an according organization within working groups inside the project network. Then, the thematic involvement of the central coordinator must be decided based on a comparison of his competencies with the requirements of the task. In the discussed case study, a large part of the single topics in the network are accessible to the central coordinator, who is therefore involved in the management of most working groups. This implies different roles for the network partners than if the management of the working groups had been completely in their hands.

For the characterization of the technology development task, a complete model, that is able to cover the full complexity of the object to be described, is currently being developed. Out of all possible technology development tasks that can be imagined, first of all those types are selected that are suitable for a development in a network. For the network to make sense, the tasks should for example have a minimum of complexity and interdisciplinarity, and should not belong to a company's core competencies. Thus, the focus is slightly narrowed onto certain types of tasks, which is a first step to simplify the characterization. The characterization itself then consists of two main parts: one part is related to network structures and processes and contains topics like modularity, interdisciplinarity or the required effort of the task. The other part is related to the content, or topic, of the technology development task and therefore focuses on the technological aspects of the task. Among these are not only a description of the topic and subtopics but also for example the steps that are required for the development (e.g. laboratory work, software development, simulation, metrology, demonstrator set-up, etc.) or requirements on the results (demonstrators, proof of feasibility by laboratory, measurement results, etc.).

## VII. Selection of partners

Another important decision that is based on a characterization of the technology development task is the selection of partners. In the case that was studied above, the network of partners was chosen by the central coordinator. This was done with a rough idea of the task and the required results. Then, the details of the task were defined in cooperation with the partners. This iterative process is typical for a European-funded network project but would not have been possible in an industrial project or with another type of public funding projects.

The selection of adequate partners requires a characterization as well – in this case, a profile of the potentially available partners needs to be drawn. This is complicated by the fact that many different types of potential partners exist, for example companies, universities, single experts, institutions or development service providers. Since all these could participate in a technology development network, the characterizing profile needs to account for a large variety. Similar to the characterization of technology development tasks, the partner profile is divided into two main parts: One part contains a description of competencies that are related to technology development in itself, for example the available topics and subtopics, the available technological resources and equipment or the level of profundity of knowledge that is available. The other part then focuses on capabilities for cooperation in networks and for contribution to a collaborative project[1].

[1] Such network-related capabilities, e.g. coordination- or communication-competencies, are in literature also named 'integrative competencies' or 'complementary competencies' *(Ritter et al. 2000)(Mildenberger 2000)*

However, the selection of partners is not finished with the characterization of their profile – the most important part of the step is still to come. The selection of partners itself is an iterative selection algorithm. It repeats single selection decisions, in which a matching of the task characterization with the available partner profiles takes place. Because the selection of partners that are basically able to contribute to the technology development is not enough, the algorithm guarantees not only a ‘best fit’ in each single decision situation, but aims at reaching an overall optimum for the entireness of the partner selection. For this, it incorporates an overview of how far the requirements stemming from the task characterization can be answered with the sum of the partners’ competencies and capacities. The single requirements are divided into ‘must’ and ‘can’ requirements, with the latter of the two additionally prioritized. Furthermore, some requirements on the partner selection are not resulting from the task characterization, but are determined by the properties of technology development in a ‘virtual enterprise’ type of network. For example, the selection of partners must assure that there is no network-internal competition regarding the topics that are involved in the technology development.

## VIII. Configuration of a project network

The successful selection of partners for the technology development clears the path for the set-up of the technology development project network. For this, various topologies can be chosen amongst, as can be seen in Figure 4.

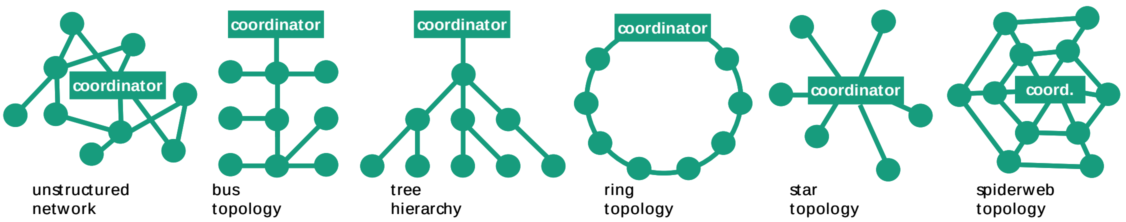


Figure 4. Examples for network topologies, incorporating a central coordinator

In between the different network topologies, the integration of the single roles and the network-internal interaction and communication differ greatly. Therefore, the different topologies have advantages and disadvantages, which need to be taken into account when deciding on a set-up for the project network. For example, a star topology increases the level of control, but also the effort for the central coordinator, while a tree hierarchy saves efforts for the coordinator, but has higher requirements on the network-related capabilities of the partners in the position of a knot.

In addition to an efficient set-up of the project network, rules and principles which steer the cooperation are defined. These rules are needed to respond to such challenges of the virtual technology development enterprise, that cannot be answered with management, structure and process. Rules are in some cases, when there is a need to regulate something without limiting the flexibility for technology development too far, better suited than a fixed structure. For example, rules contain aspects regarding the usage of project results or they demand that the amount of business generated from participating in a virtual technology development enterprise must always stay a minor part of the overall business of each partner.

## IX. Conclusion and Outlook

The challenges and success factors in technology development networks were analyzed from the perspective of the coordination of an EU-funded project and other networks. Benefiting from these experiences and based on the state of the art of management research, an innovative methodology for the management of technology development networks is being conceived. With the methodology, the central coordinator is transformed into a “knowledge entrepreneur”, who is able to offer solutions for a large variety of technological questions. This methodology, called “virtual technology development enterprise”, is currently in the scientific development and will in the future need to prove its potential in practical application.

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# Social Software in Support of Collaborative Innovation Processes

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**Abstract:** This paper aims to present an ongoing research work and its preliminary results concerning the potential advantages of the use of collaborative environments based on social Web applications to support collaborative innovation processes. For that purpose, the objective of this work is to develop a collaborative innovation management system supported in a social Web platform where the different stakeholders of an organization's ecosystem can collaborate. The work presented here is based on the requirements collected through an analysis of the factors behind already existing successful case studies and will contribute with new successful practices on the deployment and running of enterprise social software. .

**Keywords:** Collaborative innovation, collaborative environments, social software, idea management

## I. Introduction

There is no doubt that innovation has been established as the way to reach and gain competitiveness. With the rise of emerging economies, the business is entering an era of extreme competition where the only way to survive is to innovate. That is exactly one of the pillars of the Lisbon strategy (European Commission 2007), rethought by the European Commission in 2005, innovation as a driver of business change. Today organizations that survive are not the strongest and largest, but those with greater ability to adapt to changes.

On the other hand, researchers are giving clear orientations in the factors affecting a successful innovation process. The latest trends establish that participatory processes of innovation and collaboration with agents outside the organization are more successful than the fully developed within it (Blindenbach-Driessen & van den Ende 2006;Faems, Van Looy, & Debackere 2005;Hall & Bagchi-Sen 2007;Laursen & Foss 2003;Mazzanti, Pini, & Tortia 2006). Innovation based on experimentation and collaboration between organizations, universities, public sector and, of course, users (Amirall 2008).

The challenge now is how to encourage and facilitate such participation and collaboration through the use of social software This research focuses on the deployment and running of a collaborative innovation platform based on social software within a set of organizations. For that purpose, a collaborative innovation management model and its supporting social Web platform will be developed. The next section outlines the research context introducing the concepts of innovation, collaborative innovation and enterprise social software. In this section authors also make reference to the companies that compose Mondragon Corporation, cause they configure the context where this research work is being developed. The third and fourth sections describe the objectives and the proposed approach respectively and finally the last sections summarize the expected results and contribution of this research work.

## II. Research context

### Innovation

Innovation is a widely utilized and defined word, both by practitioners and scholars. The definition given by Schumpeter in 1934 (Escorsa & Valls, 1997) considers the introduction into the marketplace of a new good or production method, the creation of a new market, the finding of a new raw material provider or the implementation of a new structure in a market. Padmore, Schuetze, & Gibson (1998) go on with this philosophy, and define it as any change in the inputs, methods or outputs that manage to improve the commercial position of a firm and that is good for its actual market. Gee (1981) and Pavón & Goodman (1981) add the process concept to these definitions, and in the same way, Amabile (1988) adds creativity and Tang (1998) adds the project concept. One of the most recent contributions is the one made by Galanakis (2005), who refers to scientific or technological knowledge as the raw material or input for an innovation. In this work innovation is understood as an idea, process, system, method, service, product, policy, etc. that is characterized by being new or improved and commercially accepted.

The innovation concept as the process associated with it, has not remained constant over time. The way of understanding the innovation process, has evolved from a linear vision, where the activities occur sequentially, to a more complex one, in which activities overlap in time and there are feedback loops.

Both innovation and the innovation process have incorporated concepts such as decision making and the resulting feedback loops, and the integration or overlap in time, in order to integrate the different actors in the process over time, reducing development time of the innovation process. Finally, the integration of new technologies and networking, allowing the acceleration of the process on the one hand and learning from others and / or collaborating with others for mutual benefit on the other hand (Errasti, 2009).

The first reference to innovation models, is the one known as the linear model of innovation, concept on which studies such as Godin's (2006) make a review of its origin and historical evolution. The linear model comes only from the market perspective, ie only considers innovation processes and products that are new to the world, rejecting as product or process innovations that are new to the company, as the adoption or imitation of an innovation.

This linear model has not been the only one, and although still in use, other models have appeared throughout the twentieth century. In this sense, Rothwell (1992) presents four generations of models on the evolution of innovation, i. Technology push, ii. Demand pull, iii. Interactive Model and iv. Integrated Model, and predicts a fifth one where the networking is gaining importance. Hobday (2005) takes Rothwell's approach and raises the five generations indicating their strengths and weaknesses. More recently, Cantisani (2006) analysis the different generations, focusing on the first three, and gathering input from various authors as Bush (1995) and Stokes (1997).

The economic challenges facing require new models and concepts around innovation. The XXI century has been defined as the century of technology and knowledge, and the explosion of the information age (Robin 2002), so that these concepts should be incorporated actively in the immediate future of the innovation process. The innovation models that will be defined to face the just started twenty-first century, should take into account the evolution undergone by their predecessors, taking the best of them and leaving aside the weaknesses identified by various authors. Concepts such as feedback loops, knowledge, information technologies, markets, networking, etc. must appear in the new models. After a research work within innovation models developed through 30 years (from 1977 to 2006), Errasti, Oyarbide & Zabaleta (2009) concluded that most of them showed a similar baseline, and that the main difference lied in the particularities incorporated to the model in each particular case.

Among the new models, highlights the concept Open Innovation, a concept coined by Chesbrough in 2003 (Chesbrough 2003) and subsequently studied by Christensen, Olesen, & Kjær (2005), Chesbrough & Crowther (2006), Amirall (2008), Enkel & Gassmann (2007), Fredberg, Elmquist, & Ollila (2008) and the European Commission itself (2007). The Basque Government has also internalized this new concept of Open innovation and this is reflected in the Science and Technology Plan established for 2007-2009 (Gobierno Vasco 2007).

Another trend closely related to Open Innovation is collaborative innovation. It implies the participation of a set of different agents - ranging from employees to competitors - of an organization's ecosystem in the innovation process. The authors understand collaborative innovation processes from two perspectives: firm-centric innovation and network-centric innovation. Firm-centric innovation is focused on leveraging internal resources for the acceleration of innovation processes. On the other hand, network-centric innovation extends the innovation process beyond the organization's borders. Depending on the extent of the openness three sub-models can be distinguished.

- *Ecosystem innovation*. This concept responds to the classical extension of an organization's value chain. In many cases, the different stakeholders within a value chain possess better knowledge in certain areas. Through the opening of the innovation process this way both the organization and the different stakeholders will benefit from knowledge sharing. Google is one of the best examples of this kind of innovation (Lyer&Davenport, 2008).
- *User innovation*. This is a concept introduced and developed by Prof. Eric Von Hippel (1988, 2005). User innovation refers to the innovations performed by end users rather than manufacturers. Perhaps the most documented case study is the one of Lego (Koerner 2006). Lego engineers worked for seven years in order to develop the robotic game Lego Mindstorms and just three weeks after its launch there were a thousand hackers working on new developments of the robots. There were different contests organized by Lego and the bottom line is that the product was improved. Nowadays there are 20.000 Lego fans that have organized online innovation communities
- *Crowdsourcing*. The term was first introduced by Jeff Howe (2006) and it is defined as "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". Procter & Gamble and its "Connect and Develop" platform is one of the best early examples of crowdsourcing (Huston & Nabil, 2005).

When speaking about the innovation process, it is usually related the R & D expenditure, and indeed, numerous studies have attempted to study the type of R & D activity carried out by the organization (Beneito 2006, Cassiman & Veugelers 2006; Errasti et al. 2009; Love & Roper 1999), its R & D effort (Booz Allen Hamilton 2005; Czarnitzki & Kraft 2004, Eurostat 2008; Errasti et al 2009; Love & Roper 1999, Mukherjee & Marjit 2004; Tomita, Ikeda, & Takeda 2008; Wakasugi & Koyata 1997), how this activity is organized (Argyres & Silverman 2004; Love & Roper 1999, Mukherjee & Marjit 2004) and the innovation results obtained accordingly.

In reference to the most operational part of the innovation process, innovation requires a flow of ideas, obtained either through a formal or informal process (Koc & Ceylan 2007). This process is more effective in organizations that combine two characteristics: first, a control that drives the initiatives of the different strata of the organization and, second, a high commitment of the participants with the organization itself (Nijssen et al. 2006). In addition, staff must have an innovative range of information and knowledge sharing with different scientific disciplines and between different departments as a means to secure the connection between business opportunities and organizational capabilities and production (Nijssen et al. 2006).

In conclusion, the phase of the innovation process where idea management is developed, is one of the most critical phases. Once the idea is selected, the following tasks are related to the project management's phases, the process becomes an innovation project, whose management is supported by project management. So that the main difficulties are related to the very first phase of innovation, the front end of the innovation process, where idea generation, enrichment and selection are held.


Figure 1. The three phases of the idea management process.

### Enterprise Social Software

Social software is the term used within this research to refer to the different applications and technologies associated to the Web 2.0 term, widely introduced and depicted in a seminal article by Tim O'Reilly (2005). Web 2.0 or the social Web is a new generation of Web applications, technologies and values built upon massive and increasing data source that foster participation and collaboration among users.

At the heart of the Social Web we can find values like transparency, cooperation, openness, ease of use, all of them heading towards the building of an architecture of participation focused on the users. In fact, one of the core patterns of the Social Web is the harnessing of collective intelligence through the mentioned architecture of participation that uses network effects and algorithms to produce software that gets better the more people use it.

On the other hand, the term enterprise social software refers to the application of social Web applications to enterprise environments. There is an increasing number of case studies of the use of blogging, social networks, wikis and such social applications to foster collaboration and thus boost innovation processes. It is also worth noting the focus of social Web on people. The social Web is designed to ease the collaboration among people and foster user participation.

A well-designed architecture of participation will not only facilitate collaboration and connections among employees but as a consequence, will also enhance the ideation process of an organization. As concluded by Professor Ronal Burt in his study entitled “Structural Holes and Good Ideas” (Burt 2004) “better social connections improve ideas”. This study was carried out through a set of interviews to 673 workers of the Rytheon supply chain group. The results showed that employees who do not access the knowledge, perspective and ideas of others generated lower quality ideas. On the other, hand well connected employees generated higher quality ideas. These findings are confirmed by a recent study carried out within a Swedish company (Björk & Magnusson 2009) .

A recent study by the Collaborative User Experience Group at IBM (DiMicco et al. 2008) has delved into the employee's motivations for participating in corporate social networks through the analysis of their behaviour within Beehive, IBM’s internal social network. One of the findings which differentiates corporate social network from open social networking sites like Facebook or LinkedIn is that employees are open to meeting each other for both personal and professional reasons. When it comes to actual motivations “it appears that employees are motivated to use Beehive for three reasons: connecting on a personal level, advancing their career within the company and campaigning projects and ideas within the company.

Social networking platforms provide the basic functionality for collaboration among employees and provide a proper environment for the early stages of the innovation process. However, in order to be successful a set of guidelines must be set up in. With regard to the articulation of the architecture of participation and the adoption of social Web applications within organizations, governance is one of the main factors to be taken into account. In this sense, there are two main approaches: a top-down approach guided by management and a bottom-up grassroots and emergent approach. Reknown analysts like Dion Hinchcliffe and Andrew McAfee prefer mixed and “top-down” approaches respectively as it is necessary for the management to signal what’s valued inside the organization and to create culture (Hinchcliffe 2010) (McAfee 2009).

The architecture of participation needs to provide “the mechanisms and methods for the contributions of participants to be coordinated, integrated and synchronized in a coherent manner” (Nambisan & Sawhney 2008). It must establishe the rules and policies that will regulate collaborative networks such as the ones described above. A good example of this is the set of social computing guidelines established by IBM to guide IBMers behaviour within the social Web (IBM 2010).

**Mondragon Corporation**

Companies that compose Mondragon Corporation (http://www.mondragon-corporation.com), are conscious of the growing need of innovating in order to keep on being competitive. Innovation has become a social phenomena, and they need tools, mechanisms, they need help for managing it.

These companies know that each of them, by itself, has a short life expectancy, and that to become strong, interaction with surrounding agents and collaboration are mechanism that must be used. But, how could they do that? Many of them are familiar with the use of the web 2.0, and use different social software, but the main problem is that most of them use different software, and that they are not compatible in many cases, so that, when trying to interact, it becomes an impossible task. That's one of the main reasons of starting this research work.

The aim of the corporation is to foster innovation, and that for, they understand collaboration is needed, but it's easier said than done. They want to achieve a collaboration environment, where different agents, such us providers, competitors, customers or anyone willing to collaborate could do so. Giving an answer to this challenge is the second reason for beginning this research work.

## III. Objectives

This work builds on the results of different studies and brings preliminary experiences into the field. The main goal is to describe best practices on the use of collaborative environments for the management of the collaborative innovation process based on a practical experience within a set of companies. This main goal breaks down in the following sub goals:

1) Analysis of the factors behind the successful deployment of social Web applications within organizations.

2) Analysis of the success factors of the management of the early front-end of the innovation process.

3) Analysis of existing tools to support collaborative innovation processes

4) Development of a best practices model for the adoption of social media within corporate environments

5) Development of an open source social software suite to support the early stages of the innovation processes

In the long term the aim is to design a collaborative innovation management system supported by advanced Web technologies but at this stage the focus is on the early stages of the internal innovation process, that is, idea management.

## IV. Methodology

The approach is based on an incremental development cycle, where requirements guide implementation, and the use of prototypes during validation generates new requirements. The approach is thus validated in all phases of the project. Experience from all phases is continuously utilised to improve the next cycles of development. The following points summarise the activities within each phase:

- ***Requirements.*** In this phase the requirements will be collected from two main sources: end users and state of the practice research. With regard to end user requirements, a field study will be performed through a set of interviews to different representatives of the involved organizations in order to assess the use of social Web technologies. This input, together with the state of the practice research will be used to depict the case studies.
- ***Implementation.*** Once the requirements are gathered the necessary prototypes and the methodology will be developed. The prototypes will be in the form of Web applications for different purposes based on social technologies. These applications won't be developed from scratch, the aim of this project is to build on cutting-edge existing working solutions and apply them to the industry. The methodology will provide a stepwise approach for the adoption of the prototypes within an organization.
- ***Validation.*** During the validation phase a set of piloting activities will be carried out within at least one organization surveyed previously. These activities will be performed within real production scenarios and will be based on the depicted case studies. A set of indicators will be set up in order to evaluate the result and the success of the project.

## V. Expected results and contribution

Organizations must realize that it is more and more necessary to open to the world and collaborate with the entire ecosystem that surrounds them. Social Web applications can facilitate this step, but if the organization is not ready for assimilation and exploitation of knowledge generated as a result of this openness, little can be done.

As the result of this research work two products will be developed, both entirely end-user oriented, in this case, organizations. The products, although clearly distinct are necessarily complementary:

- A collaboration innovation model that provides best practices and requirements for the Web platform.
- A prototypical collaborative innovation management platform based on enterprise social software.

In order to measure the performance of the social network a set of metrics have been defined. The following list shows the different categories and specific metrics defined:

- Traffic metrics: measure the usage of the social network and highlights different behaviors
  - Web page views: measures number of page views within the experimentation period.
  - Unique visitors: measures the number of unique visitors to the social network during the experimentation period.
  - Average time spent on site.
  - Repeat visitors: percentage of visitors that return to the site.
- Structural metrics: measure the size and connectedness within the social network.
  - Number of members.
  - Percentage of active members: percentage of members that have contributed to the site with comments, posts or event submissions.
- Activity: measures the participation of the members within the social network
  - Number of blog posts.
  - Number of events: event calls published by users in the platform.
  - Number of forum discussions.
- Innovation: these kinds of metrics measures the results of the innovation metrics. There are many metrics to measure the results of innovation but due to the early stage of the project two main metrics have been chosen:
  - Number submitted ideas: number of ideas submitted through the forum mechanism.
  - Number of comments on ideas: number of comments on posts related to new project ideas.

Apart from these quantitative metrics users will also be asked about their initial motivations for their participation in the corporate social network.

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# New projects evaluation method for the 24h of innovation®

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**Abstract:** In this paper we present the "24h of innovation®" event based on the challenge to explore a design proposition and generate with engineering and management expertise a virtual or physical prototype in only 24 hours. Indeed, students and design practitioners form teams of around 10 members and select projects which are proposed by industrial companies. Just after the 24 hours period the obtained results (new concepts or solutions, sketches, CAD and virtual product models, prototype, storyboard, website…) are then presented by the teams in 3 minutes before a board of examiners. This contest "The 24h of innovation®" had been organized by the ESTIA engineering institute since 2007 and had gathered annually around 250 participants from students and professionals design community. First this article aims to present both on pedagogical and industrial dimensions how this experience stimulates open collaborative design activities of innovative products and services as part of the formation program for future engineers and managers. Second the question of the complexity of the evaluation of innovative design product proposition is also addressed here by the analysis of the data collected during this experience. And finally, the paper is concluded by presenting how innovation measurement could be efficient in selecting the best innovative projects in the scope of "the 24h of innovation®" challenge.

**Keywords:** 24h of innovation, MIM, Collaborative Project, Innovation Measurement, Creativity

## I. Introduction to "the 24h of innovation"

Innovation is one of the most important challenges for any companies. Today, the generation of a new product, process, service, and business model to meet user's requirement is a key point for any successful industry. In this paper, we focus on the early creative and inventive phase that is often defined as the conceptual design phase. Based on a more or less precise definition of a problem or topics, the creative design phase should lead to a new concept proposal, by giving arguments to make a commitment decision.

The "24h of innovation®" challenge is an annual event that is organized by the engineering school ESTIA in Biarritz since 2007 (http://www.24h.estia.fr/). This concept could be considered as an innovative way to generate creative ideas for companies in a few times, taking into account that the participants have 24 hours to work on innovation developments (such as new products and services, new business model, new communications…) proposed by industrials coming from different sectors, research laboratories, associations, and private persons.

The event is organized as follows: a call for project proposal, for participation, and for sponsors is sent out before the event, and the most interesting topics, participants, and sponsors are selected. At the official opening of the event, the topics are revealed, and the teams are formed (with a maximum of 10 persons per team). Then, each team has 24 hours to develop creative solutions (innovative concepts or prototypes) corresponding to the project proposals. At the end of these 24 hours period, each team presents its propositions during the short time of only 3 minutes in front of all the participants and a jury formed by innovation professionals. This jury then awards the best teams with prices offered by the event sponsors.

Since 2007, 73 projects in different sectors have been developed for SME's and large companies. Other subjects were submitted by laboratories/schools/universities, project managers of companies in incubator or particulars. Overall, 700 persons attended the different edition of the 24h of innovation® since 2007. Participants are generally motivated to work in team and to share a real problem faced by a company.

The goal of the 24h of innovation is to foster socio-technical practices (Subrahmanian et al. 2001) of the young engineers and students that are full involved in a short but intensive collaborative period with the use of creativity and design tools, marketing and communication methods... We think that this situation helps the young modern engineers (Kurfess 2001) to be integrated more easily in the socio-professional networks.

This event is thus a good opportunity to generate new ideas, to increase the creativity for the benefits of the company. Since 2007, the concept of the 24h has been exported in other places. After three editions (2007, 2008 and 2009) with several hundreds of participants from over twenty institutions in France (mostly universities, business and engineering schools…) and others universities in USA, Spain, Italy, this event confirms its innovative character. The growing interest of this event was also demonstrated by the participation of several companies (from SMEs to large and multinational groups) being either project manager or sponsor of the "24h of innovation®", which is now a registered trade name. This interest is justified with a good feedback from such an event. Indeed, the companies propose a subject (e.g. an idea, a requirement, or a research theme) simply explained by a single title with a short descriptive phrase. The companies receive then, quickly and for free, concepts of innovative solutions, virtual models, or prototypes. Moreover, by the restrictive but stimulating format for the students, most of the teams produced results with an achievement level that revealed to be quite surprising for a work realized in the short 24 hours period. Thereby, many subjects developed during the first editions, are now being industrialized and about to be launched on the market by companies. For example, after the second edition in October 2008, a patent proposal is being examined for one of the developed projects.

However innovation measurement and evaluation are one of the key points for the development of any innovative projects in their early phases. So in the scope of the 24h challenge we face also the problem of judgment and evaluation by the different stakeholders of a creative work produced in 24h. This paper aims to propose different contributions to this point with the following structure: the section 2 reports how the activities of the different teams were followed during the 24h of innovation 2007. In the section 3, we propose a comparison of different evaluation methods that were tested during the presentations that were made by the teams during the 2008 edition. In the section 4 we describe how the MIM method could be used in order to evaluate the potential of the results obtained during one project of the 24h of innovation 2009 edition.

## II. How to follow team activities during 24h?

As the main objective of the event was to foster innovation it was excluded to propose a step to step guideline for the participants to follow their activities during 24h. Our focus was to propose a practical mean to observe the innovation design development. The adopted solution has been to propose a web based application where participants have to register and login to participate to the design event as in common virtual environment. This proposed media had the advantage to procure a dynamic environment stimulating participants to report their project progress. The application allowed setting rules such as hourly reports by every participating team. Those reports have a double objective. First, it allowed participants to have a strategic overview of activities being operated in their projects. Second, it provided to the pedagogical team an online hourly review of the whole participating teams' progress (Ducheneaut and Moore 2004). The application had two main objectives, to offer to the participants an adequate media to report their progress, and provide to the pedagogical team and exploratory observation tool on how participant innovate in 24 hours.

Students were asked to depict on an hourly basis activities they were operating so as to reach their project goals. 3 main columns resumed activities being operated in an hour:
- Project Step: The steps were represented by a scrolling menu composed of nine possibilities. Each one referring to a project life cycle step, project planning, activity planning, specifications, conceptual analysis, solutions, embodiment, prototype, project costing, other.
- Considered product aspect: this dimension describes on which product part was focusing the team in a specific hour, the possibilities were: Overall product, Specific part, Functionality, Design, Emotional factors.
- Methods and tools used: on each steps a description of the methods and tools such as software's, specific methods like brain storming, calculations were to be illustrated.

The project step definition was adapted from classical project life cycle development. The aim was to expose to the participants examples of product design phases, from which they can express how they consider the innovation design process. A text field was added so that they could explain what they meant by a specific phase, and how a specific phase contributed to the innovation process. The nine phases were designed to explore how participants manipulate those concepts to reach an innovative product design. One of the phases was "Other" to provide free expression and creation to the teams to describe their innovation project structure. Each adopted design process step was codified by a specific colour. In the web base application, a graphical table illustrated the structure of the design activity hourly, by representing different colour cell in each hour (Fig 1). We will focus on this particular aspect of the innovation design project structure by exploring the student's project configuration.

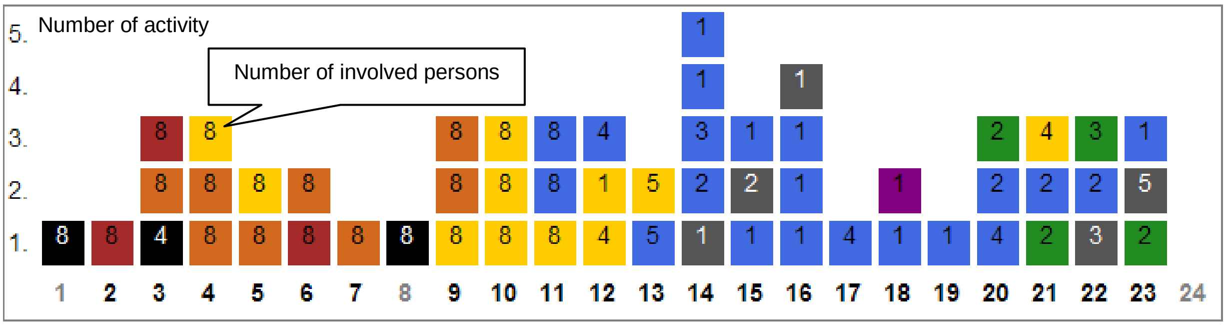


Figure 1. Example of team project steps configuration on 24 hours

The general analysis of the 19 participating teams revealed that the most used project step to describe the design activities was "Other" which represented 22% of the total 622 expressed project phases. The second most used step was "Solution" 21%, followed by "Concept" 16% and "Prototype" 12%.

| Project plan | Activity plan | Specification | Concept | Solutions | Embodiment | Prototype | Costing | Other |
|---|---|---|---|---|---|---|---|---|
| 37 | 38 | 32 | 104 | 133 | 54 | 73 | 16 | 135 |

Table 1. Total of expressed project phases

Among the 19 teams, 8 of them won a specific "prizes". The prizes concerned the following factors being evaluated by an examiners panel composed of industrials and academics. Evaluation was based on the quality of the following aspects of the developed project: Jury trophy, 2 Best prototypes, Best design, Best presentation, best technological project, Best concept, Fun project.

| | Concept | Solution | Prototype | Other |
|---|---|---|---|---|
| Winner teams | 59 | 79 | 38 | 98 |
| Other teams | 45 | 54 | 35 | 37 |

Table 2. Project phases used by 8 winner teams v/s other teams

A comparison of the used project steps among the winner teams and the other teams revealed that the most used activities were the same but in different proportions. For the Winner teams it was “Other” 27%, “Solution” 22%, “Concept” 16% and “Prototype” 10%, these percentages being calculated on the whole used activities 357 for the 1st teams and 265 for the others. The other teams focused more on “Solution” 20%, “Concept” 17%, “Other” 14% and “Prototype” 13%. The obvious difference among those teams is the number of activities launch in 24 hours. We can observe that the winner team structured their design project with other steps than the classical proposed ones. These results provide us with first facts on the behaviour of theses teams participating in the “24 hours for innovation” serious game. Further investigations need to be operated to depict the specific design process configuration used to reach innovation objective. This exploratory tool allowed us to observe how the students interact with the web base application. Functions which stimulated their participation and the way they structured their innovation activity. For the next “24 hours for innovation” event we will update the tool to have a better understanding of the processes categorized as “other” that sustains innovation process.

## III. Evaluation of the presentations

Our goal is to analyze the work of teams who worked 24h on a project, in competition against other teams. As a result, we show some data about the type of projects that have been proposed to these teams as well as the participants’ profiles.

This study focuses on the analysis of the teams just after the 24 hours of development period. A presentation according to the requirements should be done with slides and last no longer than 3 minutes. The presentations are made in front of a jury that is allowed to ask a couple of questions at the end of the presentation. Each presentation is evaluated independently in three different ways: by the jury after all presentations, by a method based on protocol analysis (with coding), and by specific indicators of design activity. The jury was composed of 4 persons who assessed the results according to 7 criteria on a scale from 1 to 10 (10 was best). The criteria were the degree of innovation, the potential of the proposed product, the finalization level, the proposal technicality, the prototyping level, the design, and the presentation. Each jury member has then been asked to reveal its 3 favourite projects. It was followed by a discussion based on the average of the results, in order to award 10 prizes: The 1st, 2nd, and 3rd prize, prototype, design, creativity and technicality, best presentation, futurist, and marketing awards, as well as the judges’ favourite. The second evaluation method is based on the protocol analysis, usually used for analyzing the design activity: individuals asking them to verbalize their thoughts, or collective (Ericson & Simon, 1993). These analyses focus mainly on the words analysis and are now often improved by an examination of gestures, actions, and use of design objects (e.g. patterns, physical and digital models, drawings). The collected data are generally very dense and rich, making the analysis tricky.

In our case, the data are captured during the presentation of the results. This situation is unique and simpler than those usually observed during the design activity. Indeed, a presentation is a communication tool towards an identified audience. Speeches are unidirectional and structured (more or less depending on the teams); their "capture" can be made by a single microphone. The place is a delimited and oriented area (the "scene"); a capture with a static video placed in the room records everything (except in special cases). Moreover, the objects are prepared in advance and not modified during the presentation (except for exception again). The technical elements of the speeches are transcribed into a text document that should be as accurate as possible. The definitive document contains approximately 9000 words, 360 words in average per presentation.

The coding is probably the most complex operation of the protocol analysis. It usually comes along with a speeches segmentation process and is consolidated by a double coding. The codes used are as follows: S: Structure, Pt: Performance targets or criteria, Ps: Effective performance, Sol: Solicitation (an achievement is defined as an answer to a solicitation), Ft: Function target, Fs: Effective function, E: External environment, in contact with the object, Nt: Need target, Ns: Need insured, U: "User", to whom the system serves.

Three criteria concerning the design activity have been evaluated from the presentations. They do not describe the activity's reality (in that case, it would have been necessary to observe it for every team) but how this activity is shown through the presentation of its result.

The first criterion is a co-evolution indicator. The co-evolution results from the inability to describe a point of view without referring to one or more complementary points of view. It is a fundamental concept that describes the design activity. The literature (Cross, 2001; Gero, 2002) refers to a co-evolution of problem/solution and actually function/structure. This concept can be extended to a co-evolution of all points of view, thus to the product parameters (Choulier 2008). The question is: do the presentations indicate a co-evolution process or just seek for ideas? The presentations can be ranked as follow (1 to 4 marks):

1. The presentation of a problem and an object proposed, with satisfaction: in the presentation, there was no sign of co-evolution.
2. The presentation of a problem and an object proposed, with examination: testing the solution is the condition for a co-evolution.
3. Listening to the presentation, one understands that the team sought to "increase" the systemic levels or / and to go further (adding functions, local structural changes…). In these cases, the functional area has clearly evolved, in-depth or by extension.
4. The co-evolution is explicitly constituted: usually when the presentation discusses "helpful" solutions that were then abandoned.

The second criterion describes a justification level.

1. There are no justifications.
2. It is the normal "intuitive" justification, the obvious fact that "it works".
3. Justifications are made and argued
4. Justifications are as completed as possible taking into account the time

The third criterion concerns the mention of the coherent process, even though it was not requested. This may be a reflex for some teams.

1. Nothing suggests that there has been a mention of a part of the process.
2. Indications are given on the process ("then", "after", "dated" actions, several successive solutions are mentioned …)
3. The process is verbalized, but quickly. For example, design tools are mentioned.
4. The process is verbalized and detailed.

All presentations of the 2008 edition have been evaluated (24 presentations out of 25 - one of them was not completed due to technical problems). For confidentiality purposes, we cannot give details on the subjects and achievements but we show a few illustrations of the final results (Figure 2).

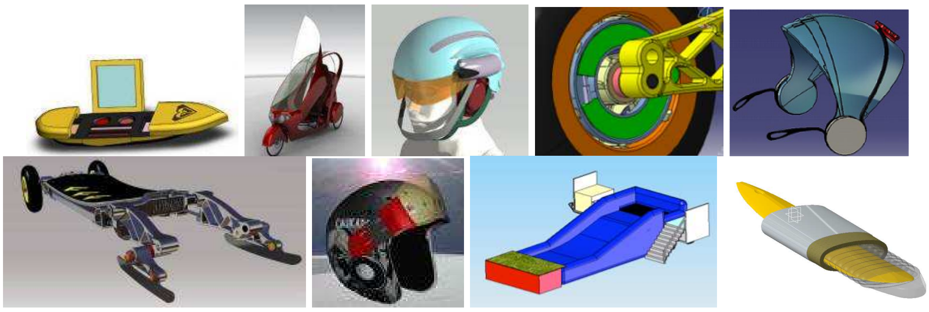

Figure 2. Examples of products concepts obtained during the 24h of innovation contest

The first analysis – and the most obvious one – is the complementary evaluation one, which allow a classification according to different criteria "Co-evolution - Justification – Process", individually or combined. However, the coding analysis is trickier for many reasons: there is several different data, variations may occur from one team to another caused by different reasons (e.g. the type of product), and finally because the numbers are low (the reason is the given time for the presentations). The distribution of different points of view will be looked at as well. These results will then be compared with the awards presented by the jury at the end of the "24h of innovation®".

As for the design indicators analysis, some presentations were also awarded in both previous groups. However, the most important element here is the significant overlap between both key evaluation which are, on the one hand the design criteria, and on the other hand the proportion of the speech affected by the structure. This is even truer when only the awarded presentations are taken into account. The awarded teams with a low score on the design criteria are in the second group. In spite of this, three teams out of five with a good score on the design criteria are in the first group. There are exceptions to this correlation, but it is important to keep in mind that the analysis is based on a small amount of numbers (due to time constraints imposed for the presentations). The type of prizes awarded by the jury must now be discussed. The winning teams with low design criteria score have been awarded with the marketing award, the judges' favourite, the design award, the best presentation award, and the futuristic award. The wining teams with a high score for the design criteria have been awarded with the technical creativity award, the 2nd prize, the 1st prize, the third prize, and the prototype award.

In the following section we propose to discuss about the MIM© and its innovation levels to help stakeholders to define a strategy to manage the future of the innovative projects.

## IV. Innovation measurement with the MIM©

MIM© has been published three years ago in order to explain how innovation could be defined in 7 levels (Monnier 2005-2009). The Monnier's Innovation Matrix© (MIM©) is an innovative tool to measure the innovation level of a supply (product and/or service). This tool is mainly composed of a two-dimensional matrix where the "X" axis represents the market level and the "Y" axis the idea, the technical level of the products or services to be evaluated. This matrix could be considered as a standard measure for different products, similar to a diagnostic framework where you may identify the parameters to be focused on in order to improve the innovation level. The MIM© is split into seven areas (fig. 3), that defines innovation in seven levels with the following semantics:

- LEVEL 1: There is only a preliminary idea for a business or a product (or service) to be evaluated. The market is not really identified. The solution to the problem is poor and needs to be confirmed. It is the lowest level of innovation
- LEVEL 2: There is a technical idea, a concept, a product or a service to be promoted in a market which is not yet identified

- LEVEL 3: There is an identified market but not a solution to answer this demand
- LEVEL 4: There is a product/service and an identified market for it.
- LEVEL 5: There is a sophisticated product/service and an identified market for it
- LEVEL 6: There is a product/service and a huge identified market for it.
- LEVEL 7: There is a sophisticated product/service and a huge identified market for it. It is the highest level of innovation.

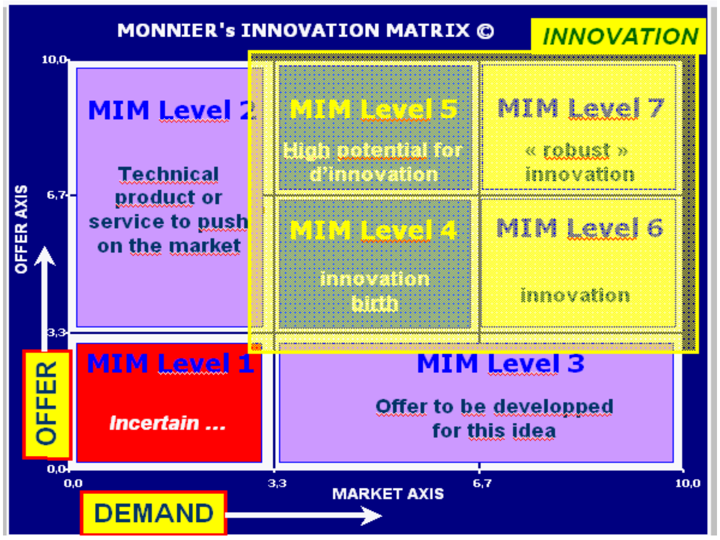


Figure 3. Monnier's Innovation Matrix©: Level of innovation for products

One project proposed by THALES R&T has been developed by one team composed of students during the 24h of innovation of October 2009. The main objective consists of studying if the “compressed sensing” algorithm could be efficient for different applications in civilian and military concept of robotics. The strategic view of the innovation evaluation at a short and long term helps decision making process. It emphases the potential added value and the return on Invest (ROI) at different stages of development.

The theory maintains that a signal must be sampled at a rate at least twice its highest frequency in order to be represented without error. However, in practice, we often compress the data soon after sensing, trading off signal representation complexity (bits) for some error (consider JPEG image compression in digital cameras, for example). Clearly, this is wasteful of valuable sensing resources. A new theory of "compressive sensing" has begun to emerge, in which the signal is sampled (and simultaneously compressed) at a greatly reduced rate.

There are many advantages with this new method: lower energy needed, less memory capacity, better restitution of the initial image, high level of security in the information transfer. The main cost of these advantages is the computing power needed for such an application.

Four students have worked on this subject. They provided a consistent report included 2 different strategies.

The first one is to consider a unique application in the spatial domain. This is a promising application domain because of a good compromise between quality and cost. The MIM© graph shows the strategic way to go from the idea to the market (figure 4 - left). In this case, because this domain required high level of quality and security, we need to reach the top high level of the quadrant number 2, that means a high level of investment to be able to win a major market which could push the technology in the level 5 of innovation and then in the 7$^{th}$ level in a very long period of time (5 to 10 years from now…).

The final proposal is to consider some other applications of this principle in different activity domains of the Thales Group. In this case, the demand could be satisfied earlier with lower investment in the supply if we address a more accessible application field (data encoding, infrared or radar application…). In this case, the way of innovation is optimized by following the diagonal of the matrix (figure 4 - right). The first applications bring resources for financing the following more complex application.

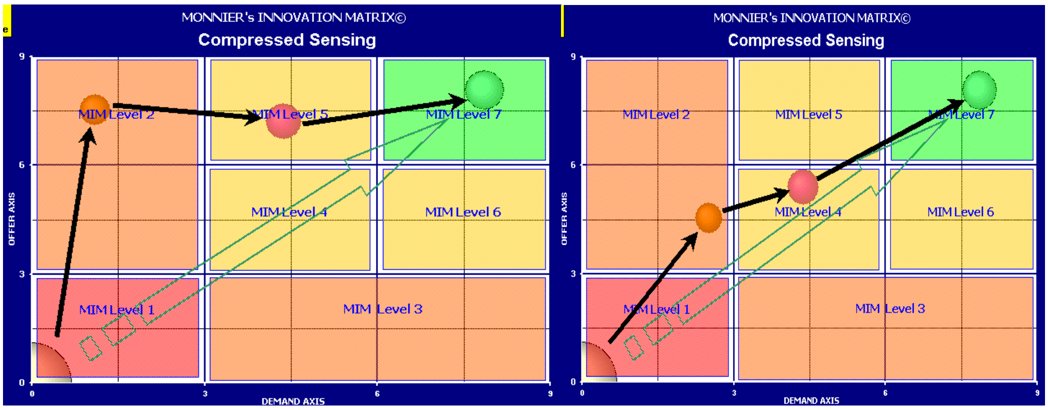


Figure 4. MIM© path for the proposed solutions

## V. Conclusion

Innovation is one of the most important challenges of the industrial companies. Today, the generation of new concepts of product, process, service, and business model to meet user's requirement is one of the key point for any successful industry. In this paper, we focus on the early creative and inventive phase that is often defined as the conceptual design phase.

Based on a simple definition of a problem or topic, the creative design phase that occurs during the 24h of innovation® can lead sometimes to a new concept proposal. Thus the concept of 24 hours for innovation is very useful for both companies and students. This paper aims to present both on pedagogical and industrial dimensions how this experience stimulates the creative and collaborative design activities of innovative products and services as part of the formation program for future engineers and managers. The involvement of students in such an event is very well appreciated by companies which may have a new vision of products usage and business opportunities. This event is also a good way for students to evaluate companies' capability to propose innovative subjects.

This article presents three independent types of evaluations of projects made by student teams (and therefore relatively inexperienced in inventive design) during the «24h of innovation®». These 3 evaluations have been made by a jury based on criteria related to design activity (co-evolution and justification quality) and by a presentation coding. Although the results are based on a particular format (characterized by the time constraint of 24 hours), it is interesting to note a certain coherence between the three types of evaluation that are established on different assessment criteria. When it comes to judging the design quality of the presented product, overlaps are observed in between the three types of evaluations, which then become complementary. The criteria (until then kept by the jury) can be completed by evaluations of co-evolution and justification quality, but also by the proportion of the speech made on the product, its performance and its functions.

We have also noticed some differences that are still explainable. Indeed, out of the 25 teams, 2 groups that have presented an advanced technological work (in terms of the coding analysis performed after the event) haven't been awarded by the jury of the 24h of innovation. This discrepancy is mainly explained by the profile of the jury members who were mostly not receptive to the arguments proposed by the groups since only one person out of the 4 jury members comes from a mechanical engineer education.

Naturally, the presentations include a low proportion of the product presentation and a superior proportion of elements justifying the choices made. The best presentations are also those that have focused on the complementary aspects of the product structure. Still, the functional and behavioral aspects are, depending of the teams, sometimes neglected. This could be easily fixed by providing contents for the presentations. The problem presentation or the objectives given by the students can also be improved by asking a more complete statement of the problem. Except for few exceptions, the statement of the process, not requested, is missing. At this point, there is a conflict with the allocated time for each presentation. Explaining the concepts of co-evolution, the multiple points of view, and the product interaction with elements of its surroundings has certainly a positive impact on the quality of the presentations and even on the quality of the work done during this event.

However, the works done during 24h are most of time only a “creative raw material” that must be analysed and rework by the different stakeholders. As any creative session, it is important to pay a specific attention to the outputs that should be analysed regarding different tools and approaches. The question of the complexity of the evaluation of innovative concept proposition is here addressed here by the analysis of the data provided by one team during this experience. If the question of the evaluation of works done by the team of the 24h of innovation® has been previously discussed (Legardeur et al. 2009), this article presents an analysis of one project made by a students team with the MIM© matrix that gives a shared view of the current situation and presents the future in term of R&D and marketing perspectives.

We think that the use of the MIM© matrix could help the company to analyse the results of the 24h teams in order to help them to integrate these specific creative outputs in their innovation roadmap strategy. Thus for any creative concepts, we show that is important to produce a possible scenario to anticipate about the evolution according to the market and the offer perspectives.

The next 4th edition of 24h of innovation® is scheduled for 22-23rd of October 2010. More information is available online on the official website: www.24h.estia.fr

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# Service systems as sustainability enhancers: a soft systems view

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**Abstract:** This paper presents research work that has been started in the frame of the ERALAN project. The research deals with one of the strategies that are getting more and more attention when trying to reduce the impact of human activities on the environment. The paper introduces the practices that could make service systems become enhancers of sustainability. It also highlights the complexity of such operations. In order to manage this complexity, a new paradigm based on soft system is presented..

**Keywords:** Soft systems, transdisciplinarity, system, service, dematerialisation.

## I. Introduction

Aiming to reduce the impact on the environment, more and more policy makers and business managers are becoming concerned with sustainability. One of the strategies that is getting increasing attention is the development of service systems or service oriented systems.

Within the framework of the ERALAN project, a group of researchers from ESTIA-Recherche and Mondragon Unibertsitatea Enpresagintza has decided to open a line of research to study service systems in more detail. The ERALAN project is funded by the “Fondo Europeo de Desarrollo Regional” (FEDER) in the frame of the Interreg IV A program, Programa Operativo de Cooperación Territorial España-Francia-Andorra 2007-2013 (POCTEFA).

Often sustainability is not the main reason of shifting from a product based business model to a service based business model. Indeed, some companies work to provide more and more functionality to their customers, or they just see it as necessary in order to stay competitive. For other companies, it is a way to get into new market opportunities. While some companies move to service systems as a natural extension of the relationship with their customers, others define service systems as the main strategy of the company.

Shifting from product to service has been studied in past research with different conceptual approaches:

- “Servitisation” is a term that has been used to describe the service orientation in traditional product oriented businesses.
- Service-dominant logic (SDL) has been also utilised, along with goods-dominant logic (GDL) and shifting the value from a goods exchange point of view to a use point of view.

The concept of a service society distinguishes the industrial economy and the service-oriented economy; in the latter, customers are looking for performance and not the simple acquisition of a product.

The service economy is often referred to as a functional economy, where the role of the manufacturer shifts towards the provision of services. The functional economy aims to create additional value for the customer, by consuming as little material and energy as possible.

Dematerialisation is another term that has increased in importance in past few years. Dematerialisation of the economy is an important field of research which deals with the problem of reducing the overall energy and the intensive use of materials in human activities.

Lastly, the term "product–service systems" (PSSs) has been defined as a system of products, services, supporting networks and infrastructure that is designed to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models. For consumers, PSSs mean a shift from buying products to buying services and system solutions that have the potential to minimise the environmental impacts of satisfying consumers' needs and wants. This requires a higher level of customer involvement and education by producers. For producers and service providers, PSSs mean a higher degree of responsibility for the product's full life cycle, the early involvement of consumers in the design of the PSS, and design of the closed-loop system [O.K.Mont].

## II. Sustainability enhancers and new business models

Service systems could be sustainability enhancers if, for example, manufacturers are encouraged to increase the recyclability of the product or the design of the product could be based on modules, with the reutilisation of some modules. Maintenance of these modules could also be part of the service, aiming for a longer life of the product and hence a reduction in the use of materials.

If the manufacturer pays for the material use and energy consumption during the use phase, there is an incentive for the manufacturer to design products to be more efficient during this phase.

Although service systems could be sustainability enhancers in many cases, it is necessary to undertake life cycle analysis in order to compare them with a product based logic. Some services, developed in order to avoid a simple product sale, could have a higher negative impact on the environment than the product sale.

The difficulty of a life cycle analysis based comparison is the determination of the scope. We find more and more analysis of energy and material use for product manufacturing, but analysis of service systems is often based on assumptions that do not take account of the full impact on some stakeholders in the service system.

There is a need to develop methods to assess the environmental impact of service systems, to take into account the complexity of such systems.

In order to establish the foundation of service system business model, it is necessary to apply the sustainability concept to the entire life cycle of the service system. Moreover, the satisfaction of user needs and the final functionality should be taken as a starting point of the business model, instead of the development and manufacturing of a product.

The term "life cycle" needs to be redefined, and needs to include the very early stages of the projects which could impact the business models. Logistic and supply chain aspects, such as reverse logistics for recycling, should also be considered more significant and much earlier; and finally it is necessary to take into account more fully the utilisation phase of the systems.

The product model based on requirements gathering, product development and product introduction in the market, is a linear model which fits less and less well into new markets and is unable to propose systems that take into account of different and changing environmental constraints.

## III. A soft systems view

We live in a period when the behaviour of many markets is turbulent or chaotic. Companies must be open to modifications and can no longer work with rigid specifications. Besides, final functionalities should be considered in the early stages of projects and they could even be the foundations of the business model. However, delaying the final specification to the latest possible time can reduce risks, by keeping options open. Hence, it is necessary to make time explicit in the management of service system life cycles.

Complexity arises from the several and heterogeneous needs, opportunities and constraints of different market segments, customers, users and other stakeholders. Moreover, it is necessary to take into account the environmental constraints.

Shifting from product to service needs a new view of the system that is being developed.

From a soft systems point of view, human beings rarely have a complete picture when interpreting their environments. The representation is usually incomplete and it does not fully integrate the complexity of the environment. Each stakeholder will describe his or her own functions, points of view and constraints, which will be different to those of other stakeholders for the same requirements or outcomes. Moreover, these functions and scope will be affected by modifications over time.

One aspect of the soft system view is the hypothesis that systems are just mental representations and not “pictures” of a reality that “exists” out there.

This paradigm could help us to deal with complexity when shifting from a product to a service orientation. It seems absolutely necessary to think “out of the box” and not to stay with a product based logic, even when a service logic is being applied in the company.

Transdisciplinarity is another aspect of this paradigm. Transdisciplinarity takes into account the views of several disciplines in the early stages of a project, but it mainly gets onto the decision board of the “makers”, as Morin has described. When shifting from product to service, the concept of transdisciplinarity seems to be a key point to deal with innovation and design processes, taking into account new approaches and new scopes. Therefore when thinking about services, it is necessary to change the mental model of the system, which is one of the features of the soft systems method.

From a product-service specifications point of view, this paradigm could be informed by existing methods and tools that are typically used in the software development, such as agile methods. Agile methods are based on frequent, incremental delivery and rapid adaptation to the current reality of the project. They are mainly used in software development but their root concept can be applied to projects in other contexts, since they are specially tailored to complex situations and projects where requirements are changing continuously.

The key point of agile methods is that all stakeholders are considered in the scope of the project and are often customers who become part of the agile development team.

Agile development is not based on detailed specification documents, since it is assumed that requirements and how they can be met will change during the life of the project and that it is not possible to make an accurate inventory of all the requirements at the beginning of the project. Instead, agile methods are based on frequent intermediate deliveries that make the customer react in the early stages of the project and hence create the possibility of changing the requirements.

From the point of view of sustainability, it is necessary to consider new approaches in order to analyse energy and material use. Rather than searching for the optimum for each subsystem, it is necessary to think about new synergies between products, services, uses, etc., which will lead to a decrease in the environment impact of the whole system. Sustainable product-service systems cross company boundaries, and integrate relevant stakeholders in the early processes and apply a new cognitive model based on transdisciplinarity.

To improve sustainability, it is also necessary to think about the upstream phases of the supply chain, since it will define the suppliers and the transport constraints for the future service system. All this information is necessary for effective design and is then provided to the consumer, promoting "design for use" and therefore promoting efficient utilisation of the resources.

We are seeing a shift away from the producer efficient supply chain, based on cost minimisation for the producer, towards the customer effective demand network, in which customers seek to maximise the value to them, often becoming part of production, acting in an agile way.

## IV. Problems for the research to investigate

The thoughts and convictions presented previously enable us to specify our research challenge.

We suggest the hypothesis that the service oriented business model is not systematically synonymous with many of the principles of sustainable development (not only from the point of view of ecological but also economic and social aspects); from this hypothesis, we propose to think about some methodological approaches which could help the project stakeholders (business venture holders, companies existing, public agencies) and the resource holders (tangible or intangible, cognitive or material, financial or not, etc) to integrate this dimension (sustainable development) in the construction (or evolution) of the business model and to evaluate the impact of this dimension in terms of value creation.

## V. The concept of Business Model

The term "business model" is often used today, in particular by managers and business founders; but, it's only since the 2000s that research on economic models appeared in established reviews or books, mainly dealing with e-business. Demil and Lecoq (2008) tell us that we had to wait for Magretta (2002) and Afuah (2004) to clarify the concept and thus to apply it to sectors other than Internet start-ups. Demil and Lecoq (2008) highlight three dimensions related to the concept of economic model:

It aims at analyzing income generation, i.e.all the proceeds from the monetization of the resources

It relies on a combination of resources and competences monetised via one or more offers to customers.

It includes an organizational dimension insofar as it allows implementation of the structure adapted to the objectives of income generation while defining in particular, among the various activities of the value chain, those which the company will carry out (and the structure of the associated costs.).

So, the authors propose to define the "economic model" as the choices made by the organization in order to generate income. They remind us that these choices rely at the same time on:

- the resources and competences to be monetized and/or to be developed,
- the offers that can be made based on the resource and competences of the organization
- on the activities necessary to generate revenue.

If some generic models company development exist at the sector level (for example: the low cost model, the open source model and the free model), the business model can also indicate all the specific choices that a company can make.

So, we think that it's interesting to review the differences existing between strategy and business model insofar as these two concepts are very close. Demil and Lecoq (2008) state that if the strategy aims to identify the competitive advantages of the company, the business model is more focused on the way to generate income and profitability, and so consideration of the role of the environment is weaker. The other significant difference is that the business model is more concerned with new projects or new business (in order to generate new sources of incomes and thus, new structures of costs) whereas strategy focuses on established businesses by underlining what exists. The last difference deals with the object of the analysis: the business model relies on internal resources needed to build a new offer when in the traditional strategic approach (which is a global approach) these resources must create the competitive advantage.

So the economic model or business model seems to be an operational tool, and it is more pragmatic to put the company into an evolution and development perspective whereas the strategy is more an attempt to explain the company's current positioning by making a list of its own resources and identifying its position compared with those of its competitors.

If the strategic thought is more located at the "macro" level, the business model approach is more at a "meso" level (Demil and Lecoq, 2008) in order to be more operational and to make relations not only between the functions impacted by the business but also between the strategic and the operational levels, by identifying how decisions could generate income. As a consequence, the business model constitutes for the company manager a kind of framework for action and decision.

Now, we would like to go further in thinking about the development of the business model, about the impact of representations, transdisciplinarity and interaction between stakeholders in this process and the key elements for operating choices and generating income.

Within this framework, we refer to research by Jouison and Verstraete (2008) which considers the business model as "a convention built about a potential business where there are some stakeholders with different levels of involvement who have provided some resources in exchange for which they have some expectations from the relationship. Their study and the proposals about how to build a business model are about the field of business creation, although they question if their tool could be used for analyzing the strategy of an existing company. Companies are involved in changing environments, and these conditions require frequent reference to the strategy and to take into account the signals from the sector in which they participate in the construction of the strategy, strategizing en route Avenier (1997).

We note that a lot of companies evolved from a business based on products to a business based on services, considering the services as a new source of income, in addition to the product income. This focus on services could allow the volumes produced to be reduced and a complete offer to be made, reducing as a result the impact of production on the environment.

Jouison and Verstraete (2008) remind us that there are different accepted meanings of the concept of business model (BM). They also remind us that the majority tends to limit the concept to the sources of income and doesn't consider the BM as the total of the sources of value generated by the business, whether related to money or not. More over, the authors explain that the business founder must convince his partners who own some resources (tangible or intangible), and this aim leads the founder to deploy an exercise to persuade partners to become stakeholders.

So, the actors must collectively agree and recognize that the business model is relevant and that the collective representation of the business model proposed by the creator and which is gradually developing could be considered as a convention to be established within a supply system, a collective representation strongly influenced by the stakeholders' expectations. The BM is considered as the representation of a business which explains how the value is generated, remunerated and shared, in a durable way. The BM is a convention about a business to which all of the partners who bring some resources take part more or less directly in exchange for future value from a more substantial relationship. Thus, the entrepreneur activates a progressive process of engagement to the conventional register which he proposes.

The theory of conventions suggests that the behaviour of a person results from what he or she believes about the behaviour of the others in a particular situation and at a given time. So, the business founder (the entrepreneur) will have to make his vision understood in order for it to be agreed, for instance an innovation (Jouison, Verstraete, 2008). The role of imitation implies that the first members encourage the others to join. The authors identify different types of agreement:

- Agreement regarding the intensity and the quality of work required, formalized through the business plan, aimed at constructing the vision and the business model of the project (which must generate sufficient shared value in order for it to be maintained)

- Agreement regarding the industry sector which works according to the rules established by the companies in the market.

- Agreement relating to the resource holders and to the specialties in question (for example: venture capital and in general various types of financiers) that the business founder must know of to be understood and to be able to interest them.

The BM is at the centre of the entrepreneurial process which, for the authors, includes five stages, with porous borders: idea (to find a business idea), opportunity (does the idea meet a market in order to become an opportunity?), the business model, the strategic vision and then the business plan (which formalizes the vision of the business founder). So, in order to support entrepreneurs and their ideas, Jouison and Verstraete (2008) propose to assist them to think about the design of the business model according to a pedagogical approach defined in three phases: A set of questions aimed at a better understanding the idea, the market, the competitors, the resources needed, the actors who own these resources, their influence and the value which the project generates for these actors.

These questions make easier the identification and analysis of the idea, the market, the positive points of the project and the risks, the customs of the industry sector, the competition, and the stakeholders' agreements… The questions about business model allow the identification of the potential resources to be mobilized, the way the entrepreneur want to link them (and the organisational configuration he wants to implement, which is a crucial point), the market participants who could become stakeholders, and the value generated for each stakeholder from the application of the resources. .

The second step is a series of iterations, in which the answers to the previous questions must inform a plan which identifies the people who own the resources needed for the project, and the entrepreneur's plans related to resource owners' expectations and influence, as well as anticipation of their attitudes. So, this plan can provide a view of all the potential resource contributors and their position in the project according to the entrepreneur's point of view.

The authors suggest the third step is the development of a graphic representation of the resource owners who now have become stakeholders in the project and contribute to the planning of the company's value generation. This visualisation helps to identify all the stakeholders, their characteristics, and the level of their contribution to the company's value generation for the short-term or longer-term. This stakeholder map makes it easier to visualize the business network of the future organization and by adding some qualitative criteria (e.g. colours, arrows, line thickness…), it is easier to identify the influence of certain relationships..

So, this tool can be useful at different levels: it can be used as a basis for discussion between the business founders. When there are several business founders, it can be used to share and to clarify their vision of the project. This tool can help the founders to synthesize and sum up at a specific time all the relationships, so they can identify their network and prioritise the engagement of the partners.

This tool is, in our opinion, very interesting and we want to think more deeply about applying it to our problems (i.e. identification of the value generated by the sustainable development dimension in a business based on services). Indeed, we want to think about the approach proposed by (Jouison, Verstraete, 2008) and to improve it by considering the three axes of sustainable development, considering from a systemic point of view the ecological, economical and social dimensions of the new business.

## VI. Future steps and methodology of the research

This paper was developed to present the topics in which we are interested and so open a new field of research into business models oriented to growth and sustainable development. We proposed different options and our next objective will be to choose one, in relation to our practical and grounded project and to develop it within our partnership with Eralan 2.

Thus to summarise the options available to us:

- To define the elements of a method that helps the sponsors of a project (private or public) to integrate the components of sustainable development in the design of the business model for the new activity

- To track the companies and organizations as their business models evolvewhile changing from a logic mainly centered on the maximization of income to a logic of taking into account the ecological and social aspects as well as the economic aspects.

- To track the sponsors of each project in incubation in the construction of the business models, taking into account all the components of sustainable development

Assessment of the services or product-service bundles: looking at the transition and impact of taking into account sustainable development in the BM

Thus, we will have to also specify the targets to which we will address ourselves: businesses in creation, businesses in operation that wish to integrate an aspect of sustainable development in their model of activity, sponsors of an idea or public project or similar, appraiser or contributor of resources, people having an influence on the orientation of the project.

Our scientific position is based on action research and the use of a qualitative methodology.

Concerning action research, Reason and Bradbury (2001), in a collective work devoted to this method of research, explain that they chose "the term Action Research to describe the whole family of approaches to research which are participative, engaged in the experiment and directed towards the action".

Among the arguments that Hlady-Rispal (2002) makes is one that first distinguishs between the qualitative and quantitative approaches, the following particularly seems to us to justify the choice of a qualitative approach: a will to center us on the subjects and not on distant “objects”, to include and understand the phenomenon of the training of the contractors to establish a generalization of it on the basis of our observations and our treatments (and not to test theories), to consider the dynamics of construction of the business model and how the dimension of sustainable development in the total context is taken into account, in its interaction with its environment by engaging us to show how (how this training is constructed) more than why causal, and by accepting that our own representations play a big role in the construction of our research.

On this subject, we stress that we are conscious that the “reality” which we “reach” through our talks and observations of situations can be considered rather like a construction that, like the objective, is exhaustive and an exact description of a given referent. We think that we produce explanations which are not a “photograph” of reality but a construction built in connection with this “reality”, built in order to produce “intelligibility” (Wacheux, 1996).

Because of our proximity with the context and scope of  a project which takes shape and which could be involved with the problems presented here, our choice as to the precise definition of the objective of our research will be strongly related to the context of project which we will launch and in which we will invest ourselves; we are considering in particular the construction of an éco-district in our immediate environment.

Thus we can indicate at the start that our research will be over two years of the Eralan 2 project (2011 and 2012) and we will start with the problems presented in this paper; we envisage to proceed as follows:

- Formalization of the context of the project which will be used as a basis for research
- Definition of the questions to be researched
- Definition of the qualitative methodology of the research
- Realization of the context of the project and discussions with certain relevant actors
- Analyses of the dynamics of the project and discussions
- Conclusion and proposals of the elements of the method related to the business model and business plan, taking into account of the dimension of sustainable development.

## VII. Conclusion

Shifting from product to service seems to be a good solution to take into account the chaotic behaviour of markets and the changing needs of the consumers, customers and users. Shifting from product to service can reduce the environmental impact, while providing the same functions.

But many companies stay with a product based logic even when a service logic is trying to be applied as the main strategy. Customers changing needs cannot be answered and the environmental impact does not decrease in many cases. In fact, it may increase. Companies seem to be unable to deal with the complexity linked to the shift from product to service.

A soft systems view has been presented to deal with this complexity. This view includes a new way to consider systems and the concept of transdisciplinarity as key issues for new product-service development - allowing new approaches and new scopes and changing mental models about systems to be considered.

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# Designing the interface between the development of technologies and products

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**Abstract:** Businesses are forced to develop new products or to improve existing ones to maintain their competitiveness. Therefore it is necessary to develop, select and validate technological ideas in a systematic process. After application-readiness has been proven, technologies must be transferred into development of products and processes. For realising an efficient development process, separating the processes of technology and product development on an organisational level has become common practise in many companies. Due to the separation of technology development and product development interface problems often occur in the development process. A methodically supported design of this interface and therefore a systematic coupling between technology development and product development has not been described yet. The complexity and effort of transferring technology into product development is generally underestimated. Minimising coordination effort, reducing iterative loops and securing a continuous knowledge transfer are main challenges in optimising this interface. The aim of this paper is to demonstrate the need for a methodically supported design of the interface between technology and product development and to present a design concept for that purpose. Identifying the influencing factors for the process design of the interface and therefore deriving a design concept is a central research task.

**Keywords:** Technology management, development process, technology development, product development, interface

## I. Introduction

Against the background of competition that is continuously getting harsher and innovative cycles therefore getting shorter an effective and efficient development of new technologies and products often is determinative for a product's failure or success in the market. This is why a systematic process must be established in order to develop, select and validate technologies. Technologies must be transferred to product or process development after application-readiness has been proven. Imagine if every time when a new product must be developed, it is only necessary to go to a huge shelf to choose one of the brand new, debugged technologies and integrate them in your product development process. Unfortunately, this image is far from the truth in practice. The transfer of knowledge often is problematic and commonly underestimated (McGrath et al. 1992, Ajamian and Koen 2000). However, a systematic coupling between technology development and product development is missing. This paper is aimed to focus especially the operative coupling of technology and product development projects. For this reason, the aim of this work is to demonstrate challenges and problems at the interface between technology and product development and to propose a design concept for this interface.

## II. Research Background

A non-uniform conception in the literature calls for a classification of technology development and product development within the entirety of the research and development activities in a business (according to Specht 2002). Research is understood as the general acquirement of new knowledge. Development is its first concrete application and practical implementation. In our understanding, development consists of product development (also referred to as series development), process development, advanced development and technology development. Technology development (also named advanced development or applied research) deals with the development of product, production and material technologies which have a significant influence on the competitiveness of the business (fig. 1). Product development is the generation of new products using the available product technologies. Analogously, process development is accomplished when the needed production technologies are ready to be used in production.

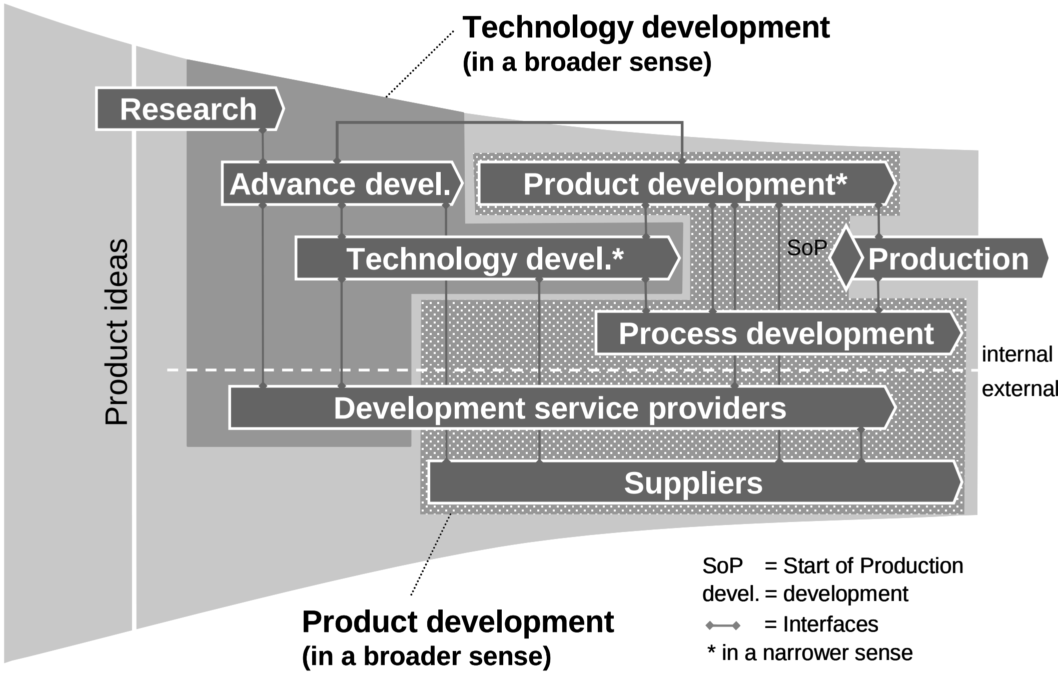


Figure 1. Development of technologies and products

It is the task of technology development to develop technologies until a maturity level is reached where basic feasibility is demonstrated and a product development project can be initiated (Homan 2005). The aims of technology development are creativity, customer benefit and level of innovation (Schuh et al. 2009). To achieve these targets, an efficient as well as effective technology development process must be ensured. Proof of principle, proof of concept and proof of application are the milestones to be verified. In order not to restrict the creativity and space of development for radical, new technologies too much the process degree of formalism must be kept at a reasonable level.

Product development is aimed at transferring the provided technologies into products. Set goals with regard to time, cost and quality must be reached (Schuh et al. 2009). Additionally products today are often complex product systems, which cannot be developed anew from ground up on a system-level. For this reason new technologies for product components are developed on the subsystem level. This also favours an organisational separation of technology development and product development. (Schulz et al. 2000). In practice, especially in large companies, this separation is well established.

On the other hand organisational separation creates an interface between technology development and product development. It must be designed carefully to ensure a successful transferring of technologies into product development. In addition to an overall consideration of the development of technology and product, which should not be part of this paper, both development processes must be linked by a technology transfer on an operational process level (fig. 2). It is assumed that minimum one technology is transferred in minimum one product, but the number of technologies and products can vary. The transfer of know-how has a special relevance because especially the transfer of high-tech technologies with a high level of know-how is complex and extensive. Until now there is no systematic, methodically supported coupling between product development and technology development (Cooper and Scott 2009, Marxt et al. 2004, Ajamian and Koen 2002, Schulz et al. 2000). With focus on the operative process design and the transfer of knowledge, challenges and problems occur at this interface which are described first in the following.

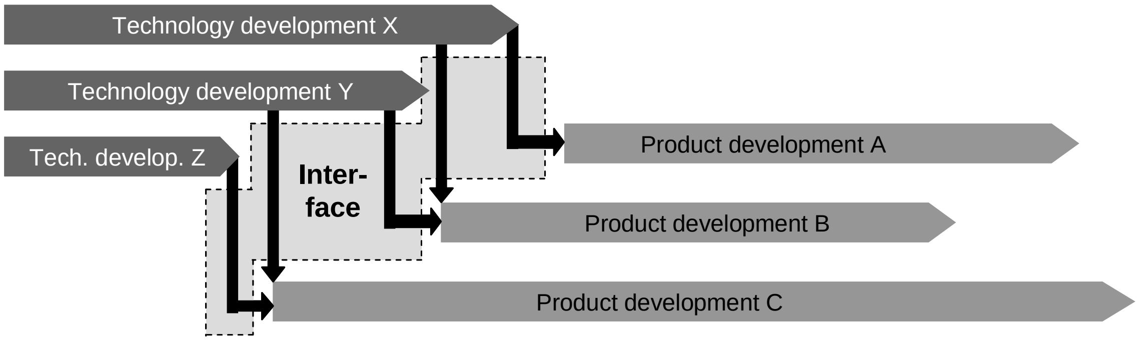


Figure 22. Interface between the development of product and technology

## III. Challenges at the interface between technology development and product development

Many executive managers assume that it is sufficient to ensure that scientists and developers document technology development carefully and transfer their knowledge in a succession of meetings. This might indeed be the basis of a successful knowledge transfer, however analysis proves that this does not suffice by far (Homan 2005, Brodbeck 1999). The complexity and the required effort of a knowledge transfer from technology development to product development is typically underestimated.

In practice this is apparent when technology developers as well as product developers are commonly dissatisfied after a technology transfer: to technology developers it might seem that the product developers have difficulties in understanding the technology development's results. Product developers, on the other hand, have the impression that the technology developers have not completely developed the technology and did not solve all the issues associated with it. Even in the case when technology transfer does lead to satisfactory results for all participants, more resources than planned are usually consumed along the way (Hanusch 2007, Homan 2005).

Up to now a systematic coupling between technology development process and product development process is missing. For this methodical support is needed since only an efficient interface design can reduce development time and support the product's success (McGrath et al. 1992). For this reason the major issues associated with the interface concerning the operative process design will be demonstrated first.

A basic issue when transferring know-how from technology development into product development is that a non-optimal amount of knowledge is passed on. There is a risk that technology developers impart too much knowledge to the product development. This may avoid bad judgement of the relevance of their insights and leads on to a high binding of human resources. On the other hand, too little know-how could be transferred. This might be due to resource bottlenecks, low acceptance between technology developers and product developers, lacking documentation in the technology development or insufficient communicative skills of the developers.

Another challenge often observed in practice is the lacking standardisation of technology and product development processes. This commonly leads to inefficient, individual interface solutions. A standardised and therefore controllable and reproducible knowledge transfer process is not attainable. Furthermore the adaption of improvements stemming from failures into other development projects in the business is hard to conduct.

In many innovation models the assumption is made that product development is always based on application-ready technology (Marxt et al. 2004). A necessity for synchronous technology development and product development arising from a lack of time is not uncommon in practice.

Often a know-how-transfer has to take place before technology development has been finished. This leads to an unstructured knowledge transfer and therefore to many iterative loops in many cases. The fact that the success rate of technology development projects is much lower than in product development projects and the technology potential itself is often not certain even at the end of the project requires a tight, early-stage integration of product development especially when dealing with complex technologies. In practice this can often be regarded as insufficient and leads to considerable difficulties in product development due to knowledge deficits.

Moreover, there are issues with knowledge transfer due to unclear responsibilities as well as obligations at the interface between the development of technology and product. Particularly due to the change of the project leader common to this stage of the development process important aspects are often not completely clarified. This causes confusions and conflicts.

On the whole, by demonstrating these challenges and issues at the interface between product development and technology development, the need for a methodically supported design of the interface was motivated. Identifying the influencing factors for the process design of the interface and therefore deriving a design concept is a central research task.

## IV. Design concept for the interface between the development of technology and product

To establish a target-oriented process design at the interface it has to be ensured that the knowledge transfer is granted by clear definitions of responsibilities and roles. Delivery points have to be defined and an interface-oriented planning of time and effort has to be effected.

For the optimisation of the interface it is essential to generate an efficient process design. Therefore a design concept was developed, pictured in figure 3. In general, the concept contains four elements: the technology development, the product development, the relational context of them, as well as the technology transfer management. Further internal or external influencing factors and design parameters should not be considered at this point. Considering the four elements above, the main influencing factors and design parameters are demonstrated.

This concept is for the synchronisation of different technology and product development processes, not only for one development project. All four parts of the concept include influencing factors as well as design parameters. “Influencing factor” means in this context factors that are changed externally and have an significant influence of the interface design. “Design parameters” means factors that might be changeable in favour for an optimisation of the interface.

Fixed influencing factors of the technology development are the technology complexity, the degree of technological innovation, the uncertainty of technology development as well as the degree of standardisation of the technology development process for example. All of those factors are not influenceable, but have a great influence on the design of the interface between technology development and product development. The effort to transfer the technology to the product development increases significantly, if it involves a very complex technology. Furthermore, if it is about a brand new development (very high degree of innovation), it therefore involves a high risk in the technology development. The product developers have to be included at an early stage of time in order to become familiar with the unknown technology (e.g. by common last feasibility studies). On the other hand, there are incremental technological developments of known technologies which feature a low risk, have a low degree of innovation and a high degree of standardization. The interface design of this kind of development is much simpler. Possibly, a detailed documentation is sufficient for the transfer. The main design parameters of the technology development are the organisational and operational structure, development resources and technical, teaching and communicational skills of the developers. Good communication skills as well as the ability to transfer knowledge significantly support the transfer of know-how. Hence, they are especially important. Those parameters, influencing the interface, are modifiable within the company in either the short-term or long-term. Therefore they are perfectly designable for the interface.

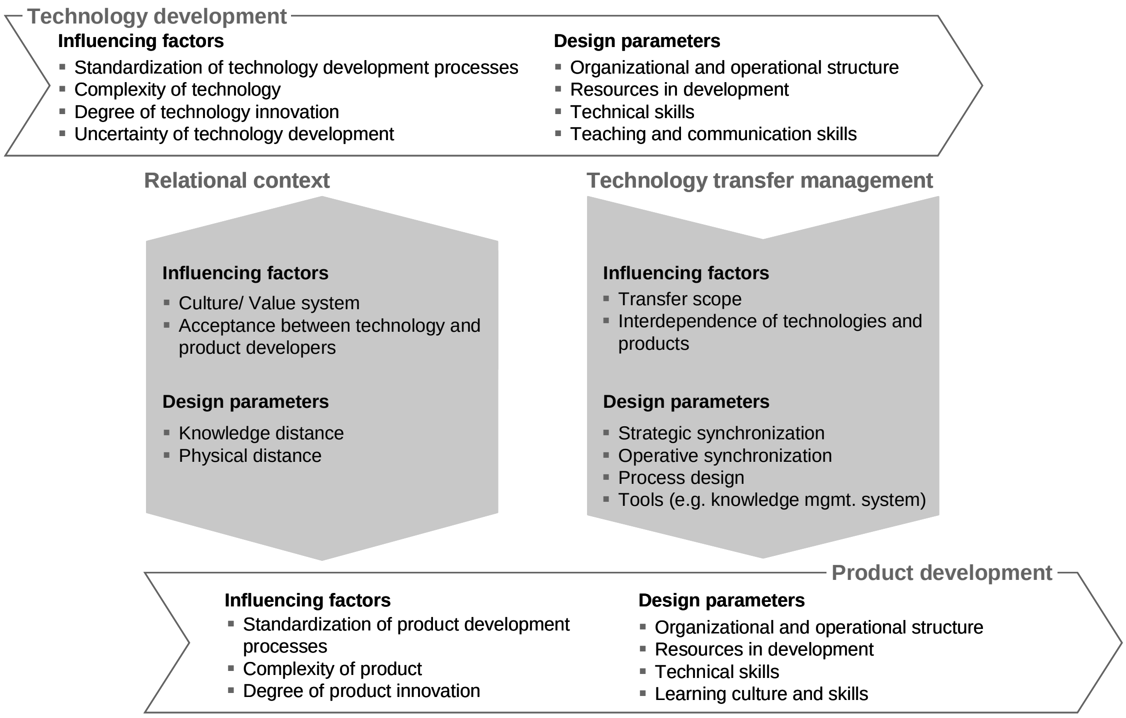


Figure 3. Design concept for the interface between the development of technology and product

Similar to the technology development, the influencing parameters of the product development are the product complexity, the degree of innovation and the standardization of the product development process. E.g., product complexity includes the number of different technologies compared to other products, the number of new components or even the interdependence of components (Lakemond 2007). With a high degree of standardisation, interfaces are easier to design since equal procedures constantly exist. For this reason, optimisations of the interface are quickly implementable. Without friction losses, advancements could be launched in the hole company. Similar to the technology development, essential design parameters include the organisational and operational structure, development resources as well as technical, teaching and communicational skills.

Influencing factors that affect the relational context of technology and product development have a great impact on the interface design. They include the corporate culture, the system of values, the acceptance between technology and product developers as well as the differences in knowledge between those two development teams. Especially a low acceptance or appreciation between the developers can lead to major problems considering the transfer of a technology, since the product developers are mostly dependent on a close cooperation with the technology developers. Furthermore, and caused by the common embryonic state of a technology that initiate a lot of tests and loops, time lags within the technology development are not unusual. This can cause problems with the process (time schedule) of product development, if it is too geared to the technology development process. A small physical distance between the development teams often affects the transfer of the technology in a positive way (Cummings 2003). For this reason, the distance is considered as a design parameter in the design concept. Another design parameter is the knowledge distance that technology developers have established by many years of experience with a new technology.

They are not allowed to exploit the advantage in knowledge that they have. On the contrary, they have to share and transfer the relevant knowledge. Depending on the prognosticated level of knowledge gap, product developers possibly have to be included at an early stage in order to transfer the relevant knowledge concerning the new technology.

The fourth element of the design concept, the technology transfer management includes the actual design of the activities of the technology transfer. Significant influencing parameters are the transfer scope as well as the interdependencies between technologies and products. The transfer scope refers to the knowledge or the contents to be transferred with reference to test results, prototypes, blue prints, etc. A rising bond of knowledge to humans, methods or organisational routines complicates the transfer (Cummings 2003). Equally, a decrease in the possibility to express or verbalise the knowledge complicates the transfer of the technological knowledge (Cummings 2003). Additionally, an evaluation of the knowledge distance (see relational context) should follow in order to derive the effort needed for transfer. In line with the above, the interface is to be designed optimally. Particularly, the technical and temporal dependence of technology and product development is important considering the operational planning and implementation. It is an essential question, if a technology is developed for one or more defined products or independently of a certain product. It is of interest what and when (or rather at which milestone) a technology could be synchronised with product development. This operational synchronization (also called program synchronisation) represents an essential design parameter. Moreover, a strategic synchronisation, that involves an alignment of technology strategy and product strategy, has to be performed. The aim is to conceptualise, establish and manage a process design (which is another design parameter in the concept) and tools that can minimise or even avoid the friction losses between technology and product development that are caused by the named negative influencing factors.

To establish an efficient interface between product development and technology development it is of utmost importance to analyse which knowledge or information has to be transferred as a first step. Primarily the technology development members with the main knowledge have to be identified (*know who*). Relevant knowledge of the technology itself (*know what*), the theoretical basis of the technology respectively the underlying basic knowledge (*know why*) as well as the necessary processes, methods or general conditions for the application of the technology (*know how*) has to be passed on by the identified technology developers to the according product developers (Schulz et al. 2000). Before it must be determined whether or not some of the technology developers also act as product developers and thereby transfer knowledge automatically.

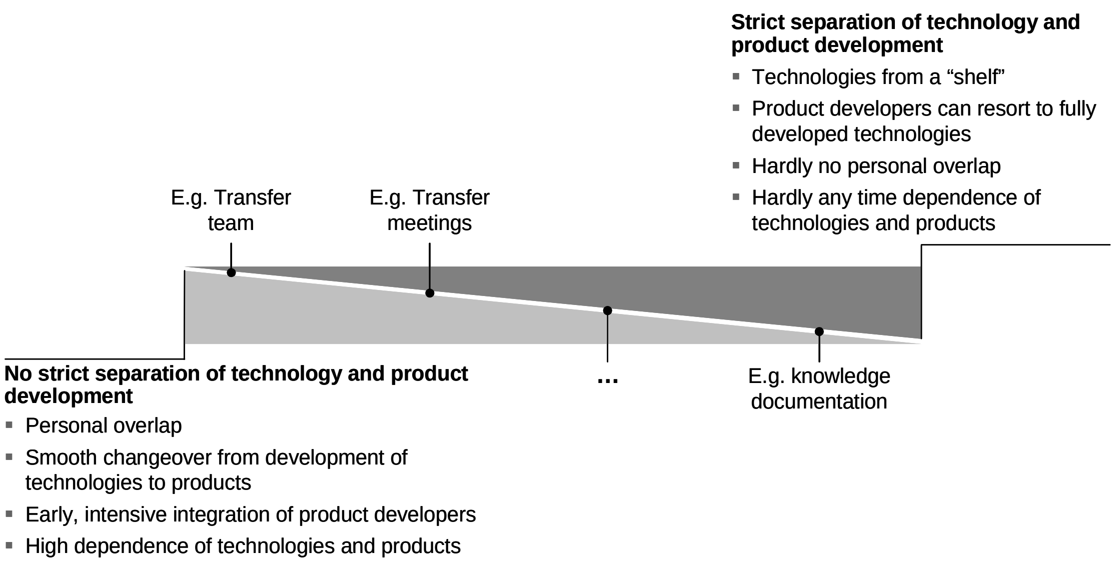


Figure 4. Operative process design options of the interface

The process design can assume a variety of shapes (fig. 4). On one end of the spectrum there is a smooth changeover from technology development to product development where no strict distinction can be made, a personal overlap exists and an early, intensive integration of product development is necessary. On the other end there is a strict separation of technology development and product development where product developers can resort to fully developed technologies, no time synchronisation is needed and involved persons hardly overlap. The transfer of knowledge can take place based on knowledge management systems, in terms of transfer meetings or - depending on complexity - by the formation of transfer teams.

## V. Conclusion

In this paper it was demonstrated that there is no methodically supported design of the interface between technology development and product development until today. Challenges and problems were discussed and it was shown that there is need for a systematic coupling between the development of technology and product. Based on this a design concept for the optimisation of the interface was proposed. Therein the design parameters of the interface on the one hand and the essential influencing factors on the other hand were presented. In the next step this design concept has to be developed in more detail. In order to do so the design parameters have to be subdivided and analysed further. Influencing factors must be examined in detail with regard to their interdependency and their influence upon on the design parameters. The aim is to derive a detailed design concept for an interface between the development of technology and product based on business-specific input variables to guarantee an efficient and effective development process. This is intended to support businesses in developing new products in a targeted and time-optimised manner in times of increasing market dynamics and ever shorter innovation cycles.

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# Development of a Technology Management Concept for SMEs

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**Abstract:** Enterprises in technology-intensive industries face the challenge of dealing with an exponentially growing amount of technological knowledge and shortening innovation cycles. Therefore, the identification, assessment, implementation and commercialisation of new technologies has become an important management task and a prerequisite for innovativeness. However, empirical research has proven that the majority of small and medium-sized enterprises (SMEs) renounces explicit technology management structures in practise. The reason for this situation can be found in a gap in theory since a holistic technology management concept tailored to the specific needs of SMEs has not been developed yet.

In this paper, a design concept for technology management in SMEs is presented. As a basis for this concept, the interrelations between typical attributes of technology-oriented SMEs, their technology strategy aims and the resulting tasks to be carried out in technology management are discussed. In this context, typical intrinsic strengths and weaknesses of SMEs referring to the ability to perform technology management are analysed. Based on these findings, design guidelines with regard to key activities of technology management in SMEs dependent on company-specific strategic aims can be derived.

**Keywords:** Technology Management, SMEs, Strengths and Weaknesses, Technology Strategy

## I. Introduction

Small and medium-sized enterprises in technology-intensive industries still constitute a fundamental part of the European economic space. Like their larger competitors, technology-based SMEs are confronted with shortening innovation cycles in a global market environment. Technologies play an important role for gaining long-term competitive advantage since their lifecycles are longer compared to products. In this context of an exponentially growing amount and complexity of technologies, technology management is considered as a management discipline of high relevance which has to be carried out systematically.

Being subject to this dynamic environment, small and medium-sized enterprises act under challenging boundary conditions: although they only have access to a rather limited resource base, they are forced to keep pace with prevailing technological developments for cost reduction or differentiation. Still, they are often not able to allocate enough capital for developing new technologies independently. Therefore, SMEs either tend to enter cooperations (Maaß 2006; Kirner 2009) or perform only discontinuous research and development (Scherer 2003). Furthermore, the threads arising from wrong decisions in the choice of future technologies are essential due to lacking capital equipment and alterative technologies for compensating failures. In order to cope with these challenges, SMEs need to foster a technology management which generates effective results efficiently under the boundary condition of limited resources.

## II. Technology Management in SMEs: State of the art in theory and practice

Despite the growing need for a systematic technology management, only a minority of companies has established respective management systems and tools so far. A survey conducted by Laube (Laube 2008) reveals that 25 percent of the asked technology-oriented SMEs have not defined technology management tasks explicitly. One of the reasons for this rather low diffusion rate of technology management in SMEs can be found in lacking methodical support: 41 percent of the companies in Laube`s study state that lacking suitable methods and tools act as a restraint for technology management.

Reviewing the state of the art in research confirms these practical findings: technology management research has not put much emphasis on smaller companies (Altmann 1998), but has rather concentrated on defining concepts fitting in the context of larger corporations (Daschmann 1994; Laube 2008). Still, Shuman`s and Seegar`s popular statement “Smaller businesses are not smaller versions of big businesses” (Shuman, Seegar 1987) which points to the demand of adapting strategic management concepts for small and medium-sized companies is also valid with respect to technology management. This means that the concepts developed for large companies cannot be employed in SMEs since some design options of general technology management are not feasible in the small business context. The following examples illustrate this aspect:

- Larger companies often organize technology management tasks to be carried out by a separate department. On the contrary, SMEs normally lack the possibility to employ staff exclusively for technology management activities. Consequently, tasks such as scanning the environment for new technologies and assessing technological opportunities systematically have to be distributed among the existing staff in technology-oriented company departments such as research and development or production.
- Some of the methods proposed in literature to support technological assessments and decisions are characterized by a high level of complexity and demand for large analytical efforts. However, the staff in SMEs responsible for technology management tasks is usually not specialized in designing and applying such sophisticated and time-consuming methods.
- Globally acting large corporations in general have a network of facilities and outposts around the world which include e.g. hot spots driving ground-breaking technological developments. Even though SMEs also tend to internationalize their business, their access to information sources relevant for technology intelligence is still limited.

Considering the mentioned items, it might be assumed that SMEs only have to cope with worse prerequisites concerning technology management compared with bigger firms. However, this perspective of SMEs deficiencies has to be contrasted with a perspective of characteristic strengths which hold true for large amount of smaller companies. Several studies investigating characteristic traits of small and medium-sized companies find that such entities often show a high level of close cooperation among the staff (Jones 2003; Zotter 2003; Behrends 2005) and a better ability to act flexible in business decisions (Zotter 2003). So far, technology management research has not addressed the question how to use the specific strengths of SMEs in order to gain advantages.

The few existing research approaches treating general aspects technology management in small and medium businesses as central topic concentrate on analysing the diffusion rate of technology management (Kohler 1998, Laube 2008) or on deriving singular design recommendations for technology management (Altmann 1998, Kohler 1998). Other work focuses on specific aspects of technology management such as the organisation of technology intelligence (Savioz 2002). A systematic and broad consideration of designing technology management with respect to the special attributes and demands of SMEs has not been carried out so far.

Concluding, one can claim that this lack in theory contributes to the limited degree of implementation of an explicit technology management in practice. Our research work therefore aims at developing a holistic technology management concept tailored to the needs of SMEs on the basis of a deep understanding of their specific contextual situation, characteristic attributes and their strategic targets.

## III. Towards a Technology Management Concept for SMEs

In this paper, we present a solution hypothesis for developing a technology management concept for SMEs based on understanding the interrelations between typical attributes of technology-oriented SMEs, their technology strategy aims and the resulting core tasks and activities to be carried out in technology management. This concept demonstrates how SMEs can take advantage of their intrinsic structural strengths in technology management while simultaneously minimizing structural weaknesses. Figure 1 shows the relevant aspects which have to be analysed in the context of the SME-specific technology management concept.

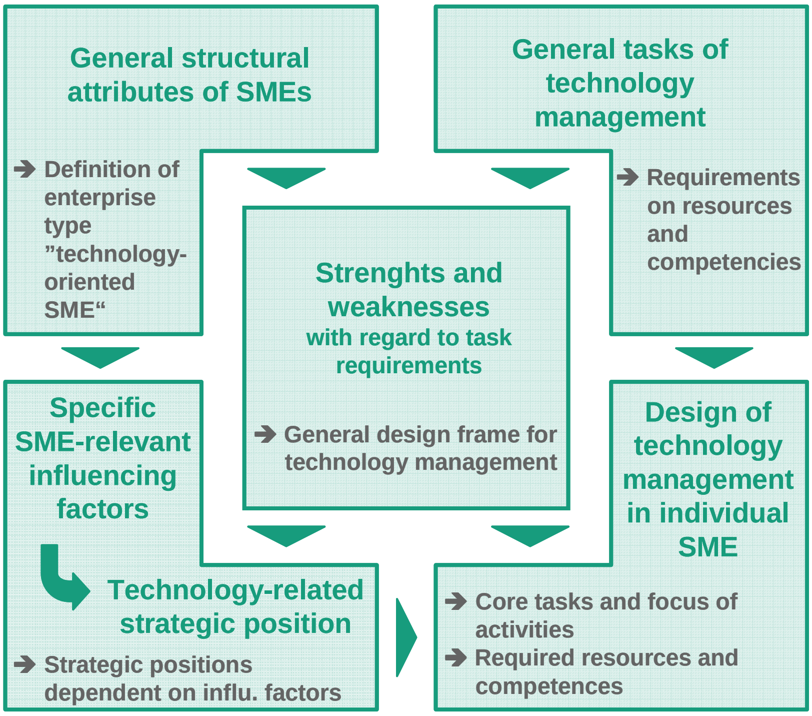


Figure 1. Deriving a technology management concept for SMEs

*General structural attributes of SMEs*

Firstly, the characteristic structural attributes of SMEs represent major determinants for the kind and intensity of activities in technology management. SMEs are usually characterized by quantitative size-related indicators such as revenues or number of employees. The European Commission has established an official definition for SMEs widely spread in research and politics[31]. However, this definition is not applicable in the context of defining an SME-specific technology management for several reasons: Firstly, nearly all companies in the European economic sector fit in this category. Secondly, the description of SMEs used in this concept has to provide a basis for understanding the SME-specific prerequisites for technology management.
Therefore, a qualitative description has to be established for our purpose which can be derived using existing research work dealing with the identification of typical attributes of SMEs. Pfohl provides a detailed list of such characterising criteria (Pfohl 2006) which can be adopted in order to define the characteristic attributes. In the following, the attributes necessary for defining the SME-specific technology management are explained. An overview on these relevant attributes can be found in figure 2. It becomes obvious that there are key attributes which act as attributes on their own and also create the base for the derivation of further attributes.

One of the major attributes for characterizing SMEs is their low level of resource equipment. Due to lacking financial means, smaller companies furthermore show a more discontinuous investment activity than their larger competitors.

In SME research, the identity of owner and entrepreneur plays an important role for explaining the management paths and culture of SMEs. The entrepreneur unifies ownership and general management, takes risks and responsibility for all major business decisions and employs his own capital. This dominant position leads to fast decision-making being the basis for a high

[31] According to the recommendation of the European Commission, all companies with less than 250 employees and an annual revenue of 50 million Euro and / or a balance sheet total of less than 43 million Euro belong to the category small and medium enterprises.

degree of flexibility and responsiveness to changing customer demands and to new provision of services and technologies. Despite these advantageous traits, the identity of owner and manager might result in negative effects such as subjective decisions and the lack of control organs.

In historically grown SME enterprises, the organisational structure reflects the stage of business development. Usually, it can be characterized by a one-line-system with flat hierarchies and shot communication and information paths (Pichler, 2000). In many smaller enterprises, strong interpersonal relationships dominate the contact of employees and management, but also the relations to customers and suppliers. Furthermore, division of work is only executed to a low extend. There organisational aspects combined with the ability of fast decision-making result in a high degree of flexibility (Behrends, 2005).

Due to their low market power SMEs usually hold a weaker position concerning prices and conditions on the procurement market. Furthermore, they are disadvantaged in achieving economies of scale. For this reason taken together with the narrow resource base, SMEs often concentrate on providing a focused product and service spectrum in niche markets where competition against large competitors does not occur. In many cases, their products are characterized by high quality and strongly customer-oriented specialisation (Pichler 2000). This concentration of business activities is also reflected in the technology base since most of SMEs only employ a low number of product and production technologies.

*General tasks of technology management*

Secondly, a general understanding of the tasks to be carried out in technology management has to be gathered first before selecting the relevant tasks and defining the focus of activities for SMEs. The Technology Management Department of Fraunhofer IPT has developed a framework for general technology management which can be applied for this purpose (Schuh 2009). In this framework, technology management is divided into the process elements technology intelligence, technology planning, technology development, technology know-how protection, technology commercialization and technology assessment. These overall technology management elements can be subdivided into tasks such as defining the information demand, searching for information, assessment and communication of information in technology intelligence (Lichtenthaler 2002; Schuh 2008). Each of these tasks require certain resources and competencies to be fulfilled properly. Those requirements have to be identified in order to be able to derive a technology management tailored to fulfil these requirements.

*Strengths and weaknesses*

Afterwards, these requirements derived from technology management tasks have to be matched with the SME-specific structural attributes. Interrelations between these dimensions have to be analysed in order to identify strengths and weaknesses typical for SMEs with regard to the tasks of technology management. The following examples illustrate this:

- The ability to assess technologies cross-functionally arises from the high degree of interrelations between different enterprise departments and constitutes a potential strength. But still...
- …the technology assessment has to focus on core aspects in order to be applicable against the background of low resources.
- SMEs often have weaknesses in acquiring adequate partners for technology development due to their limited economic impact and their restricted action radius, but…
- …due to their strong relationships with customers and suppliers, they are able to gather valuable information at an early stage.
- In technology intelligence, SMEs have to direct their resources to the core fields of interest. Therefore, the are subject to an extended risk of missing relevant trends in neglected technology fields.

By analysing each requirement in detail, a general design frame for technology management is obtained.

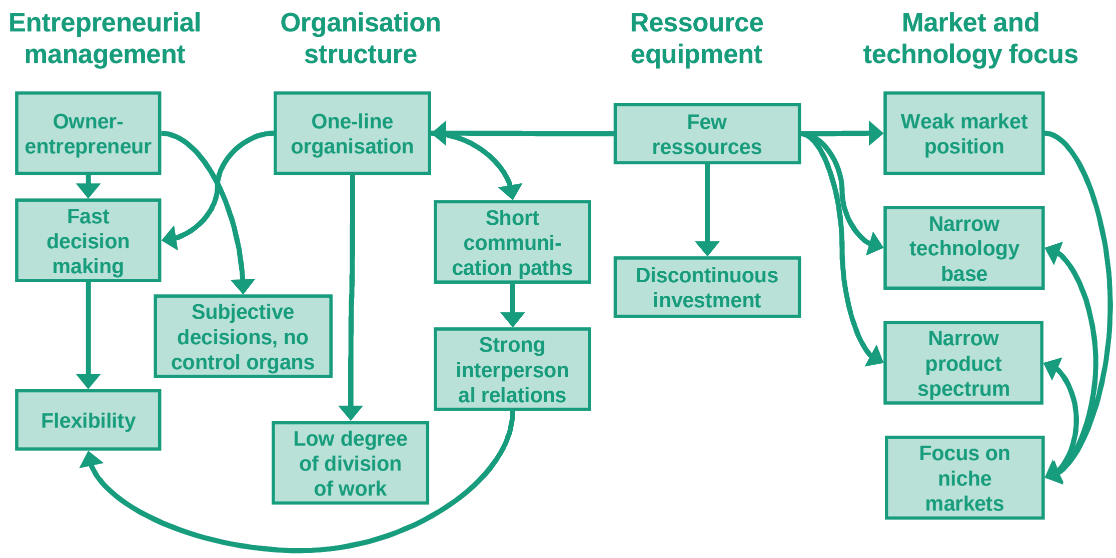


Figure 2. Relations of relevant structural attributes of SMES

*SME-specific influencing factors and technology-related strategic position*

Beside the general characteristic attributes valid for the majority of technology-oriented SMEs, further influencing factors have to be taken into account in order to define an effective and efficient technology management. For example, the competitive environment and the characteristics of technologies belong to this set of factors. Their respective, company-specific characteristics also act as a determinant for the focus of technology management activities. Furthermore, these factors influence the competitive and technology-related strategic position of the enterprise.

According to Wolfrum, technology strategy can be understood as long-term guideline related to the choice of technologies to be employed, the competence level of technology mastery, the timing of invention and market entry, the respective technology source and the principal mode of technology commercialization (Wolfrum 1994). In each of these categories, several positioning options are available. Still, not all of the conceivable positions constitute promising positions for SMEs. Being a technology leader for example is only possible in a narrowly-defined technology field due to the low level of resource equipment. Furthermore, the options for technology sourcing are restricted as well since own technology development is often considered too costly and other options requiring high efforts such as mergers and acquisitions are neither applicable.

The strategic position of an SME represents as well a decisive determinant for the design of technology management. For example, a small enterprise with the target to be technology pioneer and to apply first-in-class technologies while competing against larger companies has to establish an intensive technology management with extended activities in technology intelligence and technology planning. In comparison to that, a company with less ambitious strategic targets operating on an intermediate level of technological performance will have to allocate less resources to technology management.

*SME-specific influencing factors and technology-related strategic position*

Finally, the general strengths and weaknesses of SMEs with respect to the requirements of technology management have to be matched with the information on company-specific factors and strategic positions in order to define core tasks and activities in technology management for a specific company.

The following case of a German SME being a developer and producer of electronic products illustrates these kind of implications. The company shows the typical structural attributes explained in this paper. In order to be able to compete against large competitors, the company focuses on customers in the premium market segment. New technologies are usually developed by development partners or are bought as product technologies and then integrated into products. The value-generation of the company arises from developing best applications based on deep know-how in software development.
Due to lacking resources, the company is not able to establish an extra department for technology management, but has to spread the respective tasks among the employees from the technical departments.
In order to maximize the resource efficiency in technology intelligence and to benefit from the short information paths, the procurement department should be bound into technology intelligence – this enables purchasers to identify new technologies at suppliers systematically and to transfer the information quickly to the developers. Accounting for the fact that new technologies in the electronics sector are often developed in Asia, a technology scout should be established at the Asian hot spots in order to network with local companies. Due to the restrictions concerning global network building, the company should especially focus on maintaining strong contacts with local development partners such as selected research institutions.

## IV. Conclusion

In this paper, we have pointed out the demand for a technology management concept suitable for SMEs and have presented an approach of developing such a concept. Central components of this concept such as characteristic attributes of SMEs, intrinsic strengths and weaknesses with regard to technology management and relevant influencing factors like strategic position have been discussed briefly on an exemplary basis. Detailing this framework lies in the focus of our current and future research activities. The discussed technology management concept assists decision makers in technology-oriented small and medium-sized enterprises in designing or optimizing their management of technologies. By analysing their respective intrinsic strengths and weaknesses and their strategic position, they are able to define relevant technology management tasks and to identify respective activities. Therefore, this framework shall drive the diffusion of technology management in SME business context.

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# Index of Authors

## T



## U



## V



## W



## Z




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