A Methodology for the Selection, Assessment and Analysis of Successful Experiences

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Abstract: Embedded systems and industrial informatics represent two areas with significant research results of quite high added value. Transformation of such results into innovative products and services increases competitiveness and represents, through the enhancement of the citizens' quality of life, a pay back to the society of research funds. This transformation has not been always straightforward. Learning from successful experiences is important. The present work elaborates a methodology for the selection, assessment and analysis of successful experiences related to this transformation of research to innovation.

Keywords: Methodology, Innovation, Embedded Systems, Industrial Informatics.

1. INTRODUCTION

The European paradox expressed by the European Commission (1995) as Europe's "inferiority in terms of transforming the results of technological research and skills into innovations and competitive advantages" represents a major defect for Europe as it fails to produce innovative products and services out of mature research results and technological advancements. This in turn jeopardises the European competitiveness and standing in the global market.

Studying and learning from successful experiences might provide an insight of the different elements that contribute to the success of an effort to transform research results to innovative products and services.

This paper presents a methodology with a first step relevant to the identification and selection of good experiences with reference to the embedded systems and industrial informatics sectors, two sectors of significant added value for Europe. A second step is associated with the assessment of good experiences and the selection of the most successful among them. Finally, the methodology performs an analysis of the successful experiences with reference to their strengths, weaknesses, opportunities and threats, detailing the elements that make them successful.

Work presented in this paper is funded by the I3E (SEE/A/219/1.1/X) project (Kalogeras 2009). Chapter 2 of this paper presents the methodology followed by I3E project for the collection of 120 good experiences in the sectors of embedded systems and industrial informatics. Chapter 3 elaborates on the assessment of good experiences and the selection of a set of 30 successful experiences. Chapter 4 presents the analysis of the successful experiences. Finally, Chapter 5 provides conclusions and a discussion.

2. SELECTION OF GOOD EXPERIENCES

2.1 Definition of a Good Experience

There are many definitions of the Good Experience term, and they all come to it being the most effective and efficient way of presenting a particular result/outcome among all the others. The term is also used for the evaluation of a certain work and/or result or as a model for the development of a new or improvement of an existing method/procedure, etc.

In the present work, a good experience is associated with examples/models of successful transformation of research into innovation through various applied financial mechanisms. They detail part of or the entire innovation process.

Financial mechanisms are viewed as tools that enable innovative activities in enterprises resulting from research work of research teams either in enterprises or academia. Direct financial mechanisms represent a specific transfer of money into enterprises by subsidy facilitators for financing their own R&D or external service, i.e. research result of research teams that is applied in the enterprise. On the other hand, indirect financial mechanisms come to consulting services that enable faster and more efficient access to funds for the transformation of research into innovation, in particular for both kinds of potential users, R&D teams and enterprises. Both listed financial mechanisms are aimed at improving innovation activities.

2.2 Good Experience Requirements

The Good Experiences selected focus on the Embedded Systems and Industrial Informatics sectors. They represent successful examples of the application of the innovation process, i.e. the transformation of research results to

innovation. They focus on the entire process or parts of it, detailing the elements that led to success.

The presentation of each Good Experience comprises its theme and objectives, its general description, a description of the research team behind the Good Experience, a description of the financial mechanism that was used for the transformation of research into innovation, an identification of the means of connecting scientific research team and financiers, that is, how the financiers decided to support the research team, a presentation of the accomplished benefits for research team / enterprise, a description of the sustainability of the experience after the conclusion of the financing and a first evaluation of the Good Experience in terms of the elements that led to its consideration as a good example.

A set of 120 Good Experiences has been selected in the framework of I3E project (I3E 2010) covering a wide range of research directions and their results, different financing mechanisms and support frameworks as well as a wide distribution between different countries.

3. ASSESSMENT OF GOOD EXPERIENCES

The assessment process has to select 30 best experiences from 120 good experiences. For this purpose a methodology has been developed and applied based on 8 criteria groups. Each group contains several criteria and each of them brings certain number of points to each good experience. Since the project evaluated Good Practices from different sectors of Embedded Systems and Industrial Informatics not all criteria could be applied to each Good Practices. Therefore the final result has been calculated as a percentage determined from the GP points score (from all the applicable for the particular GP criteria) divided by the possible maximum score.

3.1 Assessment Criteria

The assessment of the Good Experiences took into account different criteria. The first category of criteria is *financial criteria*. Criteria (and their relevant grading) listed in this category include

- Attractiveness for investors measuring their expected benefits i.e. influence over the market (2 points max), long term profit (1 point max), short term profit (1 point max), value for money (1 point max) and tax decrease (1 point max)
- Financial diversification detailing the types of financing used (corporate, seed, government / private funds, personal assets) (4 points max)
- Provision of attractive financing mechanisms (5 points max)

The second category of criteria is characterised as *applicability/impact criteria*. Criteria (and their relevant grading) in this category include

- International validity measuring the application of the good experience in one country, several countries or worldwide application (6 points max)
- Range of participants measuring applicability of the good experience to SMEs, large companies, academia, research groups, individuals (4 points max)
- International synergy of intellectual resources measuring the cooperation possibilities between participants (5 points max)

A third category of criteria is denoted *realisation criteria*. Criteria in this category include

- New idea realisation, taking into account time span, approximate cost, team (approximate number of staff members – belonging to one company or university, belonging to different companies / universities) (7 points max)
- New technological realisation of an existing idea: taking into account results (better parameters / characteristics / efficiency, lower cost / size / weight, more functional use) (5 points max)
- Improvement/novelty introduction to well-known technology, taking into account results similar to the above criterion (3 points max)

The fourth category of criteria is labelled *innovation criteria*. This category is applicable to good experiences that describe recent innovations (preferably of 1-2 years) that might be a product, process, service or even a financial mechanism. For the purpose of this category a new version or repackaging of an already well-accepted technological solution does not qualify it as an innovation. Criteria in this category include

- Recent good experiences that have achieved something beyond the current state of the art in the area of embedded systems and Industrial informatics (5 points max)
- Novel ideas that have achieved a real innovation in a market niche despite the relatively low R&D effort/cost behind them (4 points max)
- Innovative prototypes ready to enter the market (6 points max)

The fifth category is denoted *time & life criteria*. Criteria in this category include

- Expected use of good experience (4 points max): less than 3 years (1 point), 3 - 5 years (2 points), and more than 5 years (2 points).
- Good experience sustainability and potential for growth (2 points max)
- Energy saving good experience with classical energy sources (2 points max)

- Environment friendly good experience (2 points max)
- Use of new energy sources (wind, solar energy, bio energy, thermal energy) (2 points max)

A sixth category of criteria is referred to as *social criteria*. Criteria in this category include

- Creating new work places (4 points max)
- Oriented to handicapped people (2 points max)
- Enhancing personal qualifications (2 points max)
- Resulting to trained staff in areas related to embedded systems and industrial informatics (2 points max)

A seventh criterion is denoted as *Transferability* (10 points max) and refers to good experiences that have achieved results that might be easily transferred to other stakeholders. Experiences which results were transferred to more then two cases, score 10, to two places score 7, and to one score 5. The possibility for future transferability has to be scored with 2 and by its lack with 0 points.

Finally the assessment methodology provides a criterion for the *Overall reviewer impression* (8 points max). This criterion was introduced in order to also collect the personal feeling of the reviewer with reference to a specific good experience.

3.2 Assessment process and results

Each good experience received three reviews by three independent reviewers, coming from different organizations shown both in Figure 1 and 2 with their acronyms. In order to have more compact results some options of "calibration" have been used. An important reason for this is the fact that every one of 120 good experiences receives reviews by different reviewers, an approach that could involve a different interpretation of the common methodology.

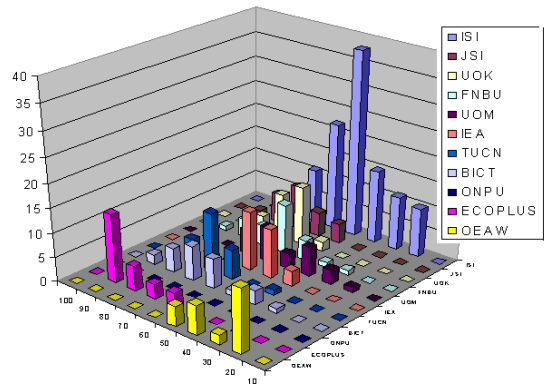

Fig.1 Assessment results before the calibration

The major principle of the "calibration" is to maintain the rank of evaluation proposed by the reviewers.

The following well known statistical methods and indicators have been utilised: average, standard deviation, median, percentile and quartile, frequency distribution.

The treatment of the results with the statistical methods has highlighted the following: there are good experiences with very high standard deviation compared to the rest. That comes from the fact that different reviewers have different scale and approach in the methodology application. In order to deal with this fact, a calibration of data has been undertaken so that frequency distribution becomes homogeneous.

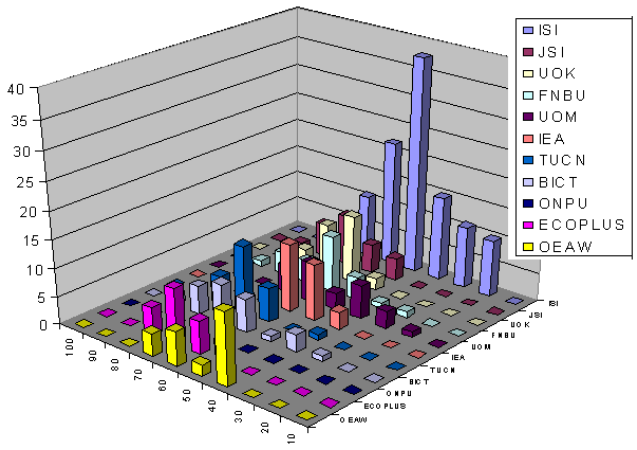

Fig.2 Assessment results after the calibration

The result of the assessment process was 30 successful experiences that are distributed in four thematic areas:

- industrial informatics (10 successful experiences)
- nomadic environments (5 successful experiences)
- private spaces (2 successful experiences)
- public infrastructures (13 successful experiences)

4. ANALYSIS OF SUCCESSFUL EXPERIENCES

Following the compilation of the list of successful experiences (I3E 2011), a further analysis of the successful experiences has been performed. This analysis emphasised on the successful experience context, the relevant policy elements, the involved socio-economic factors, the detailed objectives, the process followed comprising the project design, the project management, the project implementation, and the project evaluation as well as the financial mechanism utilised, and elements or repeatability and transferability.

The further analysis of the successful experiences has been followed by their SWOT analysis. Individual SWOT analyses of the 30 successful experiences have been made by three reviewers and a combined SWOT analysis per successful experience has been produced. Based on the individual combined SWOT analyses, an overall SWOT analysis has been produced.

In order to conclude to a meaningful combined SWOT analysis, the 30 successful experiences have been divided

into two major groups: the first including good experiences of governmental and non-governmental structures and organizations oriented towards innovation support in the field of embedded systems and industrial informatics named *Innovation Support Structures*, and the second comprising different projects for implementation of industrial informatics and companies for production of embedded systems called *Embedded Systems Production*.

Innovation Support Structures successful experiences include practices that explain different R&D and project management and support structures of companies, associations and universities. Their primary purpose is the aggregation and concentration of high-end know-how, leading professionals and production companies that will support the development of large-scale national and international projects in the field of embedded systems.

Embedded Systems Production group includes successful experiences with examples of various companies that design and produce specific embedded systems, industrial informatics applications or the entire production process automation, monitoring and control. The scope of examples covers: manufacturing systems in the heavy industry, environment monitoring and ecology, wearable medical and sports devices, data login applications, different types of navigation and position control equipment, etc.

4.1 Combined Strengths

Typically most of the practices from the *Innovation Support Structures* group are successful performance of R&D activities. Many of these practices represent entities and organizations working in close cooperation with nationally-known universities and associations. Some programs provide information on the long-term activity in the field of embedded systems and industrial informatics.

About half of the practices covered in the group of Innovation Support Structures highlight the involvement of a large number of employees (over 20-30), some organizations engage more than 500 employees in associated partners. In practice, all of these practices actively cooperate with universities, thus creating conditions for continuous improvement of their staff, as well as recruitment of new staff. Over 40% of research teams have specific responsibilities. Many of the organizations develop another major activity which may be of interest for many small and large scale companies in the sector of industrial informatics. The R&D process exposes the commercial value of novel ideas. Larger organizations cooperate with several technological institutions, where at least few organizations exist as a part of them and posses specialized laboratories and companies producing embedded systems.

Some of the organizations try to impose a new business model with the dominant participation of universities and scientific organizations, by simply looking for long-term projects with clearly explained financial mechanisms and well-described long-time development policy (20 years). All these show a properly selected and time-adaptive R&D policy with developmental potential and creation of innovative business-oriented products and services. Cooperation of the (combination) of institutional, university and business participants is a guarantee for establishing of stable business models able to apply for funding under the larger European and national programs. Some organizations have partnerships with organizations with 10 - 100 employees.

All successful experiences have the perfect on-line portfolio, that will make much easier the promotion of their business and make it easier to find partners in the implementation of larger cooperative projects. Most of these organizations have quality control certificates and contacts with institutions and laboratories to verify compliance and ensure high quality of end production and management processes inside the organization.

The group of *Embedded Systems Production* successful experiences that describes the design and producing of end products or services uses diverse business models and financing mechanisms. Most of the best practices mention a large amount of private investments. Some practices, however, combine good business policy and close cooperation with universities and scientific institutions. The diversity of applications and projects varies greatly, from small embedded systems for personal use, to highly scalable enterprise applications.

Most of the companies use their own operating staff dealing with the development, implementation and marketing of final products. Some of the presented examples show well-acquired business models. Most of the companies and joint ventures already have customers in more than one EU country. The selected best practices show the system integration solutions that have already had transnational applications. Over 50% of the solutions described comply with the recommendations for reduced power consumption i.e. are green devices. It can be concluded that most of the projects use equal amounts of public and private funding. The majority of funds to which these practices have had access were used for training and development. Some of the applications and products indicate potential for the development of applications and a wide range of services that can be developed and implemented in this sector. The range of applications includes: medical systems, production transportation monitoring, large scale industrial systems, navigation devices, different ecology applications, etc. Almost all companies in the region use producing facilities located in their own countries. This shows the potential of individual economies in the field of embedded systems and the production of specific and unique industrial informatics solutions. Normally most of the practices that are closely integrated with universities and academies have been presented on the market since more than 10 years.

4.2 Combined Weaknesses

Combined weaknesses are categorised as following:

Financial – Lack of funding diversification is the most common weakness of most of the successful experiences. In both cases, organizations supporting a specific business area or development of real products/projects, a strong dependence on one major source of funding could be noticed. The funding usually is provided by the government, an EU funding agency or another way of public funding. Since research and innovation cannot be carried out without funding, the funding diversification could be considered as the biggest weak point of most of the selected best practices.

Political – Taking into account that the financing of best practices strongly depends on governmental or EU funding, the dependency on the current political situation in the local country or on the EU administration can be outlined as a second serious weak points. Unfortunately, only a few of the selected best practices have a wide market success, not only locally, but also in other countries, and are independent of the local political situation.

Organizational – Many best practices have organizational weak points. Under this category could be listed the lack of premises, technical facilities, equipment, as well as the heavy dependence on other organizations (e.g. Universities, investors, partners, etc.).

Marketing – Another common weak point is the marketing approach of best practices. Their products usually suffer from a lack of a plan for entering the market, insufficient visibility and disputable international recognition. Only some of the products/projects have reached the market at all, and even fewer have gone beyond the prototype phase and have reached any market success. The fact that many of the best practices are promoted by clusters or other business support organizations also shows that the latter do not perform well enough. Therefore, most of the best practices have, unfortunately, limited appreciation and recognition at European level and are even less recognized worldwide.

Social – Only a few of the best practices have created new working places (jobs) and have an impact on the labor market. In fact, some of the best practices are struggling to survive the financial crisis, which influences also the new jobs offers.

4.3 Combined Opportunities

Innovation Support Structures are successful experiences that aim at facilitating the transfer of know-how, knowledge and skills in the area of industrial electronics and embedded systems. These activities are generally oriented towards raising the level of enterprises, especially SMEs.

The successful implementation of these projects requires establishing well-balanced R&D teams, feedback from enterprises, including the Academy-University segment in the process, proper network, etc. The scope of the project is of particular importance - what impact it has on the region and its relationship to the national strategy and the EU strategy.

A general overview of the 15 practices within this subgroup shows that regarding opportunities, the projects satisfy the above mentioned requirements.

The selected practices in general indicate a strategic alignment within the EU framework, the relevant country strategy, as well as alignment with the strategy of the relevant region.

The successful experiences in the *Embedded systems* subgroup aim at creating innovative products and target-oriented systems in the Embedded systems area.

The successful output of these projects requires establishment of well-structured R&D teams, a clear funding, appropriate area of operation, innovative approach (covering the above listed requirements in the general case is more or less described in the Strengths of reviews), as well as the availability of a market niche, applications in various fields, ability for incorporation into larger systems, etc.

A general overview of the 15 practices within this subgroup suggests that regarding opportunities, the projects satisfy the above- mentioned requirements.

4.4 Combined Threats

With reference to *Innovation Support Systems* the following threats have been identified:

Financial limitations: Such limitations include lack of financial resources, public funding will be affected by the financial crisis, possible country stagnation, and uncertain future sources of funding, insufficient funds to finish the successful experience, a great part of the financing of the project depends on government and EU funding, possible lack of financial resources for the future development of the successful experience, lack of clear description of the financial mechanism which would support the activities of the already developed structures, lack of local institutional support, the amount of future financial contribution of the stakeholders is not defined or certain, poorly defined interaction model with other existing funds for regional development and advancement.

Competition problems: The relevant limitations include: international competition, competition from big players, uncertain competitiveness and advancing of the companies created by the successful experiences, more attractive proposals from other regions or countries, potential vulnerability of the whole venture due to its dependency on the brokers' capacity and on the available networking activities, possible difficulties in the mass production of the developed products, human capital deficit, possible concurrence with other interactive tools and administrative

bodies that provide the same services and need for better cross border cooperation.

Market demands: The relevant threats are: global market uncertainty, poor marketing plans and decisions in the future, non-acceptance in the market), small spin-off companies are fragile, dependent on their major customers, and can easily disappear in case of a crisis, no strategic planning for creating high technology clusters with the aim of market penetration.

Legislative effects: The threats are: new government regulations, substantial governmental support and coordination is required, which is the national policy concerning the relations between academia and the enterprise sector and whether this policy impose barriers in the future.

Human capital problems: There are 5 threats: critical mass in terms of partners and resources should be guaranteed, the friendly environment at university may disappear, and the diffusion policy of the innovation culture in the regional territory may not be capable of overcoming the arisen obstacles, the small size of the company cumbers in the competition with much larger market players.

Other: The reduced role of basic research can undermine the basis for future development, the possibilities to support an extremely large variety of projects may lead to lack of competence in some cases, too many different views can cause diversions from the strategic line, university authorities do not consider it important to promote to students' efforts to create startup companies.

With reference to *Embedded Systems Production* the following threats have been identified:

Financial limitations: Different threats have been identified concerning the financial support of successful experiences, which can be summarized as follows: today's economic crisis, significant financing resources are needed for Best Practice (BP) realization, insufficient financial funds for opportunities realization, BP involves capital investments that can be overlooked, the particular project ideas and solutions depend directly on European funding to be initiated, not clearly defined issues about the requested funding for the future commercialization of the BP.

Market limitations: A total 18 threats are identified: possible market failure, applicability of the product and the market demand are limited, despite a huge market potential, some vendors are very conservative, the device may not reach the market, large players in the market, lack of a strategy for widening the BP market, without considerable marketing and promotion efforts the results of the BP can never be transformed into a product, there is a lack of a business plan to entering the market, there is not a vision about the proper product price on the market, Google Earth services competition on an European level, industrial partners should consider enhancing the range of services in order to enhance market penetration.

Missing venture capital examples: When best practices from East Europe are examined something very important can be concluded – the lack of venture capital threads that can be facilitated to transform innovation to real world service or product. The most common way of financing new development process is via European or national research and development funds. All these funds concern the first stage of transforming innovation or idea to "experimental laboratory sample". The main problem is that there are no real relationship between European funding scheme, banking system and the entire sea of free venture capital that must be facilitated in appropriate scheme to establish the strong boost up of innovation products.

Recession problems: Identified threats: recession leads to limited resources for company development and to the decrease in demand in emerging markets in the SEE region. In some cases a problem may arise - users' employees would want to boycott the use of tracking device in order to prevent them from being tracked.

Successful Experience realization: A total of 5 threats are mentioned which are summarized as follows: the verification and validation of the BP must have been a big challenge, the modifications of the developed BP control could be complex and difficult to realize, no plan for implementing partnerships through vital contracts, the developed BP can become obsolete, unreliable or insufficient, there are possible contradictions between legislation in different countries, the potential unauthorized access to the system by hackers.

5. CONCLUSIONS

The paper proposes a methodology for the selection of Good Experiences, their assessment and selection of Best Practices based on specific criteria and the analysis of these Best Experiences. It presents a general approach for identification of good practice examples in certain area, selection of the best of them, analysis of the results and development of a guide that could be used as a reference for future success in that area.

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