VIRTUAL SPACES FOR INNOVATION AND R&D EXPLOITATION

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Introduction

During the last few years public organisations and companies have started using information and communication technologies and the Internet in order to facilitate the dissemination and commercial exploitation of R&D results and research-based products and services. Numerous virtual spaces have been created by academic and research institutions, technology transfer organisations and specialised consulting companies; they host online databases and innovation tools and offer professional services assisting companies to adopt new technologies and develop innovations. Small and medium sized enterprises, which do not dispose internal R&D departments seems to be appropriate users of these spaces; they gain access to research results from all over the world, can communicate their particular technological problems and needs, and get insight into product and process innovations.

This paper focuses on these IT-based platforms for the exploitation of R&D results and online technology transfer and innovation tools. The first part looks at the cooperation

between industry and academia, defining models of technology transfer and practices linking physical and digital dissemination of R&D and innovation. It reviews mainly the relevant literature and examines how traditional technology transfer practices may be improved with the use of information technology and online tools. The second part examines a series of virtual spaces for innovation and R&D dissemination. It starts with the discussion of the typology of online tools for technology transfer and innovation; three main categories are defined with respect to tools focusing on dissemination of technological information, management of innovation, and online learning. Then we examine in detail an online application, the *Digital Research Centre for Cooperative Innovation*, which combines tools from the three types above. It is a new infrastructure of Aristotle University giving access to R&D results created from academic and research institutions of Central Macedonia, online innovation guides, and tools facilitating new product development, licensing, and spin-offs. We analyse its components, the type of research information it offers, the quality of listed research results, products and services, the geographical coverage, the tools and services facilitating innovation and technology transfer, the institutional network supporting the Centre, and the business model of its financial sustainability.

In the final part, based on this experience, we discuss the value added by online applications for the dissemination and exploitation of R&D results: the difficulties in the supply side and the activation of a wide network of technology providers feeding the applications; the difficulties in the demand side and the communication problems with end-users; the integration of virtual spaces with technology transfer back-offices. The question is to what extent online innovation tools and digital innovation spaces contribute to 'distributed innovation', an innovation model based on small R&D units, contract R&D, and networks of co-operation between technology providers and users.

1. Technology transfer, academia and industry

Research centres and university laboratories are becoming today strategic-support organisations for technology development, forming pools of know how and innovations for entrepreneurial activities (Dosi et al. 1988). This orientation of universities marks a significant change in their internal structure, integrating teaching, research, and the provision of services to industry. The establishment of communication methods and mechanisms for transferring technological knowledge and R&D results from research institutions to companies is necessary in order to bring this knowledge into use.

> 'The technology transfer process spans the stages from R&D to commercialisation and beyond, but with particular focus on the interface between R&D (often by a university research center, a corporate unit, or by a government laboratory) and commercialisation (often carried out by a private company' (Rogers et al. 2001).

The impact of technology transfer from universities to firms can be observed in many successful paradigms of innovation development. The emergence and development of small, high-tech firms, mostly spin-offs from universities, in Ile de France, Cambridge and Milton Keynes, for example, is based on their collaboration and close links, and outsourcing technological capabilities to universities located in the same area. Knowledge generation and dissemination from universities to firms through close collaboration is the key factor for the development of these small innovative firms (Crang and Martin, 1989; Cooke, 1996). Industrial clusters, is another example characterised by networking and strategic alliances among geographically located firms, inter-related in the value chain (Porter, 1990); clusters can not be effective unless they form an expanded network with universities, research centres and development agencies in order to obtain a powerful base for knowledge generation and information flow (Simmie and Sennett, 1999; Juniper, 2002).

In general, we may say that the need of enterprises for leaner organisation of production, for acquiring information about new technologies and markets, and for evaluating new technologies and so forth., has created an increasing necessity to acquire information from external sources, which in turn, has enhanced the role of universities and other research institutions. Chesbrough (2003) argues that the 'closed' innovation model, based on R&D departments developing technology in-house for the sole use of their corporate needs, is becoming more and more obsolete. Modern technology leaders do part of their own research and pioneered a new model of 'open' innovation, in which companies import knowledge from external sources while letting their own innovations enter the market.

Recent studies, highlighting the public benefit and the economic impact of the technology transfer process, focus on defining the different patterns by which the technology dissemination from research institutions to firms takes place and their outcomes in terms of efficiency. From these observations, two distinguish models for the technology transfer process can be identified. The first refers to the establishment of links between universities and firms through formalised research processes, such as research contracts, patents, or 'buy-sell' transactions; the second considers technology transfer as a collaborative activity occurring within networks of formal and informal relationships between universities and firms (Harmon et al. 1997).

In the former model, transfer of technology is seen as a linear process resulting from a one-dimensional relationship between technology supply and demand, where suppliers and users of technology function independently and the gap between them is bridged by adapting the former to the needs of the latter. This process presupposes more formal forms of technology transfer in terms of contractual search or patenting the technology developed at the university

and transfer patent rights to firms. It also suggests that both business and university laboratories must find ways to externalise and publicize respectively their requirements and offerings. A problem arising from this model is that the majority of firms, and specifically the small ones, do not have, if at all, a well-developed formal search procedure to find a needed technology (Harmon et al. 1997). In this case, universities should find the appropriating channels to overcome the constraints in bridging technology supply with demand.

The second technology transfer model relies on interdependences, interactions and interactive learning between different bodies, arising from collaboration networks and collective learning processes (Cooke and Morgan, 1998; Cooke et al., 1997; Edquist, 1997; Freeman, 1995; Komninos, 2002; Lundvall, 1992; Lundvall and Johnson, 1994; Morgan, 1997; Nelson, 1993; Nonaka and Takeuchi, 1995). According to this view, interactions through various forms of cooperation and networks activate learning processes, which in turn activate the generation and acquisition of knowledge. The learning process, as a process that promotes the capacity of firms to learn or generate new knowledge, takes the form of a collective process, which occurs from various inter-firm relations and cooperation between firms and research bodies via joint research projects, and other formal or informal links. A significant outcome of such a collaboration system is the sharing and articulation of tacit knowledge, which enhances information flows and technology transfer. This collective sharing, articulation and transfer of knowledge among the actors involved in the process constitutes the basis for the operation of territorial systems of innovation and localised interactive learning processes (Kyrgiafini and Sefertzi, 2003).

In both models of technology transfer, via formal procedures or collaboration processes, research activity is seen as a major contributor to the creation of information, knowledge and

new products, which in turn needs distribution systems and learning networks to arrive at and be absorbed by companies. In the formal model, a major problem derives from difficulties to bridge supply with demand, because firms usually don't now what universities do, or because universities don't now what firms need. As transfer of technology is the movement of technology via communication channels from one organisation to another (Rogers et al. 2001), exteriorisation of the university activities, establishment of information systems and elaboration of ways for the promotion and dissemination of existing R&D developed through research is of prime importance. In the collaborative model, even if it seems to be a more efficient way for technology transfer, difficulties also arise, regarding the establishment of collaboration networks and links. Obtaining an interactive learning process through close collaborations, presupposes the generation of appropriate business culture, an institutional supporting framework, interface mechanisms, and trust for co-operation, knowledge sharing and collective learning.

To overcome these problems, policy makers have launched a number of measures and supporting interventions to increase technology transfer and learning capabilities. Great attention was given to the Information Society and to intangible infrastructures as significant factors for the integration of technological knowledge and innovations into the learning process. Intangible infrastructure and 'knowledge capital' relate to assets which have value but no physical or material substance (Landabaso, 2000). They are also characterised by a low level of fixed resources and by a high capacity to adapt to changes (Azzone and Maccarrone, 1997). Besides service provider organisations, intermediary business support institutions, technology transfer offices, business consultancies and innovation centres, intangibles factors are the information and communication technologies, data bases, and online delivery systems, which constitute important learning mechanisms, directly linked to

the development and use of knowledge. These technologies and systems, affording sharing, diffusion and transfer of information and knowledge across different agencies, may lead to the creation of virtual communities, as well as virtual universities, research centres, online technology transfer organisations, and specialised consulting companies (Juniper, 2002), and, most importantly, to the increase of shared knowledge and collective learning through maximizing information access and availability (Cargo, 2000).

The virtual aspect of universities is already successfully practised in online training and education. Expanded activities in this field emerged for the online transfer of R&D results, technology information, consulting, and such like, which results in the creation of communication channels with firms. Furthermore, virtual spaces enhance the interactive learning process by integrating beyond the delivery of information, and other aspects of the learning process, such as demonstration, assisting companies to resolve problems, learning by reflection and assessment, interactivity and creation of web networks (Allen, 1998).

Taking into account the possibilities given by online technology transfer and innovation support application, we can conclude that formal and informal methods of knowledge transfer may be substantially improved with the use of these intangible methods. In the following sections we look closer at different aspects of online tools and applications for R&D dissemination, and the practical problems arising during their operation at both supply and demand.

2. Online platforms and tools for technology transfer and innovation

A large variety of virtual innovation spaces have been created to assist organisations and companies to externalise technological knowledge, manage product development, and adoption of new technology through outsourcing. We may classify them in three main categories, according to the content and online tools that they incorporate.

The first category includes virtual spaces for the dissemination of information, knowledge and technology. These spaces, also called 'Online Technology Marketplaces', encourage technology transfer and enhance the interactivity between research and business communities. They contain the R&D intellectual property (technologies and innovations) of their partners and utilize the Internet to make it widely available. Online technology marketplaces offer the universities and research institutions, which are the main suppliers of technologies, the ability to extract tremendous value from the intellectual property they are willing to share. At the same time small and medium sized enterprises, which do not have internal R&D departments, gain access to research results from all over the world along with insights into product and process innovations. In this way SMEs can bring products to markets more rapidly while reducing development costs. A typical example of online technology marketplace is *CORDIS Marketplace***,** available at <http://www.cordis.lu/marketplace>. It is a free online service, maintained from European Commission, in which users can find a selection of the latest and best technologies emerging from European R&D. CORDIS Marketplace focuses on key exploitable results in three sections: business, science and society; it also offers links to support organisations around the world, helpful technology business tips, and more. Another case is *Yet2.com Global Technology Marketplace*, available at <http://www.yet2.com>. Founded by a private company it is a marketplace for buying and selling licensable technologies, know-how,

processes, and similar intellectual property. Yet2.com is focused on bringing buyers and sellers of technologies together by offering the companies and individuals the tools and expertise to acquire, sell, license, and utilise some of the world's most valuable intellectual assets. At a regional level, *Madri+d Regional Information and Technological Promotion System,* available at <http://www.madrimasd.org>, disseminate R&D from universities and research centres located in this region. It is based on a network of universities, public research centres and private non-profit organisations linked to the technological innovation of the Madrid region, with the mission to manage and disseminate intellectual capital of regional institutions and companies and define common strategies and methodologies in the exploitation of research results.

The second category is about virtual spaces that contain online tools based on expert management of knowledge for the application of innovation. These tools may help users to solve specific problems that arise during the innovation process in a company or organisation. We may find on the web tools for technology watch, cost-benefit analysis, technology audit, creativity, marketing of innovation, benchmarking, project management, human resources management, business process reengineering, supply chain management, value analysis, and so on. The terms of use for these tools vary. Thus, a lot of them can be used free of charge whereas others must be purchased or used per subscription basis. Furthermore the complexity and the degree of interactivity vary among implementation of the tools. An example is the *Virtual Technology Park Platform* available at <http://www.NewVentureTools.net>. It is a virtual innovation environment, which has been developed by a network of European technology parks, university labs, and technology transfer centres of Finland, Germany, Greece, and Portugal. Six online tools are available, free of charge, to help in resolving typical technology transfer problems, such as technology

watch, technology audit, technology assessment, networking, marketing of innovation, and financing of innovation. A simplest version may be found at the *Spin-off Toolbox* available at <http://www.NewVentureTools.net/e-tools>, which is an online toolbox dedicated to help users during the creation of a spin-off company. The toolbox has been developed by URENIO Research Unit, and contains four simple applications focusing on business planning, marketing, cost-benefit analysis, and technology assessment.

The third category is about virtual spaces which offer e-learning platforms in order to assist computer-based learning in the field of technology transfer and the management of innovation. The users' training is based on roadmaps: step-by-step learning how to deal with technology transfer or innovation development problems. The users, while following the steps of the roadmap, are exposed to methodologies about how to solve the problem, support materials (procedures, tools, companies and organisations, case studies, etc.), additional assets (articles, presentations, sample deliverables, references, etc.), deliverables that he/she has to complete, and evaluation of results. Assessment consults whether one passes to the next step or to run the same process again. An example may be found at the *Digital Innovation Centre* available at <http://center.innothessaly.gr>. It is an online application of the Region of Thessaly, Greece, which contains two roadmaps dealing with new product development and spin-off creation.

In many cases there is overlapping of platforms and tools belonging in different types. The purpose of overlapping is to give better functionality and communication among the sub-processes of technology transfer. This is the case, for instance, of the *Digital Research Centre for Co-operative Innovation* (DRC), which combines an R&D dissemination platform with e-

learning roadmaps and innovation management tools. In the following paragraphs we will look closer at the DRC to describe its structure, functionality and combination of tools.

The **Digital Research Centre for Cooperative Innovation** <http://www.vrc.gr> is an online infrastructure under development in the Region of Central Macedonia, Greece, combining access of public and private organisations to R&D results created from the academic and research institutions of the region, and guides and tools facilitating new product development, licensing, spin-off creation, and the management of quality. The Centre has been set by the Network of Innovation, Quality and Sustainable Development of Aristotle University of Thessaloniki. It is a non-profit association, founded in 2001 from ten laboratories from the departments of Urban and Regional Planning, Architecture, Agriculture, Mechanical Engineering, Civil Engineering, and Informatics (Fig. 1).

Figure 1: The Digital Research Centre's Home Page

The planning of the Digital Research Centre was based on extended market research which assessed technology needs and demand in the sectors of agriculture, insurance, manufacturing, energy, consulting, construction, transportation, information and communication technologies banking, tourism, and health. The market research revealed the lack of R&D department in the majority of regional companies and the absence of systematic collaboration between academic organisations and companies; the survey also helped in defining the areas in which there is high demand for technological solutions. The DRC combines tools from all three categories of virtual spaces for technology transfer and innovation management mentioned above. In particular, the Centre consists of three layers (Fig.2).

Figure 2: Layers of the Digital Research Centre

The first layer is made by an online database for the dissemination of R&D results. The most important research outcomes, especially those that lead to the development of new products, new production processes and new services, are listed in a database. Technology providers from universities and other research and technological institutions submit profiles and detailed information about research products and services, while technology users from both the private and public sector can access this information over the Internet. The database entries are categorised in scientific categories and market applications so that companies and public organisations can easily find what they are searching for.

Data collection is based on three registration templates that each research organisation has to complete. The first template <http://www.vrc.gr/files/template_laboratory_en.doc> describes the research organisation, the second <http://www.vrc.gr/files/template_product_en.doc> the research-based product, and the third <http://www.vrc.gr/files/template_service_en.doc> the research-based service. Providers may submit templates online or by e-mail. After validation and verification these are stored into the database. The type of information describing research products and services was defined after in-depth discussion inside the research community. The scope is to give adequate information while not overloading the registration procedure. The market research and the companies' views have also been taken into account. R&D results are categorised using two different classifications:

- According to scientific categories and academic disciplines in which the results belong. The selected scientific categories and subcategories mainly satisfy the needs of academic organisations and provide information about the fields of science and technology related to the R&D products in question.

- According to market applications and commercial and industrial sectors in which the result may have potential impact or use. Available R&D results and products are classified with respect to their relevance to Management, Development, Construction, Manufacturing, Energy, Environment, Informatics and Automation, Quality, and Services. Each of the above market application areas has several subcategories.

Figure 3: R&D results, products and services feed and retrieval

The second layer is an online innovation learning platform. It is based on online roadmaps (guides) that clarify aspects of R&D exploitation and use. The roadmaps are complete methodological guides that help users (laboratories, companies, technology brokers, and intermediary organisations) accomplish, in a new and innovative way, the tasks of new product development, spin-off creation, intellectual property management, and management of quality (Fig.4). Furthermore, this layer includes two online communication tools between academia and businesses, a technology-matching tool and a discussion forum. These both create a digital space where entrepreneurs, SMEs, and public organisations can post their technology needs that are automatically communicated to the closer technology provider in order to open a dialogue and find a solution.

- New product development roadmap is a learning platform and collection of tools that guides the user through the five stages of the new product development process: ideas generation, evaluation of ideas - selection of the final idea, product design, prototyping, and commercialisation. Assessment points allow the user to continue or kill the process.
- Spin-off creation guides the user through the four stages of a spin-off company's creation process: identification of a potential new product, analysis of the business opportunity,

investigation of issues regarding intangible assets, and preparation of the business plan. The same assessment procedure links the different steps.

- Intellectual Property Management is a roadmap for the creation, management and commercial exploitation of intellectual property. It covers various topics related to intellectual property such as licences, patents, copyright, disclosures, trademarks, registered designs, design rights, and so forth, while providing the relevant legislation and case-law.
- Management of Quality shows users how to introduce and operate a management of quality system in their company/organisation. It informs the users about the International Standards and presents the activities of Quality Management and Quality Assurance. A list of the accreditation of testing and calibration laboratories in the region of Central Macedonia is also available. The roadmap is particularly important for laboratories and companies working in the field of testing and destructive evaluation.

Figure 4: Roadmaps dealing with new product development, spin-off creation, intellectual property management, and management of quality

Roadmaps are divided in thematic steps. Each step deals with a specific problem and provides the solution to this problem with methodologies and tools. The user also has at his/her disposal support materials such as procedures, tools, companies and organisations to consult, case studies, and additional assets such as articles, presentations, sample deliverables, and references. At the end of each step the user should complete a final deliverable and evaluate it against a given self-assessment template (Fig. 5). Where appropriate, the user can use online tools included in the different steps, which are available over the Internet.

Figure 5: Roadmap Step Content

The third layer covers technology dissemination activities and small pilot projects testing technology transfer and innovation, mainly the co-financing of efforts where companies and university laboratories cooperate in the development of commercial products or services based on R&D results.

Box 1: Pilot co-operation projects initiated from the DRC

1. Evaluation of the use of high resolution satellite images in identification and mapping of cotton fields
2. Development of software for the calculation of long-term levels of atmosphere pollution in urban areas
3. Development of software for the simulation of atmosphere flux and pollution dispersion at local level
4. Digital information systems and data bases for metropolitan areas
5. Development of software for the assessment of seismic movement in the design of public constructions and buildings
6. Management of the agro-environments with GIS applications
7. Digital platform for monitoring innovation and regional development
8. Energy saving in agriculture with the use of Aeolian appliances
9. Modelling and prototyping glass green houses

The operation of the Digital Research Centre depends strongly on the mobilisation and the active participation of regional stakeholders. A regional network of research, production, and technology transfer agencies has been formed in order to activate the services of the DRC: procurement of knowledge and information about 'who is doing what' and 'who needs what' in the fields of research outcomes and technology. The actors involved belong in two groups: The first group consists of academic institutions: Aristotle University of Thessaloniki, University of Macedonia, Technological Educational Institute of Thessaloniki, Technological

Educational Institute of Serres, National Centre for Research and Technological Development, Technology Park of Thessaloniki. The second group consists of business representative organisations, including the Federation of Industries of Northern Greece, the Exporters' Association of Northern Greece, the Traders' Association of Thessaloniki, the Trade Unions Centre of Thessaloniki, the Industrial and Commercial Chambers, the Association of Northern Greece Information Technology Enterprises.

The above mentioned components show that the Digital Research Centre for Cooperative Innovation has both digital and physical dimensions, which stimulate and enhance the cooperation between research organisations and companies allowing knowledge and expertise possessed and developed by universities to flow directly into business and society.

Overall the Digital Research Centre seeks to promote the technological dynamism of the region, exploiting the outcomes of the research conducted in the university laboratories, recording the technological needs of the regional companies, and cross-linking technology supply and demand. Thus it may sustain the efforts towards the development of a knowledge-based regional economy. The impact on the regional economy is expected in three domains:

- Encouraging the links between research institutions and businesses. Scientific research in the region is mainly conducted by university laboratories and, although covers a wide range of scientific areas producing a variety of results, is abstracted from the real needs of firms. Existing links and cooperation between research and production are quite limited, mainly due to the isolation of both parts and the lack of interaction mechanisms. The Digital Research Centre is being developed towards bridging this gap enabling the commercialisation of work done in laboratories. DRC provides the mechanism to gather and correlate inputs from the supply side (university laboratories, research and

technology transfer institutions) with those of the demand side (companies). The database of research results facilitates companies to reach the technology required for the creation of products and the launching of innovations. In parallel, the recording of the technological needs of companies may enrich the research directions of academic organisations.

- Fostering networks between university laboratories, technology transfer organisations and companies in view of creating clusters in different technological fields. Clusters formed by groups of innovative enterprises, academic and research institutions and other support organizations are recognised as structures embodying a developing knowledge base, allowing interaction flows through technology and knowledge transfer. These relations can strengthen the fabric of the region, and enable traditional industries to renew or differentiate their products.
- Disseminating and diffusing research results, both in the physical and virtual space, to the benefit of an innovative regional culture. The easy accessibility of the DRC, the number of users of its services - companies and research laboratories - the number of laboratory templates inserted in the database, the number of users of the digital applications allow the impact of the virtual services of the DRC to be measured. In addition, the initiation of pilot applications concerning the development of new products with the use of R&D results is a primary indicator of an effective dissemination.

The creation of the Digital Research Centre was financed by the ERDF's Innovative Actions program and national resources, while a small part of the total budget is provided by laboratories and companies involved in the pilot applications. Openness and transferability are crucial factors of sustainability. The main features rendering the Digital Research Centre easily transferable, are related to:

- Broadness: DRC is addressed to all production units, regardless of specific branches, sectors and size. It is open to any scientific and technological field, thus covering a wide range of services and products. The broad character ensures that the system may successfully operate focusing on more narrow fields of application - it may focus on specific production sectors and corresponding service and technology providers, taking a cluster character - or on even broader scientific fields, including further research categories.
- Easy accessibility and involvement procedures: Information included in the DRC and the services provided might easily be reached via the Internet, which becomes a widely applicable tool. The recording of technological needs of companies and the presentation of the research activities of laboratories is based on the completion of simple templates.
- Multilanguage structure and standard technical requirements, including the information management system, the database, the discussion forum, and the web applications.

The fact that the Digital Research Centre for Cooperative Innovation has been built using open architecture and standard information, web, and database technologies enables its expansion into other regions. DRC can be easily adapted to the conditions of any regional system, as, apart from the major concept of providing a mechanism linking demand and supply of technologies, it includes several supporting services and portals, which may be differentiated according to the specific fabric of the region. The structure adopted allows the services it provides to be extended with the inclusion of information for intermediary organisations (business associations and consultants), public and private agencies, and funding mechanisms, offering additional online applications and creating sub-spaces in different technology and market segments.

3. Online innovation and technology transfer in operation

The online innovation tools and R&D dissemination platforms in which we were involved gave us the opportunity to investigate the users' views and the problems encountered during their operation. The experiences we are discussing here are based on the operation of the Digital Research Centre in the region of Central Macedonia, but we also take into account conclusions from the operation of similar applications in three other regions. Firstly in the region of Thessaly, two online roadmaps were set to facilitate new product development and spin-off creation working jointly with a rapid prototyping centre. Secondly in the region of the Peloponnese, online tools were incorporated and tested in the project for a Virtual Incubator, which is part of the Regional Innovative Actions Programme Finally in the region of western Macedonia, an online innovation platform is under construction combining technology management and e-commerce tools in the framework of the project for a Virtual Technopolis.

It is important to underline this new orientation of regional authorities towards digital platforms and tools facilitating the development or adoption of innovations; it marks a new direction in regional policy and infrastructure creation towards intangible assets. It is a promising new trend in the EU structural policy, in line with the decisions of the Lisbon (2000) and Barcelona (2002) European Councils for the creation of the European Research Area, promotion of common technology platforms, and making Europe the most competitive knowledge economy in the world (European Commission, 2002; and 2003).

We will discuss the operation of these virtual innovation platforms and tools from three different points of view: from the perspective of the technology provider who lists services and technologies in the virtual space; from the perspective of the user who visits the virtual

space and uses its tools and applications; and from the perspective of the system itself and the back-office developing the intelligence of online tools.

Working with technology providers

Virtual spaces containing modules for R&D and technology dissemination have to be developed in close co-operation with R&D and technology providers. The effectiveness of an online R&D dissemination database directly depends on its diversity and richness in R&D results, technologies and products; however, it is quite impossible to construct such a database without the direct involvement of the R&D organisations, research teams, and technology developers that have created the R&D results. It is not a question of intellectual property rights, though this dimension also exists. Only R&D and technology organisations have the knowledge to describe research results precisely and give information about the technology in question, its eventual use, sectors of application, and conditions for exploitation.

In the case of the DRC and in view of facilitating co-operation with R&D organisations and technology developers we created different templates to codify and register R&D information. As mentioned, there are three templates available, one for labs, one for products, and one for services. The provider has to download the template for the DRC website, fill it, and send it back to the DRC. The whole operation takes less than 30 minutes for someone who knows the case. Beside the simplicity of the procedure, we found considerable difficulties in getting the R&D and technology providers involved. The problem behind this reluctance is a lack of motivation and low expectations from online technology exploitation. R&D organisations do not seem to be sufficiently convinced about the value of online

technology dissemination, negotiation, and transfer; that there will be a return from the registration of an R&D result / product onto a public database.

Interviews on the causes of this reluctance and the motivation of technology providers for listing R&D information revealed three main obstacles. The first is organisational; you always have to go down to the research team in order to get accurate information. Even in large organisations, this information is rarely stored in advance or transferred to administrative personnel. The second relates to the temporality of research teams; it happens very often, the research group to be dissolved with the end of the research project. This diminishes interest in the post-project phases and the eventual exploitation of R&D. Chaotic intellectual property right settings also decreases the involvement of the initial R&D team in the post-project exploitation. The third obstacle is related to the maturity of the online technology marketplace itself; to date very limited online technology transfer is taking place, and few users are looking systematically for technology via this route.

The significance of these obstacles is that virtual spaces may easily lose their collaborative dimension. The permanent link to research teams and organisation is crucial. The virtual space is less a repository of past knowledge than a tool enabling one to follow the entire life cycle of research, from conception, creation, and application of knowledge. A pure virtual function impoverishes the full potential of online innovation and technology dissemination.

Views of users

The real value of online innovation and technology transfer platforms and tools appears during their use. A series of new problems emerge with the creation and use of such tools, which may be better understood within the wider landscape of technology transfer as online

tools accommodate the main routes of technology transfer, facilitating technology licensing, technology dissemination, and technology learning, discussed in the first section of this paper.

Interviewing users about technology dissemination through online platforms, we observed a very positive appraisal of the opening of university R&D to public viewing. This was emphatically stated by small innovative companies working with internal product development teams; for them information about R&D from university labs is an additional source of inspiration and product innovation. The non-profit character of universities and the tradition against information disclosure helps see online applications as sources for new ideas, products and technologies from which they may benefit. It also became clear that taking advantage of online R&D and innovation tools is possible only when companies have some internal R&D or product development capability. At least a small product development team is necessary to adapt research results to the company needs for products and markets.

Investigation about the use of virtual innovation spaces in technology licensing reveals two main domains of interest. The majority of users visit the virtual space to be informed about third party R&D and find technologies that match their specific technology needs; a smaller percentage look at these spaces to better understand technology licensing and find models and best practice on formal technology agreements and licensing contracts. However, users find regional R&D information systems more appropriate than global ones (such as Cordis or Yet2com), which is explained by the fact that the former offer information in their language. Another advantage of regional systems is when a technology interest is found it is easier to get in touch with a technology provider located nearby and take additional information or

have a demonstration. Cultural (linguistic) proximity and geographic proximity make communication and technology co-operation much easier.

A criticism frequently stated concerns the summary presentation of new technologies or R&D results, which makes understanding rather difficult. No doubt, multimedia presentation, drawings, pictures, and demo may improve the description of content and understanding; but these forms of communication demand higher bandwidth, which is not always available. This criticism neglects the fact that the virtual space is just the first step, finding a reference point for co-operation; next steps rely on direct communication between technology providers and users.

In the field of technology learning, the online roadmaps which guide towards the solution of a problem step by step, were very much appreciated. Demonstration of the new product development roadmap in higher education engineering departments revealed an interest in using it in the classroom for computer-assisted product development. In all cases, knowledge disseminated through these applications is rather formal than tacit knowledge. Procedures and expected results are clearly defined in advance, though the way these tools are used is open to imagination and creativity.

We should underline that online platforms and tools are appreciated by companies disposing R&D departments and involved in technology transfer and new product development on a permanent basis. Organisations without some internal R&D and technology development capability cannot take advantage of online applications. Adoption of new technology and innovation is possible by combining internal and external capabilities. A fully distributed

innovation model is not operational. ICTs and the Internet have not changed the internal-external interaction in innovation much.

Increasing the intelligence of online tools

Understanding the added value of online R&D dissemination and problem-solving suites gives them their real dimension and allows for their optimal effectiveness. Most important in our view is the articulation between physical and digital R&D and innovation spaces: the use of online platforms and tools to assist the activities of real-world research and innovation teams and networks. A virtual-virtual situation (as opposed to physical-virtual) is a very weak solution.

The intelligence of digital innovation spaces may be gradually improved from this link to real-world innovation teams. Having permanent feedback from researchers, technology transfer experts, innovation professionals, and technology policy makers allows for a trimming of the internal procedures and knowledge generation functions of digital tools.

Information technologies used are rather conventional; most design and development creativity goes into the setting of logical circuits and knowledge routes allowing for a breakdown of a complex problem into its simplest constituting components. Finally, the conceptual framework on which online tools rely combine the codification of expert knowledge, the follow-up of routines, and an increased capacity for storing and retrieving information.

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Figure 1: The Digital Research Centre's Home Page

Figure 2: Layers of the Digital Research Centre

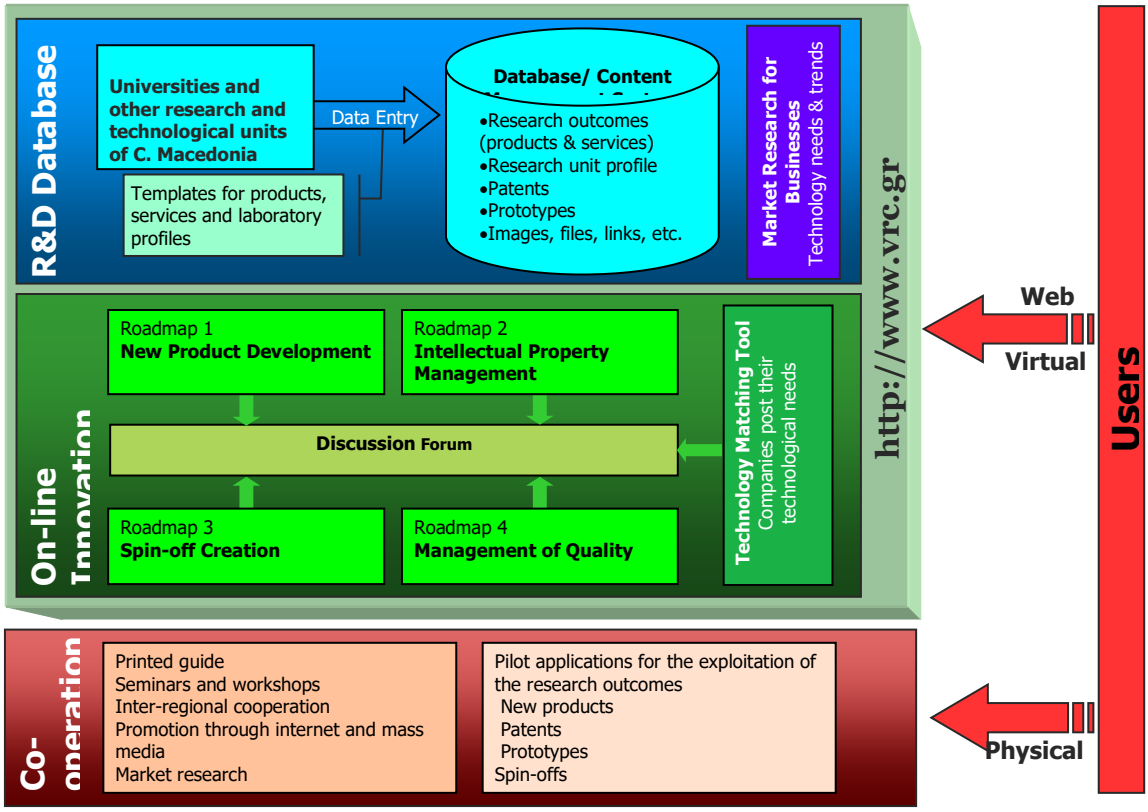


Figure 3: R&D results, products and services feed and retrieval

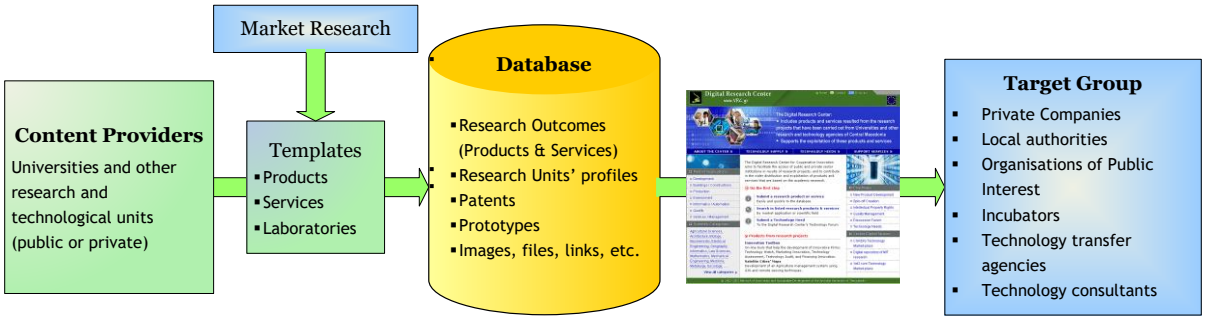
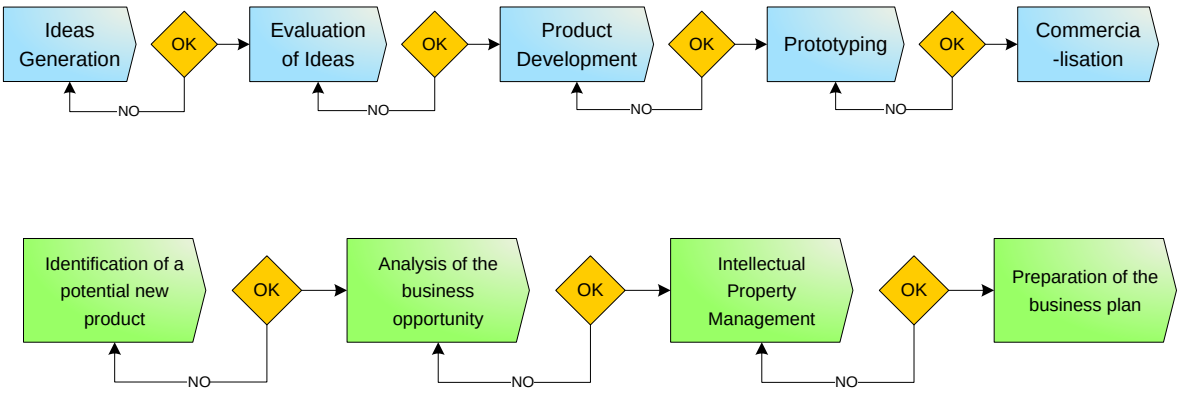
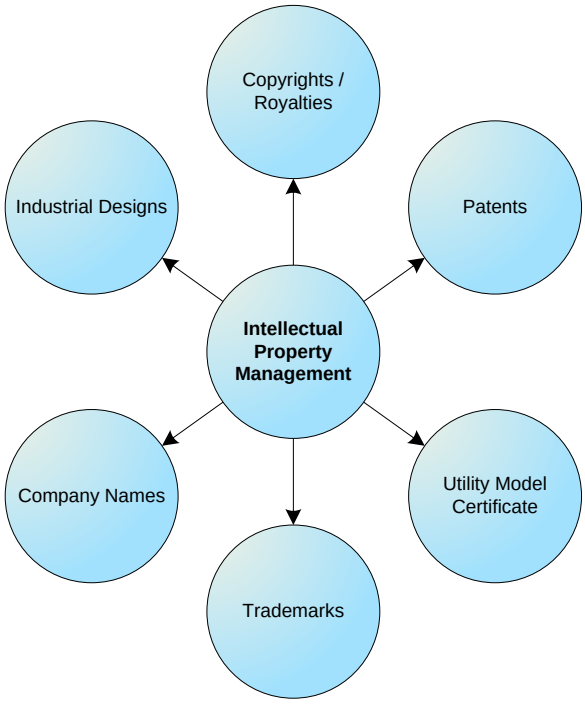


Figure 4: Roadmaps dealing with new product development, spin-off creation, intellectual property management, and management of quality





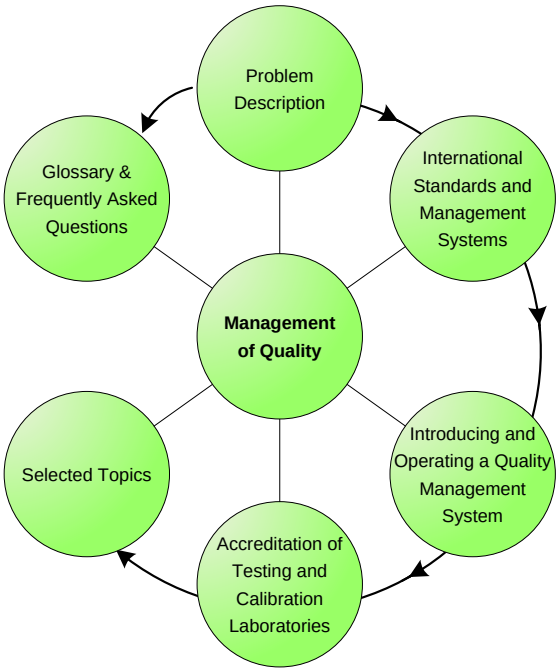


Figure 5: Roadmap Step Content