Virtual Open Innovation System (VOIS) with the Case Study: Partnering Research-Innovation Project ROBOTOOL-1 [1]

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Abstract

The emerging Industry 4.0's enabling technologies are bringing opportunities for new manufacturing business models and profound corporate and societal changes. These changes' main characteristics are an urgent need to understand and exploit companies' key competencies, enabled by their value chain's internal and external innovation ecosystems. The open innovation culture of continuous improvements and search for more competitive solutions are the main characteristics of these new manufacturing landscapes. With their business, professional, and social networks, knowledge workers, supported by collaborative culture and proper leadership, become the main drivers of Industry 4.0 business success. The capability to collectively recognize and exploit the personal, organizational, and regional potential is one of the critical competencies of modern knowledge-based businesses. Successful partnering of such knowledge innovation communities presents the essence of effective and efficient Industry 4.0 enterprises. This paper discusses characteristics of such open virtual research-innovation communities, the proposed model of virtual open innovation system (VOIS), and its illustration in the case study from the toolmaking-machine industry sector.

Keywords: digitalization, technology, virtual organizations, innovation communities, research-innovation programs/projects, technology platforms, collaborative design and engineering, virtual collaboration platforms, open innovation ecosystems, manufacturing, toolmaking, partnering-alliances

1 Industry 4.0 - Challenges of Manufacturing SMEs

The emerging Industry 4.0 enabling technologies are reshaping the landscapes of our industries, economies and societies.

Addressing the Industry 4.0 related technical challenges is not enough. More than twenty years ago, Celente wrote in his book that futurists often equate advances in technology with civilization advances [1].

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To exploit innovative technologies for all stakeholders' benefit requires a profound understanding of how these novelties will affect business and personal lives, organizations and how they will reshape organizational landscapes, societies, and culture.

Houser wrote [2],» Computer scientists and engineers shouldn't be the only people shaping the future of artificial intelligence, according to the group led by researchers from MIT's Media Lab.«

We can say that this is not valid for artificial intelligence only. It's valid for the majority of Industry 4.0 enabling technologies and their implementations programs and projects. We need to understand and adequately address their implications to secure value for all involved stakeholders.

Manufacturing companies operate in a highly competitive context as they sometimes subjected to fierce global competition in terms of new products, production technologies, new materials, legislative, or organizational or business model developments and usually rely on innovation only to cope with the competitive advantage through an increase in productivity and increase in other relevant manufacturing figures, such as flexibility or agility.[3]

Many SMEs face a lack of expertise, short-term strategies, the lack of an expert sup-port function, limited resources, resistance to changes, and more. [4]

Based on these facts, we can conclude that the efficient and effective Industry 4.0's corporate strategic transformation and changes needs:

- A proper understanding of Industry 4.0 enabling technologies, related opportunities, and potential for the observed industry sector and involved businesses,
- Understanding of industry global trends and value migration,
- Competencies for setting up a short and long term business development strategies,
- Awareness of own key competencies, as well as internal and external corporate innovation ecosystem potential,
- Competences for exploitation of available internal and external industry innovation potential,
- Portfolio of research-innovation projects and programs organized internally or co-organized with the inter-organizational value chains partners,
- Leadership and empowerment for developing and implementing needed interrelated, simultaneous technical, organizational, personal, and business culture strategic changes.
- Digitalization awareness and literacy of all involved stakeholders, and
- Fostering and development of innovation collaboration culture.

SMEs need to increase the pace of their innovations to survive in the global high competitive markets. Industry research and innovation are becoming critical success factors of their success. Organizations can overcome limitations of internal research-innovation potential by exploiting their business partners' and regional innovation ecosystems' innovation potentials.

2 Potential of Industry Open Virtual Research-Innovation Communities

Being an SME and competing with the bigger competitors in globalized markets is an almost impossible task. Therefore, specialization, collaboration with industry partners, and sustainable innovation capabilities are essential for survival and maintain competitiveness. Competencies to recognize internal and external innovation ecosystem potential and how to utilize it is becoming critical success factors of modern SMEs.

The global knowledge base provides a list of conceptual frameworks that can help address these industrial challenges, and it was developed in the last twenty years. Here we can mention Tapscott [5], who coined blueprint to the digital economy, Pallot, Prinz, and Schaffers [6], with their concepts of the future workplace, Camarinha-Matos, Afsamanesh, and Ollus [7] presented systems and practices of virtual organizations, and other numerous theorists and industry experts.

With their inter-organizational value chains and innovation ecosystem strategic alliances, virtual dynamic learning organizations enabled by open innovation [9] communities and collaboration platforms are examples of such theories and organizational concepts used in the proposed Virtual Open Innovation System (VOIS).

Most of the existing studies point out that virtual organizations are a temporary consortium of partners from different organizations established to fulfill a value-adding task in terms of product or service to a customer [10]. Virtual organizations are temporary alliances between organizations to share skills or core competencies and resources to better respond to the new collaboration opportunities [11]. This way, virtual organizations represent collaboration between formally nonconnected organizations or persons who establish vertical or horizontal links and present themselves to the customers of their products or services as a single association. Apart from the professional literature concerning virtual organizations emphasis is also given to the information and communication technology as well as to the absence of the central control functions [12, 13, 14, 15]. In a virtual organization, the central control functions are replaced by the horizontal redistribution of responsibilities and agreed-on coordination authorities among the collaborative partners. Although the virtual organization is a very flat and weak structured organization, it needs the adequate structure of the virtual organization's integrators, interests' domains agents, and members who collaborate on agreed topics. Such integrators and agents must be good leaders and virtual community organizers.

Strategic partners with their collaborative endeavors create various virtual organizations and increase the involved partners' innovation potential. Industry research and innovation communities (RICs) are integral parts of such industrial's innovation ecosystems. These virtual communities use various e-tools and web-based platform services that enable and support their communications and collaborative work.

EU Institute of Technology and Innovation (EIT) argues that the innovation community is innovation in action. Its work is world-class and covers the entire value chain from education to research to business creation, demonstration, start-up incubation, marketing, communication, and sales. It is a living entity that connects people and organizations – a dynamic partnership, ready to adapt to the changing realities of its field and the emerging needs and challenges of Europe. [16]

How to transform the innovation community potential of identified collaborative business partners into the innovation community power, which will generate value for all involved stakeholders? The effectiveness and efficiency of such partnering demands need a joint virtual organization with a clear understanding and overall support of its value proposition, vision, strategic goals, implementation strategies, used technologies and resources, organizational structures, processes, coordination, and leadership issues.

3 The VOIS - Virtual Open Innovation System

The subject of incremental and radical innovations has to be all corporate products and services with all related, intertwined business and technology processes. The ideas and initiatives for such innovations can come from the various internal and external stakeholders of the observed industry cases and their innovation ecosystems. It has to be promoted and coordinated based on the collaborative open research and innovation program business cases relevant for the observed industries and co-defined by the industry innovation ecosystem core partner(s).

Such open innovation systems and inter-organizational collaboration must be properly orchestrated, motivated, enabled, and promoted by adequate leadership, promoting open innovation culture.

We recognize three levels of an open innovation ecosystem observations (Figure 1):

1. **Level 1:** The industry research-innovation collaboration business case initiative – strategic driving forces, proposers motivation, their collaboration interests, and value propositions for potential involved internal and external partners of the observed innovation ecosystem;

2. **Level 2**: Research-innovation communities - presents a virtual communities potential of available knowledge organizations and workers who are willing to exchange knowledge, experiences and co-create ideas for improvements of

existing solutions or implementing various new research-innovation projects/programs;

3. **Level 3:** VOIS - Virtual open innovation system - presents the virtual organization established by the innovation ecosystem's business case core partners to organize, support, coordinate, and enable partnering activities of this thematic research innovation communities on the areas of collaborative interests within an observed innovation ecosystem.

The VOIS comprises five interrelated modules, three virtual organization modules, and two modules presenting special cloud computing services to support virtual organization operations performance.

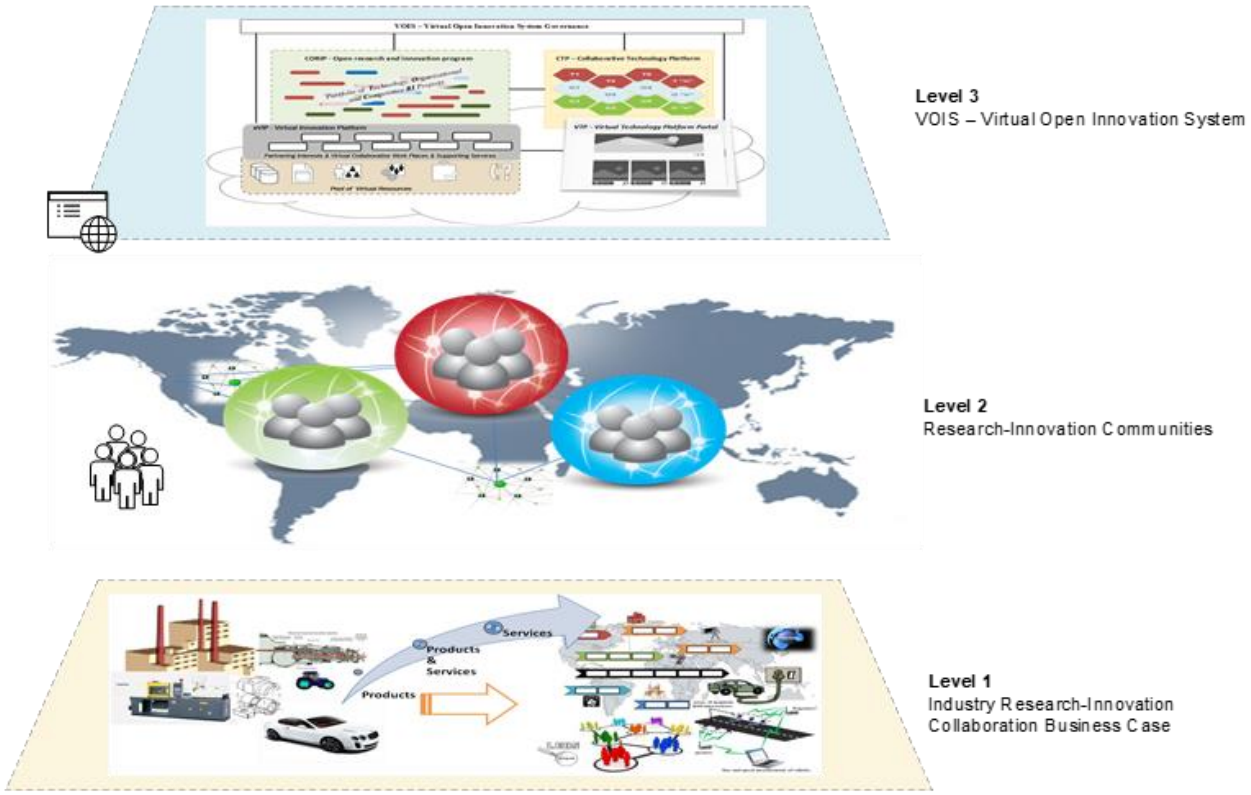

Fig.1: LENS Living lab's levels of an innovation ecosystem observations

Virtual organization modules are:

- Collaborative open research and innovation program (CORIP),
- Collaborative technology platform (CTP),
- VOIS governance

Cloud computing service modules are:

- Virtual innovation platform (eVIP),
- Virtual technology platform portal (VTP)

Collaborative open research and innovation program (CORIP) – Such a collaborative program defines collaborative partners' strategic intentions, expectations, shared strategic goals, coordination of related partnering initiatives and projects for the stakeholders' value creation. ISO 21 500 defines the program as a group of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually. Program management is the centralized and coordinated management of a program to achieve the program's strategic bene-fits and objectives. [17] This definition is used as a baseline for further definition of collaborative open research and innovation program (CORIP). CORIP covers a portfolio of individual applied research and innovation projects coordinated to obtain common identified strategic benefits of involved partners, who collaboratively govern and organize such programs. The open innovation program is available to all motivated program stakeholders who can in various ways contribute to the achievement of the program's benefits and goals and are willing to follow the program's operational standards and code of ethics.

Virtual innovation platform (eVIP) – represents the virtual collaborative working environment to support CORIP's operations by custom-designed cloud computing systems and services. eVIP provides the working environment that supports and enables research-innovation community members' communications, information exchange, and cocreation within their collaboration interests, projects, and other partnering tasks.

Collaborative technology platform (CTP) – Technology platform presents technologies as reusable assets [18]. Our CTP definition customizes this definition as a cluster of thematic technologies that the industry research and innovation community develops and offers to develop further applications, technologies, processes, systems, and services. CTP supports the commercialization of CORIP's and other thematic complementary products offered by the research-innovation community members.

Virtual technology platform portal (VTP) - presents technology platform virtual open market. Presents cyber value space, where technology platform supply and demand sides interact and do commercial acts. VTP provides a communication hub with online one-stop-shop market services, enabled by search engines and with the support of cloud-computing systems and services.

VOIS governance - is performed by the coordinator and co-organizers of such virtual open innovation systems, focusing on orchestrate coordination and management of

VOIS's virtual organization and virtual system modules to achieve their strategic goals and expected benefits.

The VOIS is described in the VOIS Charter developed and accepted by core VOIS partners. VOIS Charter defines strategic inputs, clients, value propositions, business models, services, core partners, VOIS modules, organization, collaboration management, expected collaboration and co-creation activities, related costs, and overall benefits.

Figure 2 illustrates presented VOIS modules and their relations.

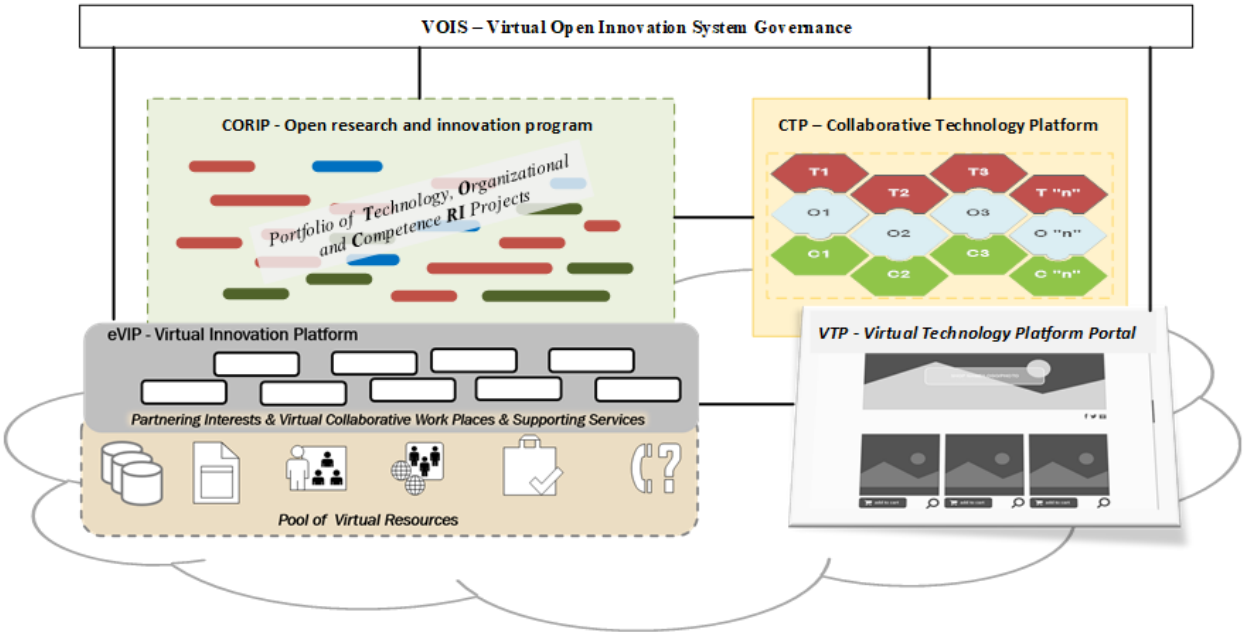

Fig.2: VOIS modules and their relations

A VOIS initiator can be any organization(s) that is an active player in the value chains of the observed industry sector's innovation ecosystem. VOIS initiator(s) is(are) considered an organizer(s), integrator, enabler, and prime-leading coordinator of such a thematic research-innovation community. The next chapter presents the practical VOIS business case from the machine and toolmaking industry sector.

4 Case Study of the Partnering Innovation Project ROBOTOOL-1

4.1 Introduction

Manufacturing of modern industrial products requires various industrial tools and mechanical devices in individual production phases of product manufacturing. This industry sector is highly innovative, presented by the high-labor intensive manufacturing

SMEs. The growing global markets of new industrial products supply imply a growing need for new tools and manufacturing technologies.

Like all representatives of manufacturing industries in the EU, toolmakers face global competition and the pressure on cost reduction imposed by competitors from the Far East. An answer to the above problems lies in radical innovations and exploitation of "smart technologies" based on extensive use of Industry 4.0 key enabling technology applications and the smart factory concept's implementation. [19, 20, 21].

Imagine a production process of tools or custom-designed machines for various industry clients, where toolmaking experts, CNC machine operators, and other workers in such manufacturing process carry out various operations within specific workplaces requiring numerous manual skills with agility and flexibility issues, where they are facing possibilities of errors and quality issues, and needs a significant amount of time and demanding workers qualifications. How to address described challenges by the utilization of smart manufacturing concepts and technologies? [22]

The idea for this partnering research-innovation project came from the LENS Living Lab researchers, co-founding partner of the Competence center ROBOFLEX, established by the industry partners of EU project HORSE [22] to support robotization and digitalization transformation processes in manufacturing SMEs. In collaboration with the proposed project's leading partner company ETRA - experts for industrial automation and robotic system integration, who identified this project as a business opportunity to acquire new technologies and markets, the partnering industry research and innovation project ROBOTOOL-1 was initiated. The Faculty of electrical engineering and computer science and the Faculty of logistics (both are members of the University of Maribor) researchers were invited. The regional specialist in toolmaking - EMO Toolmaking company, producer of tools for the EU automotive industry, was invited as an innovation partner and a pilot business case.

The ROBOTOOL-1 project's idea and motivation were to support manufacturing SMEs in this industry sector within their transformation efforts towards digitalization and smart manufacturing 4.0 scenarios implementation.

The primary project goal was to identify and conceptualize the technology scenarios of RiWP - hybrid robotized and digitalized workplaces (mixed use of collaborative robots, augmented reality, and automatically controlled vehicles) and illustrate their practical value by the industry pilot applications.

Besides this, the industry guidelines for the manufacturing SMEs are developed to support exploitations of this project deliverables. The guidelines include presenting potential technology solutions, catalogs of developed technology implementation scenarios, and Smart Manufacturing digitalization architecture.

The complementary goal of this project was to establish a sustainable collaboration with the ROBOTOOL-1 project partners in the areas of development of digitalization and smart manufacturing technologies for the needs of project-based manufacturing SMEs in the toolmaking and machine industry sector (ROBOTOOL 4.0).

The project partners present the initiators and core partners of this new open research-innovation community RIC ROBOTOOL 4.0, which will continue to collaborate after the ROBOTOOL-1 project completion and be open to all interested ROBOTOOL 4.0 innovation ecosystem' stakeholders.

The RIC ROBOTOOL 4.0 core partners mapped and extensively discussed their development strategies, motivations, interests, and value chain expectations from this long-term partnering initiative. Based on these inputs, the VOIS ROBOTOOL 4.0 Charter and implementation modules were initiated, developed, and start-up.

4.2 VOIS ROBOTOOL 4.0

The technology framework TFRD[2] is developed based on the identified shared strategic intentions, based on the ROBOTOOL-1 Project, and its developed reusable technology concepts, components, solutions, and support services. The TFRD presents the strategic baseline for further research-innovation initiatives and projects of the newly established partnering open research-innovation program CORIP ROBOTOOL.

The collaborative technology platform CTP ROBOTOOL is co-created to support the commercialization of the CORIP ROBOTOOL projects' reusable deliverables and other TFRD connected products offered by the ROBOTOOL 4.0 core partners.

The virtual collaboration workspace is formed for the needs of CORIP ROBOTOOL projects implementation. This workspace was developed as a virtual innovation platform (eVIP), using a cloud computing tool (CCS) ExArca. The CCS ExArca is designed as a flexible internet-based communication backbone to support the collaborative performances of various innovation community initiatives.

CCS ExArca is a secured multi-level communication and virtual workspace support-ed by a secure socket layer (SSL) and state-of-the-art encryption algorithms to secure the data exchange and communications between ExArca users. This system supports the use of CPS-IoT, AI technology modules, and applications. The whole infra-structure lies on top of the database, which supports BD operations.

The Technology Platform Portal (TP) ROBOTOOL 4.0 operates as the internet-based open market for reusable technology solutions with related services developed and provided by the ROBOTOOL 4.0 innovation community partners. Industry clients can

[2] *TFRD – Technology Framework for Robotization and Digitalization. TFRD includes the portfolio of technological (T), organizational (O), and competencies (C) products and services needed in the strategic transformation processes towards Manufacturing 4.0.*

browse and find needed developed technology components, organizational solutions with supporting services provided by the ROBOTOOL 4.0 innovation community for their needs.

The VOIS ROBOTOOL 4.0 governance is provided by the regular annual ROBOTOOL 4.0 development conferences, coorganized by this open research-innovation community core partners. Company ETRA is the VOIS ROBOTOOL 4.0 leading coordinator and enabling organization. With the support of the Competence Center, ROBOFLEX provides virtual collaboration workspaces and project management office services to CORIP ROBOTOOL 4.0 partners.

The VOIS ROBOTOOL 4.0 is the first industry thematic VOIS developed as an integral part of a regional digital innovation hub (DIH) for the manufacturing industry, fostered by the Competence center ROBOFLEX.

5 Conclusions

The “Strategic Value Creation Networks” is one of the five key drivers to achieve the EU industry 2030 vision. To respond to these opportunities, Europe needs to build on regional ecosystems that embrace their own smart specialization, help to bridge regional disparities, and provide the platform where all the actors can combine their knowledge and co-create the content, context, and learning experiences. The fundamental changes in the role of local production networks, which arise from a new logic in which servitization is becoming increasingly important, are expected. [23]

The proposed VOIS is a practical example of this new logic. VOIS supports described intentions by providing a holistic, systemic approach and services for such manufacturing industry' collaborative innovation business cases of their regional strategic value networks creation.

The integrative complexity [24] approaches are needed, where all relevant technological, organizational, economic, and social aspects of the observed business cases are simultaneously addressed properly.

Critical collaboration driving forces and issues for successful partnering are collaboratist leadership combined with phronetic intelligence, trustworthy supportiveness, integrity competence, consistency, openness, and loyalty [25].

There is no doubt that the complexity of technologies and fast-changing emerging business environments of manufacturing SMEs calls for specialization and sustainable collaboration with its value chains' business-innovation partners. The borders between organizations are blurring. Interorganizational research-innovation communities (RICs) and their collaboration in innovations are critical drivers of such new inter-organizational value chain partnering business landscapes. The Industry 3.0 manufacturing SME's

business success depended on its productivity and internal innovation power. Today's Industry 4.0 companies face challenges of inter-organizational productivity and exploitation of inter-organizational innovation potential from their value chains. Inter-organizational partnering and innovation are becoming critical success factors of modern manufacturing SMEs.

Such a business environment needs good leaders capable of long-term shared thematic inter-organizational and interpersonal partnering in supporting sustainable technology research and innovation, practicing interdisciplinary approaches, and developing a culture of open innovation.

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During his studies he already participated and helped with the technical support of organizing virtual project schools for family's company INOVA Consulting. He also helped with other projects and event organization, regarding the LENS Living Lab virtual laboratory, where he contributed with his innovative ICT services and knowledge.

With his involvement in the family business, he also started working on a project for the virtual collaboration environment in 2009. In 2013 the project received an award from Slovenian Logistic Association (SLA) as a R&D project of the year. In 2014 he established a joint venture company, which provided hybrid technology solutions in critical communication organizations such as firefighters, police departments, highway maintenance companies, and other virtual and spatial distributed operations.

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