TECHNICAL UNIVERSITY
OF CLUJ-NAPOCA
ROMANIA

TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

HABILITATION THESIS

Quality and innovation management within smart and sustainable industrial and academic projects

Domain: Engineering and management

Assoc.prof. Mihai DRAGOMIR, PhD

2018

To my family: Diana, Gabriel and the next generation

ACKNOWLEDGEMENT

There is much work and hope that has gone into this thesis, as it is difficult to summarize about 15 years of activity and prepare a robust plan for the next 30 years or so. My journey has been significantly influenced and helped along by many people, some on a personal level, some on a professional level, some in both domains and many others in areas I probably do not understand yet.

Institutionally, I am indebted to my alma mater, the Technical University of Cluj-Napoca, especially the Faculty of Machine Building and the team of the Department of Design Engineering and Robotics. Professionally, I would not be here without the help of the true academics that have guided and supervised my development, Prof. Sorin Popescu and Prof. Daniela Popescu. Also, I owe many thanks to my colleagues, friends and collaborators from the university: Prof. Călin Neamțu, Lect. Ștefan Bodi, Lect. Radu Comes, Lect. Grigore Pop, Lect. Emilia Câmpean, Assoc.prof. Dan Hurgoiu, Prof. Liviu Crișan, Prof. Stelian Brad, Lect. Vasile Tompa, Assoc.prof. Emilia Brad, Dr. Simona Oprea and many others. I would also like to mention the many PhD, master and bachelor students that I have worked with during this period.

On the personal side my gratitude goes to my parents, who have inspired into me the love for knowledge, education and discovery, and relentless work ethic that helps me every day. At the same time, I consider that no matter what you achieve in life, the most important thing is to pass your spirit and the love of all that is right and noble, and what is more noble than education and knowledge discovery, to your children. My deepest appreciation goes to my family, Diana and Gabriel (at the moment), they are my support, my inspiration and the ones that make all the hard work worthwhile.

This list would not be complete without mentioning some external collaborators, companies and persons that have become friends over time: Vienna University of Technology and Prof. Numan Durakbasa, Steinbeis-Europa-Zentrum and Daniela Chiran & Dr. Johnathan Loeffler, Lucian Blaga University of Sibiu and Prof. Claudiu Kifor, Prof. Mihail Țîțu and Assoc.Prof. Lucian Lobonț, Cluster Mobilier Transilvan and Ciprian Morcan & Dr.ing. Lucian Pitic, Romanian Association for Quality and Dr.ing. Liliana Nițu and many others.

If by any chance, I have forgotten somebody, I would like to address my thanks to everybody who helped me take step by step in my career and get to the point where I can defend this habilitation thesis.

Assoc.prof. Mihai Dragomir, PhD

REZUMAT

Prezenta lucrare a fost realizată de către Conf.dr.ing. Mihai Dragomir, din cadrul Universității Tehnice din Cluj-Napoca, pentru obținerea atestatului de abilitare în conformitate cu legislația românească. Lucrarea este structurată în trei mari capitole, la care se adaugă Introducere, Concluzii, Sumarul contribuţiilor și Bibliografie. Primul capitol se referă la cele mai importante contribuții academice și științifice aduse de autor de la obținerea diplomei de doctor în domeniul Inginerie și management (2010). A doua secțiune principală tratează tematicile de cercetare cele mai active în momentul de față, iar ultimul capitol conține un plan strategic și operațional de dezvoltare în direcția conducerii de tineri doctoranzi. Primele două părți menționate sunt la rândul lor divizate în subcapitole omogene din punct de vedere tematic.

Teza de abilitare se sprijină pe rezultatele obținute de autor în cariera academică, care sunt sumarizate și subliniate la începutul fiecărui sub-capitol sub forma unui tabel sinoptic. Sunt menționate în aceste fel principalele realizări pe dimensiunile cercetare(articole publicate sau prezentate, cereri de brevete, proiecte) și didactică (materiale pentru învățare, proiecte, cursuri/prezentări), dar și principalele elemente de experiență și vizibilitate industrială și academică. Din punct de vedere structural, tematicile abordate sunt tratate prin intermediul studiilor de caz, aplicate în diferite domenii de activitate, industrii sau companii, sau derulate sub forma altor tipuri de proiecte cu specific universitar sau economic. Între diversele tematici se pot observa puncte de interconexiune și interdisciplinaritate.

Capitolul Introducere prezintă o scurtă argumentație a autorului privind decizia de obținere a abilitării din perspectiva experienței acumulate și a viziunii de cercetare dezvoltată, precum și câteva realizări deosebite obținute în ultimii 8 ani, de la obținerea doctoratului.

Capitolul 2, denumit Direcții de cercetare mature, cuprinde două tematici principale care au constituit preocupări științifice în perioada menționată și care se află din punct de vedere al ciclului de viață la apogeu, rezultate transferându-se deja sau urmând să fie transferate în curând către mediul economic sau către partea didactică. Astfel, tematica Dezvoltarea produselor noi a fost implementată cu succes în colaborare cu firmele membre ale Clusterului Mobilier Transilvan, și se află în faza de aplicare în alte domenii high-tech. Sunt prezentate trei studii de caz, unul referitor la concepția unui sistem AR de colocație, unul privitor la proiectarea unui pat de spital inteligent și unul referitor la strategia de crearea de mobilier inovativ. O altă tematică abordată privește sistemele de management calității avansate și transferul tehnologic/suportul inovării, autorul activând peste 10 ani în consultanța de specialitate, complementar cu activitatea academică. Studiile de caz incluse propun o perspectivă complexă asupra provocărilor aplicării acestor soluții manageriale în sectoare de maxim interes și

actualitate cum sunt cercetarea industrială și energia regenerabilă. Autorul este implicat direct în acest domeniu chiar în momentul de față, conducând compartimentul pentru management universitar al UTCN, precum și Oficiul UTCN din cadrul Centrului de inovare și transfer tehnologic dunărean Cluj-Napoca.

În capitolul 3, intitulat Direcții de cercetare emergente au fost reținute tot două direcții principale, care demonstrează preocupările științifice curente ale autorului. Domeniul antreprenoriat și bio-economie în relație cu conceptul Industry 4.0 este susținut de participarea într-un program Fulbright-RAF la Universitatea din Rochester și de un proiect european de tip Interreg-Danube. Experiența dobândită în aceste activități constituie baza pentru studiile de caz incluse în capitol. Următorul sub-capitol prezintă o direcție cu potențial semnificativ în viitor, o zonă interdisciplinară între științele umaniste, inginerie și programare. Este vorba despre domeniul digital humanities în care autorul a fost implicat în special în zona de arheologie digitală, respectiv folosirea acesteia pentru o mai corectă cunoaștere a adevărului istoric și pentru diseminarea patrimoniului cultural către un public mai larg. Aceste două dimensiuni ale activității științifice sunt corelate cu tendințele europene și mondiale și beneficiază de suportul unor proiecte de cercetare sau instituționale, ceea ce le sporește șansele de a genera rezultate valoroase în viitor.

Capitolul 4, ce poartă titlul Dezvoltarea carierei academice prezintă succint viziunea de evoluție pe termen lung din punct de vedere al nișelor și direcțiilor de cercetare pe care autorul o propune odată cu acest pas către independența academică deplină. Este realizată o analiză multicriterială a celor mai importante nișe pe care se dorește concentrarea eforturilor, în corelarea cu industriile cele mai adecvate pentru implementarea realizărilor și îmbunătățirilor obținute, subliniind-se caracterul aplicativ obligatoriu pentru cercetarea în domeniul Inginerie și management. Concluziile din capitolul 2 și acțiunile din capitolul 3 sunt folosite ca elemente de intrare, propunându-se tematici integratoare. Capitolul mai conține și un scurt plan operațional, fiind evidențiate în primul rând politica de resurse umane și managementul riscurilor, elemente esențiale pentru succesul unui colectiv de cercetare. Dorința autorului este ca acest plan să fie implementat pe parcursul mai multor ani în cadrul unei viitoare echipe, alături de tineri doctoranzi.

Capitolul Concluzii, subliniază implicațiile aspectelor prezentate și face referință la elemente suport care pot susține concretizarea măsurilor propuse, din sfera sprijinului instituțional, a motivării membrilor echipei de lucru și a relațiilor internaționale care pot aduce oportunități de colaborare sau publicare. Ultimul capitol cuprinde un sumar al principalelor contribuții prezentate de autor în cuprinsul tezei.

ABSTRACT

The present paper is authored by Assoc.prof.dr.ing. Mihai Dragomir, from the Technical University of Cluj-Napoca, in order to obtain the habilitation certificate in accordance with the Romanian legislation. The paper is structured in three major chapters, plus Introduction, Conclusions, Summary of contributions and Bibliography. The first chapter deals with the most important academic and scientific contributions brought by the author from the moment of obtaining his PhD in Engineering and Management (2010). The second section focuses on the most active research themes at present, and the last chapter contains a strategic and operational development plan towards advising young PhD students. The first two parts are in turn divided into sub-chapters homogeneous from a thematic point of view.

The habilitation thesis builds on the author's achievements in the academic career, which are summarized and highlighted at the beginning of each sub-chapter as a synoptic table. These contain the main results on the research dimension (published or presented articles, patent applications, projects) and didactics (learning materials, projects, courses / presentations), but also the main elements of industrial and academic experience and visibility. From a structural point of view, the themes are addressed through case studies applied in different fields of activity, industries or companies, or carried out as other types of projects of a university or economic nature. There are interconnection points and interdisciplinary between the different themes.

The chapter Introduction presents a brief argumentation of the author about the decision to obtain the habilitation from the perspective of the accumulated experience and the developed research vision, as well as some special achievements obtained during the last 8 years, after obtaining the doctorate.

Chapter 2, called Mature Research Directories, comprises two main themes that have been scientific concerns over the period mentioned and which are from the point of view of the apogee life cycle, the results being already transferred or to be transferred to the environment soon economically or to the teaching part. Thus, the Theme Development of new products was successfully implemented in collaboration with the member companies of the Transylvanian Furniture Cluster, and is in the application phase in other high-tech areas. Three case studies are presented, one on the design of an AR collocation system, one on the design of a smart hospital bed and one on the innovative furniture design strategy. Another topic addressed is the advanced quality management systems and technology transfer / innovation support, the author working for over 10 years in specialized consultancy, complementary to academic activity. The case studies included offer a complex perspective on the challenges of applying these

managerial solutions to areas of maximum interest and timeliness such as industrial research and renewable energy. The author is directly involved in this field right now, leading the university management department of UTCN, as well as the UTCN Office of the Danube Technology Center for Innovation and Technology Transfer Cluj-Napoca.

In Chapter 3, entitled Emerging Research Directions, two main directions have been retained, demonstrating the author's current scientific concerns. Entrepreneurship and bio-economy in relation to the Industry 4.0 concept is supported by participation in a Fulbright-RAF program at the University of Rochester and a European Interreg-Danube project. The experience gained from these activities is the basis for the case studies included in the chapter. The next sub-chapter presents a significant potential direction in the future, an interdisciplinary area between humanities, engineering and programming. This is the digital humanities field in which the authoress was particularly involved in the area of digital archeology, namely its use for a more accurate knowledge of historical truth and for the dissemination of cultural heritage to a wider audience. These two dimensions of scientific activity are correlated with European and world trends and benefit from the support of research or institutional projects, which increases their chances of generating valuable results in the future. Chapter 4, titled Academic career development, briefly outlines the long-term vision of the niches and research directions that the author proposes together with this step towards full academic independence. A multicriterial analysis of the most important niches whereby his efforts are concentrated, in correlation with the most suitable industries for the implementation of achieved results and improvements, is underlined, emphasizing the mandatory applicative character for the research in the field of Engineering and Management. The conclusions in Chapter 2 and the actions in Chapter 3 are used as input elements, with integrative themes being proposed. The chapter also contains a short operational plan, highlighting primarily human resources policy and risk management, key elements for the success of a research team. The author's wish is that this plan be implemented over several years in a future group, alongside young PhD students.

The Conclusions chapter highlights the implications of the issues presented and refers to support elements that can help the implementation of the proposed measures, such as institutional support, the motivation of the team members and the international relations that can bring opportunities for collaboration or publication. The last chapter contains a summary of the main contributions presented by the author in the thesis.

LIST OF ABBREVIATIONS

AR	Augmented reality
ARHMD	Augmented reality Head mounted display
CTQ	Critical to quality
CH	Cultural heritage
DTC	Danube Transfer Center
DTCN	Danube Transfer Center Network
EaP	Eastern Partnership of the European Union
EFQM	European Foundation for Quality Management (no longer an acronym)
EU	European Union
EUSDR	EU Strategy for the Danube Region
FEA	Finite element analysis
FMEA	Failure Modes and Effects Analysis
HMD	Head Mounted Display
ICPR	International Conference on Production Research
I&E	Innovation and entrepreneurship
IP	Intellectual property
ITT	Innovation and technology transfer
ISO	International Organization for Standardization
MiD	“Made in Danube” project - Interreg Danube Transnational Programme
MOOC	Massive open online course
NPD	New Product Development
PA8	Priority area 8 - Competitiveness of Enterprises
PLM	Product lifecycle management
QC	Quality control
QFD	Quality Function Deployment
QMS	Quality management system
SFH	“Smart Factory Hub” - Interreg Danube Transnational Programme
TIN	Transnational Innovation Network
TRL	Technology readiness levels
TUCN	Technical University of Cluj-Napoca
VR	Virtual reality

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS

1. INTRODUCTION

According to the Romanian law of National Education, no. 1/2011, with its subsequent modifications, the habilitation process is a mandatory step for any academic or researcher, from a university or a research institute, to become a PhD advisor and lead young researchers towards obtaining their PhD degree by conducting research, publishing results and publicly defending a thesis. Also, within the Technical University of Cluj-Napoca, according to the Regulation for the occupation of academic positions, obtaining the habilitation certificate, and then being admitted to the Doctoral School of the university, is a condition for becoming a full professor. Considering the author's experience for almost a decade and a half in this field, the present thesis is being submitted to fulfill these criteria and to prepare the establishment of new research directions within the university.

The main goals of this document are split into three directions that should characterize, in my view, the development of any researcher and faculty member:

- to present, put into context, and establish connections and cross correlations among **the most significant research results obtained so far**, since obtaining the doctorate;
- to describe **the current research interests and demarches**, including active initiatives under implementations and those in a state of preparation and development;
- to establish and explain a vision for the future, including research domains, possible topics and intended results, from a short-term to a long-term horizon.

Based on this concept, the chapters of the habilitation thesis follow a logical sequence based on chronological relations, industrial and economical applicability of the results and the complexity of the themes and discussions associated with the contributions of the author. In order to make the elements clear and to explain how they all fir together, and how they will support the new developments respectively, in each chapter, there has been included a synoptic table describing the most important real-world experiences and impacts of the presented topics. A special consideration has been given to the third section, that details the research and academic management plan that the author intends to follow in the future, during his career. This is considered to be very important because it will affect both the research output of the author and his host institution, the Technical University of Cluj-Napoca, and the cultivation of a new generation of researchers in the field of engineering and management who will go on to influence in their turn companies and academic establishments in Romania and abroad.

The core idea when creating this plan, which includes strategic lines and operational aspects, was to ensure productivity, impact and accountability for all those involved. Since this will involve the creation of a „school of thought" in my new capacity as a PhD advisor, along with research related subjects and the concerns for finding financing and publishing of patenting

the results, a significant amount of effort will have to be dedicated to selecting the most adequate future PhD students and to creating a work environment that is conducive to creativity, innovation, entrepreneurship and social responsibility. A network of industrial partners, as well as stakeholders from other domains of the socio-economic environment is discussed as a support framework for research in industrial engineering and management.

Ultimately, since habilitation also deals with the teaching component of an academic career, the possible developments in this area are discussed in each section of the present thesis, especially for master students, who already have the required knowledge and experience to make a difference in industry and could also become young researchers that purse a PhD degree.

The current work marks a significant point in the author's development and evolution as a researcher and member of the academic community. If the PhD thesis that was defended 7 years ago valorized the work of a beginner researcher that has been perfecting his skills, the present document aims to demonstrate the maturity and proficiency of an experienced researcher and to offer assurances about the vision and proficiency that I will infuse in my future position as a PhD advisor.

My scientific career, which spans the last 14 years, has two main directions of interest: quality engineering and management and new product development, which I consider closely related because one deals with process improvement, while the other deals with product improvement. Within the first one I have made scientific contributions through my PhD. research and publications indexed in the Web of Science, while in the second one I have worked considerably within national and international projects and co-authored books, patent applications and practical results. One of the ways in which this direction has materialized is by contributing to solutions and applications in the field of digital archaeology, developed jointly by the research team that I belong to (lead by Prof. Daniela Popescu and Prof. Călin Neamțu) with the history museums from Cluj-Napoca and Deva, and the Faculty of History at Babeș-Bolyai University from Cluj-Napoca. I consider these academic experiences, together with the industrial ones, a valuable addition to my competence and I would like to expand on them within by targeting my future work towards improving industrial processes in order to help companies better face the ever-changing requirements of stakeholders with respect to innovation, quality, environmental friendliness and social integration. My experience so far has put me in a good position to tackle these subjects with both entrepreneurial pragmatism and scientific accuracy, while my international exposure will contribute to an objective and proactive transfer of knowledge.

The project FP7-INCO-2013-9-R2I-ENP-609531 Knowledge Transfer Community to bridge the gap between research, innovation and business creation - NoGAP, for which I served as partner manager for the Technical University of Cluj-Napoca within the project consortium, has given me the opportunity to get involved in developing and implementing innovation support mechanisms to facilitate the efforts of researchers, companies and information multipliers from the Eastern Partnership (EaP) countries (Ukraine, Georgia, Belarus, Moldova,

Armenia, Azerbaijan). As part of this project I have contributed as first author to two handbooks in the field: Innovation Management & Transnational Partnership. Training for SMEs and Start-Ups/Entrepreneurs published in 2014 at the Steinbeis Edition publishing house and Handbook for services in IPR and Innovation Management available on the project website www.no-gap.eu. Also, I have contributed as first author to two other reports that can be accessed through the project website, one dedicated to Technology Transfer Environmental Analysis in the EaP countries and the other one regarding an array of 26 innovation audits performed within these countries under my team's coordination. These results, together with delivering 9 trainings to personnel involved in the innovation area, represent significant contributions to the development of the innovation eco-systems in the Eastern Partnership and gave me unique insights on how to set-up, manage and get results from innovation driven projects. Additionally, I acted as consultant for 6 companies in the EaP in the field of intellectual property rights, I published a best practice paper at the ICPR-AEM & QIEM 2016 conference and I have been invited to use or share my expertise as reviewer for the International Spectator journal (Italy) and as trainer for the FP7-INCONET-EAP - STI International Cooperation Network for Eastern Partnership Countries project.

I had the chance to be research project director for the project entitled Research for developing and implementing into production innovative furniture, which was part of the Competitiveness Pole "Transylvanian furniture cluster" financed by the Operational Programme „Increase of economic competitiveness". The project had a total budget for research, innovation and introduction into production of approx. 895.000 Euro and has generated a number of 17 scientific articles (6 indexed in ISI ESCI, 6 indexed in ISI CPCI and 5 in other scientific databases, e.g. Scopus, Ebsco, Google Scholar) and 8 patent applications (7 filed at OSIM in Romania and 1 translation filed at EPO). The innovations described in some of the patent applications have also been showcased at 2 Invention fairs in Romania and have obtained 5 recognition diplomas / awards / medals. The main drive of the project was to develop a modern and innovative furniture offering that could be manufactured by a start-up company, and also to execute the necessary studies and research demarches that would make these products and associated processes robust and deployable in the new company. Within this project, I have gained considerable experience as manager, having to coordinate a team of cca. 20 people to a deliver upon a complex network of tasks and deliverables. Also, my work as a researcher was finalized with contributions on three directions: improved project management for new product development endeavors, as it can be seen in the article "Applying SigmaFlow Simulation Software for Improving the Quality of an R&D Project", innovative furniture products generated using structured methods, observable in the article "Efficiency and resilience in product design by using morphological charts, and new approaches to enhance product development and manufacturing, as it can be noted in the article "Methodology and case study in the furniture industry using photogrammetry and 5 axis machining". All these contributions have been implemented during the project in the partner start-up company which is now equipped to compete on the national and European market with viable, advanced

products, mostly in the area of smart furniture, capable to integrate IT&C and significantly increase the quality of life for its users.

My articles have been recognized through indexation in the main international databases and the citations received: ISI Web of Science - 40 papers, 29 citations, h-index 2, Scopus - 18 papers, 30 citations, h-index 3, Google Scholar - 55 papers, 92 citations, h-index 5. The most significant ones are the 3 papers published in the ISI Web of Science indexed journals that are included in the second quartile of their respective domains, the so-called "yellow area", and one in the third quartile which is significant due to its topic that combine innovation / new product development tools with environmental management. Also, if we consider the scientific spread of these articles, we can see that besides the mentioned domains, another two areas identified in this paper as mature have yielded good results (management systems and academic management), as well as an area of transition to future developments (sustainability).

- **Dragomir, M.**, Popescu, S., Neamțu, C., Dragomir, D., Bodi, Ș., **Seeing the Immaterial: A New Instrument for Evaluating Integrated Management Systems' Maturity**, Sustainability, vol. 9, issue 9, 2017, ISSN 2071-1050, Q2 quartile
- Călin Neamţu, Dan Hurgoiu, Sorin Popescu, **Mihai Dragomir**, Herbert Osanna, **Training in Coordinate Measurement Using 3D Virtual Instruments,** Measurement, Volume 45, Issue 10, December 2012, pp. 2346-2358 (available online 8 October 2011), ISSN 0263-2241, IF (2012) = 1,130, AIS (2012) = 0,338, Q2 quartile
- C. Neamțu, V.C. Măruțoiu, I. Bratu, O.F. Măruțoiu, C. Măruțoiu, I. Chirilă, M. Dragomir, D. Popescu, Multidisciplinary Investigation of the Imperial Gates of the 17th Century Wooden Church in Sălișca, Cluj County, Romania, Sustainability, vol. 10, issue 5, 2018, ISSN 2071-1050, Q2 quartile
- Popescu, S., **Dragomir, M.**, Pitic, D., Brad, E., **Method for competitive environmental planning**, Environmental Engineering and Management Journal, ISSN 1582-9596, 11(4), 2012, pp. 823-828, IF (2012) = 1,117, AIS (2012) = 0,085, Q3 quartile

Based on these differentiating elements, and the accomplishments I have presented in my resume and the habilitation dossier, I welcome the opportunity to structure, analyze and plan for the future my academic career for the benefit of all stakeholders.

2. MATURE RESEARCH DIRECTIONS

2.1 New product development in the „smart" era

2.1.1 Contributions

Category	Involvement and obtained results
Academic experience	**Faculty in charge** of the courses Design for quality and the environment - Master's in Quality engineering and management (2013-2017) and Design for quality - Master's in Computer aided design of manufacturing syst. (2012-2017) **Adjunct faculty** at "Lucian Blaga" Univ. Sibiu (2014, 2015) teaching a Continuous improvement project **Invited talk What's new in new product development in Eastern Europe?** Southern Illinois University at Edwardsville, Illinois, USA. Co-authors: Ștefan Bodi, Paul Bere, Diana Dragomir (2017) **Speaker/Trainer** for an Innovation management training in the framework for the project FP7-IncoNet EaP, 2015 Minsk, Belarus **Speaker Furniture - from tradition to the internet of things,** Transylvania Clusters International Conference, Cluj-Napoca, 23 June, 2016 Invited lecture **Industrial Engineering research at the Technical University of Cluj-Napoca**. University of Pittsburgh, Pennsylvania, USA. Co-authors: Călin Neamţu, Radu Comes (2017) Speaker **Trends and innovation opportunities in the field of furniture** (presentation in Romanian) (Bodi Ștefan, with Dragomir Mihai and Dragomir Diana), expoDESIGNwood, 16th edition, Brașov, 30 March 2017 Speaker **Best practices in RDI in the furniture industry in the North-Western Region**, Entrepreneurial Discovery Process, NW Regional Development Agency, Oradea, 26 October, 2016
Practical experience	Patent application **Smartphone support with docking station role**, RO132018 (A2), **Dragomir Mihai,** Bodi Ștefan, Popescu Sorin, Solcan Sergiu Patent application **Table with multiple functionalities**, RO131703 (A2), Criste Adrian, **Dragomir Mihai**, Șteopan Andrei, Dragomir Diana Patent application **Multi-purpose reconfigurable stool**, RO131611 (A2), Șteopan Andrei, **Dragomir Mihai**, Criste Adrian, Gherman Bogdan Patent application **Height-adjustable table with mechanism of moving in relation with a fixed base**, RO131608 (A2), Banfalvi Lorant, Popescu Sorin, Scurtu Iacob, Vaida Călin, **Dragomir Mihai** Industrial contracts **2010-2011 Thomas Romania Plastic SRL, 3D measurement solutions for plastic parts, Contract director (budget 5250 lei); 2013-2015 Turdeana SA Turda, 3D measurement solutions for parts in the automotive industry**, Member of the project team.
Supporting projects	2014-2015 European Regional Development Fund, POSCCE, 12.P01.001 13 C3, **Research for developing and implementing into production innovative furniture**, part of the 12.P01.001 Competitiveness Pole "Transylvanian furniture cluster", **Research project director (budget 895.000 €)** 2015-2018 EU, Erasmus+ 2014-2020, Key Action 2 Strategic Partnership Projects, 2015-1-PL01-KA202-016875, **Geometrical Product Specification and Verification as toolbox to meet up-to-date technical requirements**, Member of the project team 2011-2012 Werth Messtechnik GmbH Germany, **Project concerning software development for coordinate measuring machines**, Member of the project team

Category	Involvement and obtained results
	2014-2016 EU, Programme "Cooperation", FP7- ICT-2013.3.3 b (iv), project no. 610551, **EXPRESS - Mobilising Expert Resources in the European Smart Systems Integration Ecosystem**, Contact person deputy, TUCN assoc. partner 2017-2019 Interreg - Danube Transnational Programme, DTP1-1-071-1.1, Improving RD and business policy conditions for transnational cooperation in the manufacturing industry - Smart Factory Hub (SFH), Partner communication manager (TUCN budget 181.986,60 €)
Research articles	**M. Dragomir**, D. Banyai, D. Dragomir, F. Popescu, A. Criste, **Efficiency and resilience in product design by using morphological charts**, Energy Procedia, 2016, vol. 85, pp. 206-210, ISSN 1876-6102 **Mihai Dragomir**, Sorin Popescu, Zsolt Buna, Ioan Zăbală, **Enhanced hospital bed with smart functions**, 2016 ICPR - AEM and 4th QIEM, Cluj-Napoca, 25-30 July 2016, ISBN 978-606-737-180-2, pp. 317-320 **Mihai Dragomir**, Diana Dragomir, Ştefan Bodi, Lucian Pitic, **Dealing with component lifecycle disparity in smart furniture**, 3rd International Virtual Conference on Advanced Scientific Results (SCIECONF 2015), May 25 - 29, 2015, ISBN 978-80-554-1059-3, pp. 269-272 S. Popescu, D. Pitic, **M. Dragomir, Creativity, Idea Management and Innovation - Prerequisites for New Product Development in a Furniture Start-Up**, 2014 ICPR - AEM and 3rd QIEM, Cluj-Napoca, 1-5 July 2014, ISBN 978-973-662-978-5, pp. 406-410 **M. Dragomir**, B. Zalany, D. Dragomir, F. Popescu, S. Solcan, **Case study in product quality and environmental planning to achieve comfort within indoor working spaces**, Revista Română de Inginerie Civilă (Romanian Journal of Civil Engineering), Vol. 7, Nr. 2, 2016, pp. 164-171, ISSN 2068-3987 D. Popescu, **M. Dragomir**, S. Popescu, C. Neamțu, **From smart products to smart manufacturing in emerging economies: challenges and insights from the furniture industry**, DEStech Transactions on Engineering and Technology Research, 24th ICPR, Poznan, Poland, 2017, ISBN 978-1-60595-507-0, pp. 93-97 **M. Dragomir**, Ş. Bodi, O. Iamandi, D. Dragomir, **Applying SigmaFlow Simulation Software for Improving the Quality of an R&D Project**, 2014 ICPR - AEM and 3rd QIEM, Cluj-Napoca, 1-5 July 2014, ISBN 978-973-662-978-5, pp. 143-147 R. Curta, Z. Buna, **M. Dragomir**, R. Comes, D. Banyai, **Methodology and case study in the furniture industry using photogrammetry and 5 axis machining**, Acta Technica Napocensis Series: Applied mathematics, mechanics, and engineering, Vol. 58, No. 1, 2015, pp. 53-58, ISSN 1221-5872
Teaching materials	**Mihai Dragomir**, Oana Iamandi, Ștefan Bodi, Robert Gohla, Daniela Chiran, **Innovation Management & Transnational Partnership. Training for SMEs and Start-Ups/Entrepreneurs - Handbook**, ISBN 978-3-95663-013-2, Steinbeis-Edition Publishing house, Stuttgart, 2014 (168 pag.) (English-Russian) Călin Neamţu, **Mihai Dragomir**, Daniela Popescu, Sorin Popescu, Radu Răcășan, **Uncertainty of conventional measurements - Incertitudinea de măsurare în metrologia clasică**, ISBN 978-973-662-783-5, UT PRESS Publishing house, Cluj-Napoca, 2012 (172 pages) (English-Romanian) **Scientific advisor** for the diploma projects of the students Petruse Mihai, Zăbală Ionică, Bachelors of engineering in Robotics, which won the prize offered by Star Transmission Cugir, 2014 - they developed and built a 3D printer of their own design that has been used as a teaching resource

2.1.2 Case studies and results

AR co-location system development

As it can be noticed in the synopsis above, the author's contributions in the area of new product development have been focused on developing and customizing algorithms and tools from the area of customer centered design and Design for X in the various industrial and academic fields that have been required assistance in improving competitiveness or coming up with new innovative solutions to complex challenges. The industrial based projects have been geared towards creating and patenting new IP that could bring about market advantages for the partner or financing companies, while the research / education sector has been interested in transferring these skills to trainees and students and developing creative project concepts.

We will present further a case from the latter category, that has been focused in transforming into reality (i.e. prototype) an incipient idea in the area of digital humanities, in this case digital archaeology which is raising interest to many our partners – augmented reality colocation assistance system (ARCAs) for delivering expertise in situ (the domain of application does not have to be archaeology, it can be applied to any application that requires field work, e.g. civil engineering, mining/off-shore engineering, environmental science, geology, anthropology, social sciences, healthcare, performance arts, etc.).

Let us presume that we want to establish a connection between two points, A and B, the caller is located in point A (field worker or member of the public) and the called one in point B (expert). The user from point B can receive directly on the AR glasses' display the image that the user from point A is seeing and he can listen to the sound acquired by the incorporated microphone. The user from point B is able to send information to the user from point A in the form of text, sounds, images or 3D models that can be overlapped directly over the actual environment, with the help of an augmented reality application. In point B, both the AR device and a computer can be used in parallel to facilitate the additional information transfer towards the caller. The communication between the two points can be made possible using a server client platform. This platform will facilitate the remote connection between points A and B without real IP addresses or audio-video data streaming servers. The communication platform should allow a large number of simultaneous connections and also the connection of a single caller with multiple users (point to multipoint), to enable the sharing of expertise on a productive and even commercially viable scale. The communication system will also allow the connection of a caller for searching and viewing information stored in the knowledge database. This way, solutions can be searched to problems similar to the one the caller faces. The knowledge sharing system can offer instruments for searching, classifying and uploading files, audio-video recordings or other tools specific to a database (e.g. cross-referencing, archive, etc.).

The communication system is scheduled to be complemented by a specific app to allow access to all possible collocated functions. This kind of application is useful for the development of guided virtual tours through the site, with the information shown in real time

on the AR device and correlated with the surrounding environment by processing the data collected from the positioning and video sensors incorporated into the glasses (this will be the phase two of the new product project).

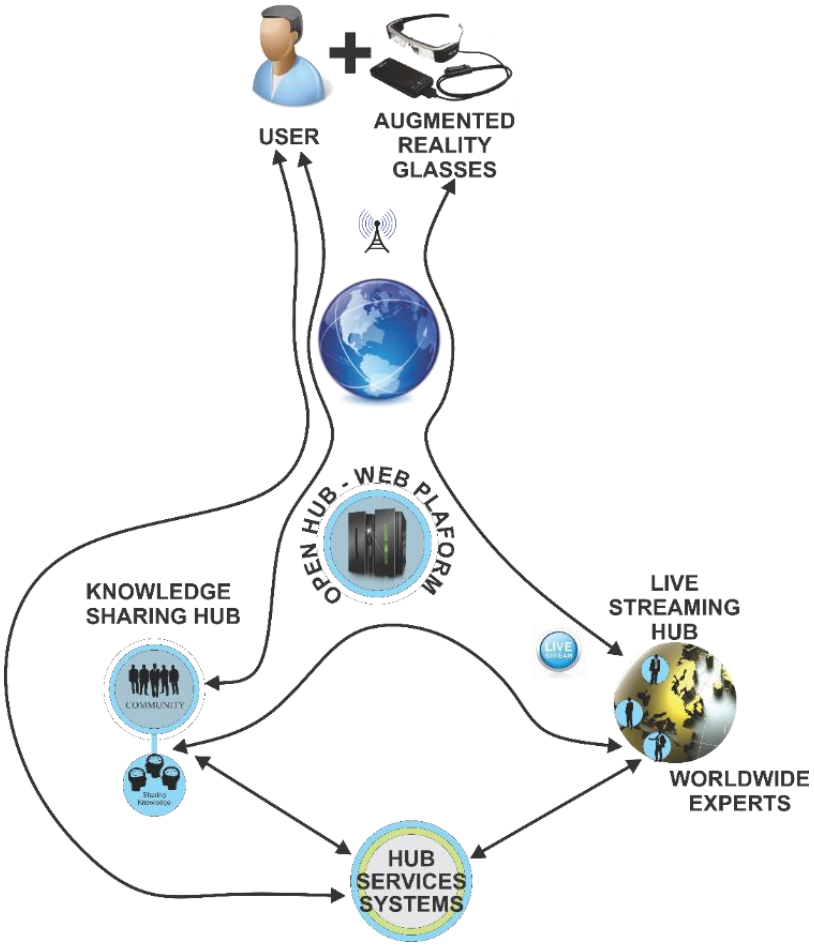


Fig. 2.1 - Global concept of the ARHMD proposal

The ARCAs platform (Figure 2.1) will offer an integrated solution to the archaeology experts and to the public for exploring, interacting and valuating the historical heritage of the European continent. Below, we describe the main instruments that will be developed and made available:

- Immersion - a navigation system with GPS based on Google Maps, that allows the planning of a tour (for example, of the city), using the various monuments and museums as reference points, alongside the information attached to them (for example, the visiting hours or prices). The leisure concept of geocaching will be use and enhanced in order to provide immersive experiences in history. This instrument will implement two different tracking systems: classical, with target, and marker less, based on natural feature recognition.
- QuickDigi - this will be an instrument that will allow a quick digitization, using the integrated camera from the AR device, the GPS sensor and the photogrammetry principle. This application enables the uploading of various images on the server,

that were captured by the user, and by processing these images on a separate dedicated server, a 3D model will be generated, which the user can view on glasses.

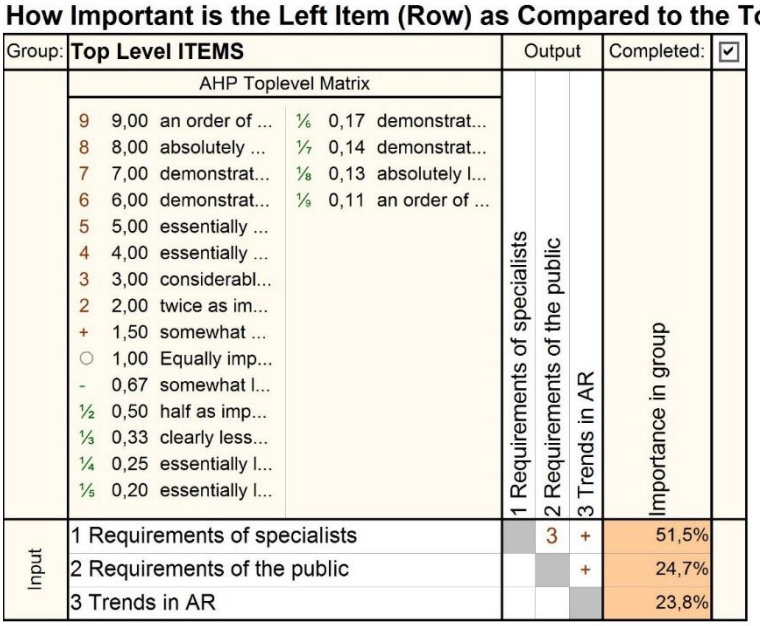
- QuickTag - this service allows pointing on a virtual map a monument or archaeological site, that will be available to other users, as well and through "Cultural Map" there can be automatically acquired information such as the GPS position, monument / museum image or, if it is available in the database, the 3D model and virtual tour.
- QuickSize: this tool allows rapid, real-time measurement of the approximate dimensions of artifacts or archaeological sites offering the user a better documentation. For example, in an exhibition of numismatic coins the user can directly measure the diameters of the coins through the window and then he will be able to store the data directly in the database.
- Recharge: Most of the AR glasses have a limited internal storage space (usually under 8GB) and many of them offer a microSD slot for adding an additional 32 GB, and for this reason we need a tool for uploading and downloading information for off-line use. If a user goes into an area in which an Internet connection is not available, then they will be able to download content before entering that area and upload the information stored on the device after returning to an area with internet access. To use downloaded content GPS data will be processed for correct positioning in space.

In order to prepare for the ARCAs development, we have undertaken a general analysis for developing the proposed innovative solution. This analysis uses a structured new product development approach and is meant to offer scientific fundament to the demarche, while at the same time concentrating the experience of the development team. There are three main stages to the presented algorithm, undertaken by the team in accordance with the real and concrete situations that can be encountered while exploring archaeological sites:

- determination and understanding of requirements, for achieving oriented design and implementing a solution-based approach;
- deployment into system and sub-systems characteristics for establishing product targets, functions and features;
- innovation based on technical constraints, for materializing the inventive potential of the proposed system.

The first stage was achieved on three directions: brainstorming sessions with history and archaeology experts in order to determine the requirements of the specialists, analysis of feedback from previous events and projects to determine the public requirements towards the proposed system and an analysis of literature and the market to determine the trends in the AR field. All these requirements have been processed with the help of the AHP method (Analytical Hierarchy Process) applied with the help of the Qualica QFD software. This process involves two steps, ranking of the requirements categories themselves, and then ranking within each

category, while in the end the results are concatenated for a general ranking of requirements. These results are necessary to gain a detailed understanding of the way the innovative product should be conceived in order to respond to all stakeholders in a balanced and creative manner.

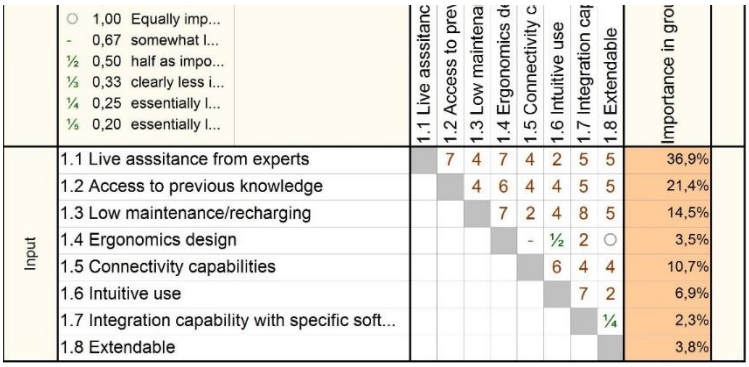


How Important is the Left Item (Row) as Compared to the T

Group:	Top Level ITEMS	Output			Completed: ☑
	AHP Toplevel Matrix	1 Requirements of specialists	2 Requirements of the public	3 Trends in AR	Importance in group
	9 9,00 an order of ... ⅙ 0,17 demonstrat...				
	8 8,00 absolutely ... ⅐ 0,14 demonstrat...				
	7 7,00 demonstrat... ⅛ 0,13 absolutely l...				
	6 6,00 demonstrat... ⅑ 0,11 an order of ...				
	5 5,00 essentially ...				
	4 4,00 essentially ...				
	3 3,00 considerabl...				
	2 2,00 twice as im...				
	+ 1,50 somewhat ...				
	○ 1,00 Equally imp...				
	- 0,67 somewhat l...				
	½ 0,50 half as imp...				
	⅓ 0,33 clearly less...				
	¼ 0,25 essentially l...				
	⅕ 0,20 essentially l...				
Input	1 Requirements of specialists		3	+	51,5%
	2 Requirements of the public			+	24,7%
	3 Trends in AR				23,8%

Fig. 2.2 - Ranking of stakeholder requirements groups

The ranking has been performed by the proposal team, keeping in line with the European best practices. One can see that history and archaeology specialists will have the most influence in the design of the system, as they will also be the main and principal users. Also, they are the one that have the possibility to multiply the effects of the system, by improving their own research approaches to archaeological sites. The public, which will give the social dimension of the envisioned innovation, will contribute to about a quarter to the importance of the processed requirements in product development, while the trends in the field of AR will contribute a little less. It is of course, necessary to know and even anticipate these tendencies, to provide a useful and marketable product at the end of the development process.



	○ 1,00 Equally imp... - 0,67 somewhat l... ½ 0,50 half as impo... ⅓ 0,33 clearly less i... ¼ 0,25 essentially l... ⅕ 0,20 essentially l...	1.1 Live asssitanc	1.2 Access to pre	1.3 Low maintena	1.4 Ergonomics d	1.5 Connectivity c	1.6 Intuitive use	1.7 Integration ca	1.8 Extendable	Importance in gro
Input	1.1 Live asssitance from experts		7	4	7	4	2	5	5	36,9%
	1.2 Access to previous knowledge			4	6	4	4	5	5	21,4%
	1.3 Low maintenance/recharging				7	2	4	8	5	14,5%
	1.4 Ergonomics design					-	½	2	○	3,5%
	1.5 Connectivity capabilities						6	4	4	10,7%
	1.6 Intuitive use							7	2	6,9%
	1.7 Integration capability with specific soft...								¼	2,3%
	1.8 Extendable									3,8%

Fig. 2.3 - Ranking of the requirements of specialists

On their specific analysis, experts have provided opinions concerning the most important requirements they will have towards such a system. The most important ones concern the access

and use of knowledge from peers and colleagues, either in the form of live discussion (critical in collaborative work and colocation) or in the form of previously stored knowledge within the system (the knowledge base). Also, a low maintenance system (especially the mobile component) and good connectivity capabilities are important for the successful adoption of such a system.

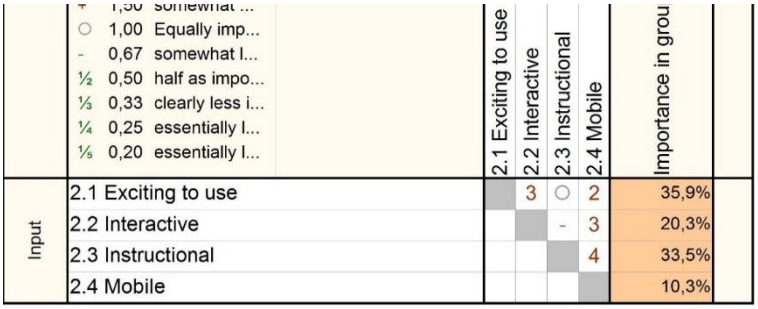


Fig. 2.4 - Ranking of the requirements of the public

For the second stakeholder, the general public, the analysis reveals a balanced approach among the 4 requirements: to have an exciting system, that is at the same time instructional and to have a mobile device that is at the same time interactive. Achieving all these goals is a complicated task, but it is important that the new system contributes to the larger understanding of history by the European public.

The last category that has been ranked is the one dedicated to AR scientific and technological trends. This analysis only takes into account a small number of trends, but in the eventuality of approval of this proposal, it will be significantly extended, as will be all the others and the process as a whole.

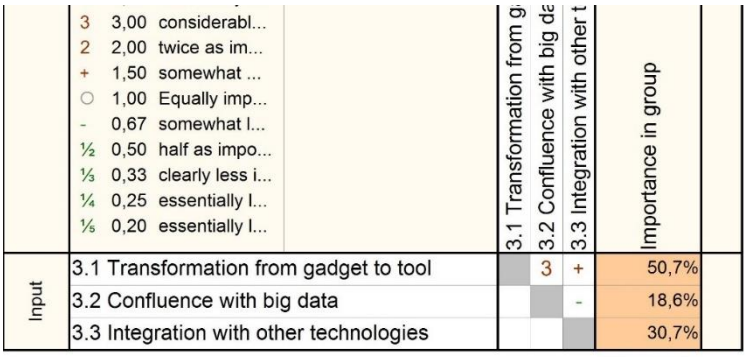


Fig. 2.5 - Ranking of the significant trends in AR

The results reveal the fact that the current transformation of mobile gadgets, including ARHMDs, into practical work tools, is the most important factor to take into account, especially considering that this product might become available in time frame of cca. 4 years. Also, the possibility to interface the system with archaeology specific or general software constitutes a further constraint on the development process.

In the end, the results are aggregated, and a full list of requirements is put forth as a basis for the innovation process, where all parties are represented. As it can be seen, the final list is

actually a mix of the three categories, based on a compound importance score. Addressing these requirements in the order they appear in the final results of the Analytical Hierarchy Process will yield a system that conforms to and satisfies the needs and expectations of all stakeholders (formulated or unformulated requirements). Also, working in this way, the development process is more structured and connected to its intended audience and the final result will come to the aid of the users in a proactive manner (performant solutions delivered in an intuitive and unconstrained manner at the proper moment). Also, the figure below shows the process of normalization that the Qualica QFD software performs automatically in order to narrow the gaps between the importance rankings of the various requirements.

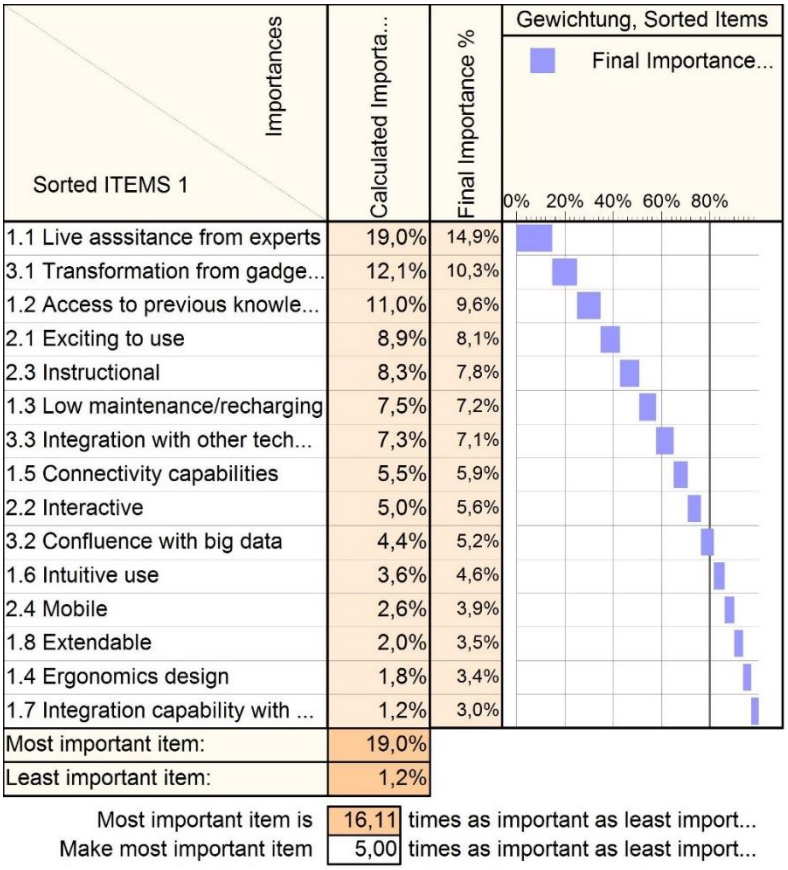


Fig. 2.6 - Final aggregated ranking of requirements towards the ARHMD system

The second stage of the innovative development process is to deploy the ranked requirements into the proposed technical characteristics of the AR-based system. For this, a list of the main characteristics has been developed by the project team with the help of experts. This is not a detailed or final list, but it is rather used for gaining an overall understanding of the future product and for planning the proper development activities within this proposal. The deployment is performed using the Quality Function Deployment method (QFD) applied with the help of the Qualica QFD software. The full graphical support of the method, also known as The House of Quality, is presented below:

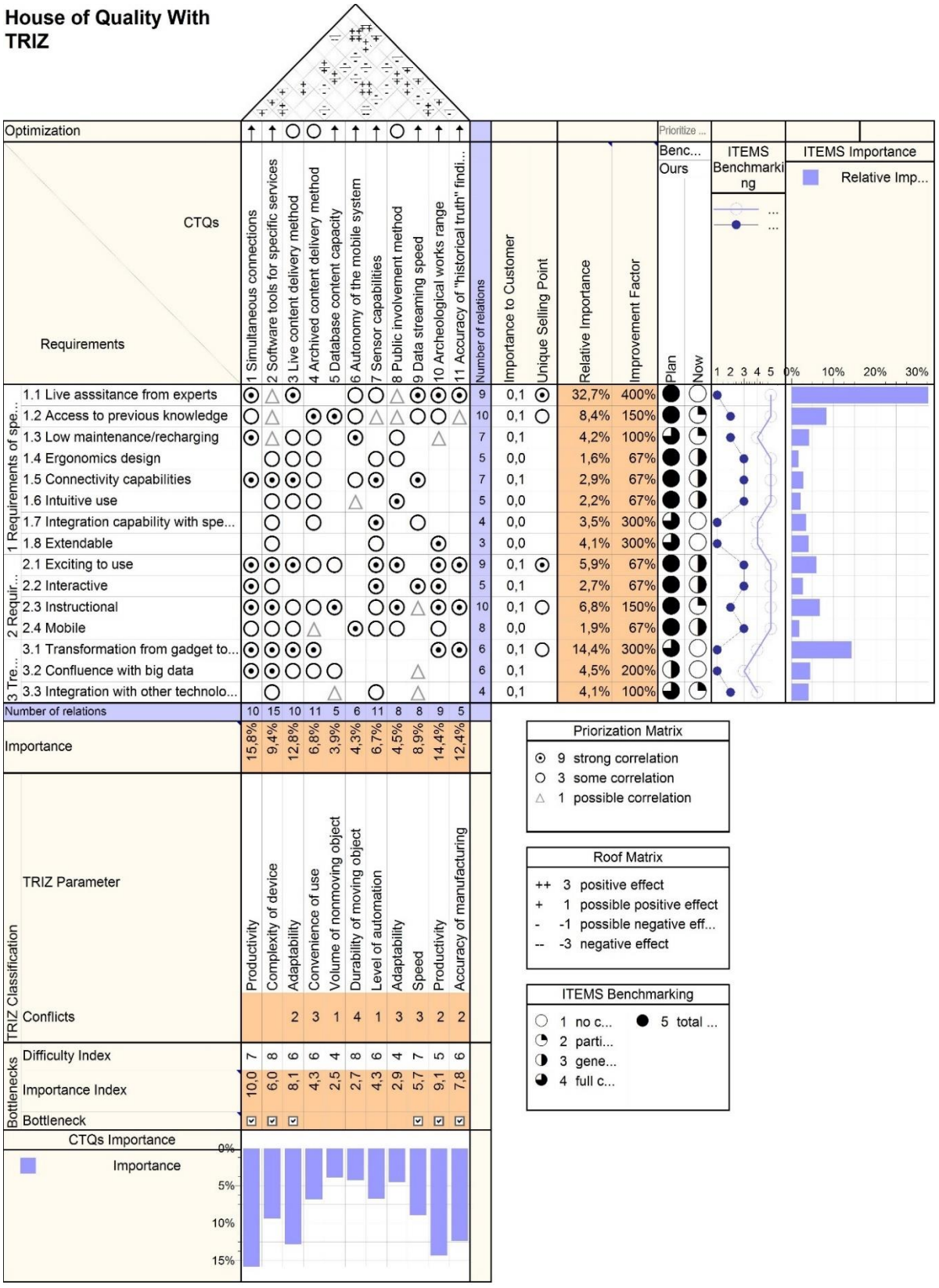


Fig. 2.7 - Quality Function Deployment used to rank product characteristics for the design and development process based on importance of aggregated requirements

As it can be seen from the above figure, we obtained a ranking of the main product characteristics that we should follow in the development process. The four main such traits of ARCAs are:

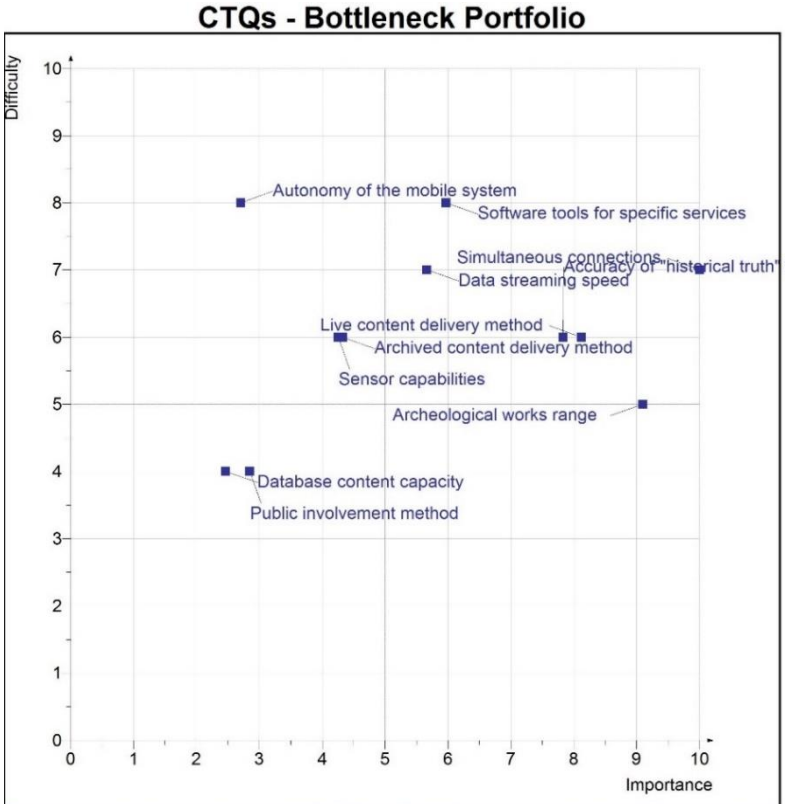
- the ability to provide a large number of simultaneous connections, which impacts the way specialists and the general public interact with and use it (live or from the knowledge sharing system);
- the specific software tools that can be made available within the system and provide the extended functionalities and the immersive experience for the use;
- the range of archaeological activities that can be performed in an improved manner with the help of this system;
- the delivered historical accuracy of the results that come out from employing the system, in order to keep the experts and the public in the scientific approach to European history.

These findings further guide the implementation process, keeping the development team on topic and within the constraints (time, budget, impact, image). A few examples of how requirements processing modifies the actions of the team are:

- choosing GPS sensors with high accuracy and low bandwidth requirements that can transmit from remote areas either raw data of data overlaid on a map (quick-map) in order to give the archaeologist on site the ability to assess the artefact or construction that is being studied and confer with colleagues about their use, purpose or implications in historiography;
- simultaneous use of up to 5 AR devices live on site that are being monitored from a laboratory / university / museum in order to gain missing information for a given site with the aim of detailing its understanding in the historical context;
- web platform access of the public to the devices through the use of interactive applications for delivering a history class or just for fun.

Two additional analyses have been performed in connection with the main relationship matrix of the QFD method, which related the requirements and the characteristics of the product and provided us with the insights above regarding the project design plan. One of these analyses, performed by Qualica QFD, deals with bottleneck in the future product development. These are the technical characteristics for which the resulting importance rating is high and for which the technical difficulty and complexity level has also been judged as being high by experts. The graphical support of this analysis can be seen in the figure below. Most features have been assessed as having a high degree of technical difficulty (the upper half of the graph), but also many of them are in the right-hand side half, that includes the characteristics with high level of importance. In the previous figure, figure 2.7, it can also be noted that 6 of the 10 studied directions are classified as bottlenecks. These include the 4 characteristics detailed before and 2 additional ones: live content delivery method and data streaming speed. As a consequence, when the development process will consider these, precautions have to be taken that they are solved up to the level of expectancies of the customer, while exhibiting the

necessary technical suitability. This means that the 6 characteristics will receive more attention (i.e. resources and time) in the development process and they will have to be tested and validated thoroughly in the project.



Bottleneck CTQs

	Target Value	Difficulty	Importance
Simultaneous connections		7	0,16
Archeological works range		5	0,14
Live content delivery method		6	0,13
Accuracy of "historical truth" findings		6	0,12
Software tools for specific services		8	0,09
Data streaming speed		7	0,09

Fig. 2.8 - Bottleneck analysis of projected technical characteristics of the system

The second analysis performed based on QFD deployment data is the market opportunity map that shows the possible improvement avenues in solving the requirements addressed to this system. As it can be seen in the figure there is a significant potential for treating all of the requirements in innovative ways. There is a performance gap of between 67% and 400%, as it can be seen in Figure 2.7. Of course, the ideas proposed in this document will form the basis of the innovation process, but there are also other important ideas and technical solutions that could come up and be integrated within the final system. Based on this analysis, a special significance must be attached to solving the requirement for “Live assistance from experts”, which enables the main function of the system, AR based colocation in exploring and studying archaeological sites. It has the highest importance value and the highest improvement potential, further consolidating the idea that this is the main selling point of the future system and the main area where innovative solutions should be created in the product development process. The roof of the House of Quality permits the evaluation of mutual influences between the

generic product technical characteristics, based on the match or mismatch between their optimization directions. All negative influences, in our case 21 instances, constitute possibilities for innovative intervention based on the TRIZ methodology (Theory of Inventive Problem Solving) that seeks to solve conflicts between the evolution scenarios of technical characteristics based on a set of 40 generalized inventive principles.

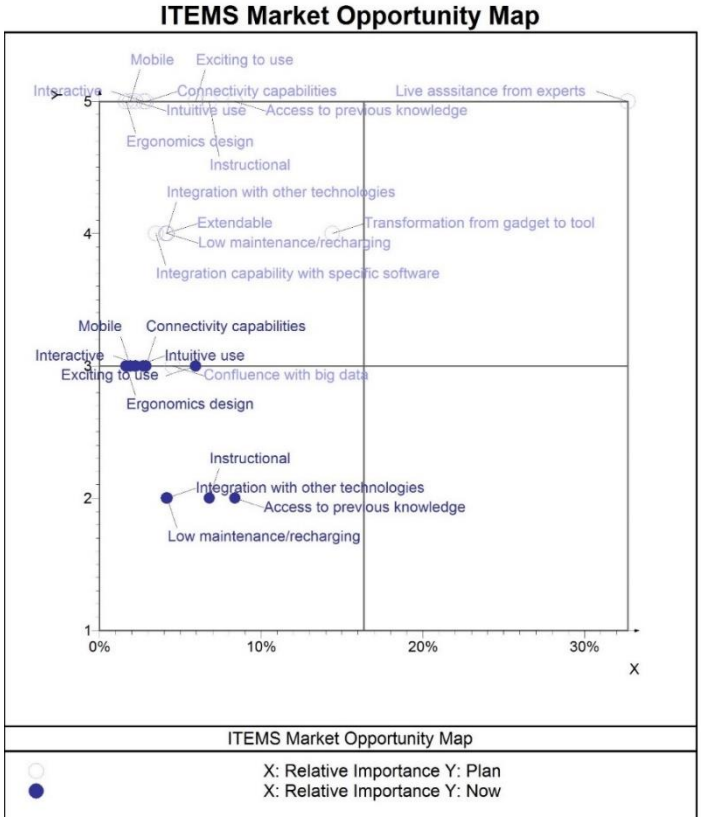


Fig. 2.9 - Market opportunity analysis for solving requirements

Each of the technical characteristics has been associated with a specific TRIZ parameter and the software Qualica QFD provides the standardized solutions for each of the identified conflicts. The current proposal is not intended to solve these issues right now, just to give an overview of possible directions for innovation in the product development phase. It will be the task of the project team to adapt all of these innovative principles to the studied situation and come up with the best possible solutions. We present an excerpt from this analysis, with a few generic solutions proposed for discussion in the future new product development process.

TRIZ Solut...

Cause	TRIZ Parameter	Undesired Effect	TRIZ Parameter	Inventive Principles		New Concepts
3 Live content delivery method	Adaptability	6 Autonomy of the mobile system	Durability of moving object	Segmentation	Divide an object into independent parts. Make an object sectional. Increase the degree of an object's segmentation	Additional battery
						Solar charging
				Inversion	Instead of an action dictated by the specifications of the problem, implement an opposite action. Make a moving part of the object or the outside environment immovable and the non-moving part movable. Turn the object upside-down	Chemical battery based on local resources
						Muscle power charging
						Mobile generator for AR HMD
						Auto stand-by mode
				Transformation of the physical and chemical states of an object	Change an object's aggregate state, density distribution, and degree of flexibility, temperature	Low consumption
		9 Data streaming speed	Speed	Prior action	Carry out all or part of the required action in advance. Arrange objects so they can go into action in a timely matter and from a convenient position	Archive or compress data
						Use cloud computing
				Spheroidality	Replace linear parts or flat surfaces with curved ones, replace cubical shapes with spherical shapes. Use rollers, balls, spirals. Replace a linear motion with rotating movement; utilize a centrifugal force	Separate control and AR streams
				Transformation of the physical and chemical states of an object	Change an object's aggregate state, density distribution, and degree of flexibility, temperature	

Fig. 2.10 - TRIZ based product innovation

A smart solution for healthcare

This case study presents the results of applying the NPD process in the field of furniture manufacturing, with influences also from the area of VR, programming and material sciences.

The first project was born due to the need of the local furniture manufacturers from Transylvania to develop and offer on the market complex products with a high-degree of value added. Due to the economic evolutions in Cluj-Napoca and the surrounding areas after the financial crisis of 2008, the cost of labor and materials is on the increase and no longer can companies in the furniture business, big or small, rely only on making simple and cheap products, especially since the competitive pressures on this direction coming from external factors, from the EU and beyond, made them incapable of having enough production volumes to justify diminishing margins.

As it is well known in the country, the Romanian healthcare sector requires considerable infrastructure investments to ensure better care and less chances of nosocomial infections. In these conditions, the HOpE product (Enhanced Hospital bed) idea was born and is being carried over by a team at TUCN (Prof. Sorin Popescu, Prof. Călin Neamțu, Assoc.prof. Paul Bere and the undersigned) through a couple of stages of technological readiness level (from TRL 1 to 3). As literature points out (Ghersi, et al., 2018), there are currently important scientific preoccupations in the area of smart bed design. The main features of the concept to which I contributed are tri-fold, each addressing a major shortcoming of the current solutions:

- innovative mechanical structure utilizing a single mechanism to perform several movements (raise bed, roll patient, transform into armchair);
- VR enabled systems to facilitate healing and medical procedures (self-care sensors with tracking device and personal environment cupola);
- silver ions based materials to diminish the level of harmful bacteria in the hospital environment and to ease up the moving and relocation of the bed.

For the requirements engineering process, a diverse focus group was summoned including representatives from the three engineering areas mentioned before (4 persons), company representatives from the classical and the innovative sides of the furniture industry and medical professionals (two doctors and two nurses). The patient perspective was ensured based on previous hospital experiences of all the involved participants. The identification of requirements has been done using guided and unguided interview, and discussions about case studies and scenarios. The filtered and processed requirements have been deployed in the same meeting into critical to quality (CTQ) technical characteristics (Fig. 2.11). These have formed the basis of the product formulation process in terms of functions and components, together with a market study and survey of available patents and applications in the field.

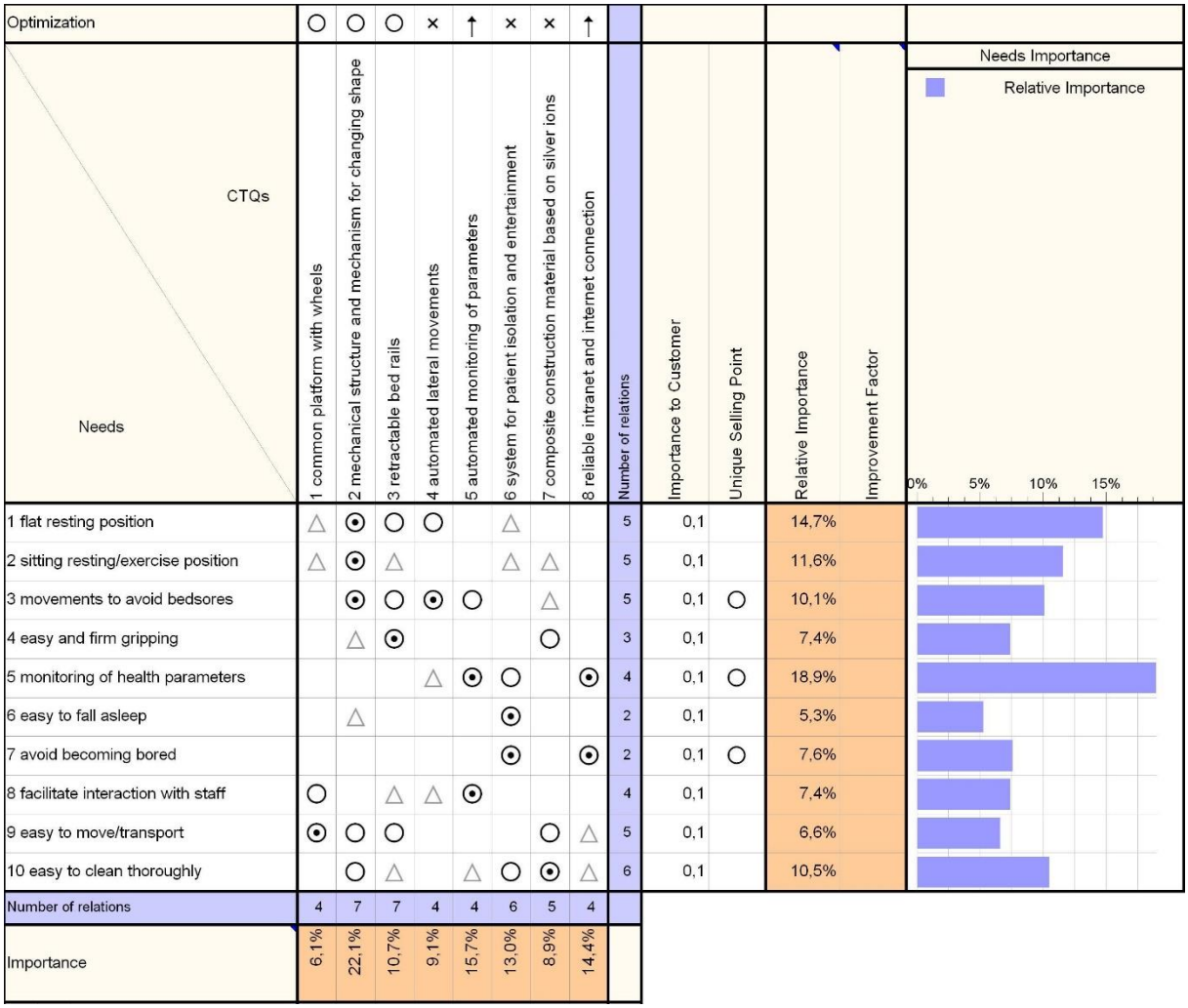


Fig. 2.11 - Deploying requirements into CTQ characteristics

The first two characteristics can be seen in Fig. 2.12 which demonstrates the roll motion used to diminish bed sores for patients that are under long term care and the personal space environment that ensures intimacy, quietness, personalized settings for lighting and air, and access to entertainment (digital, or classic, such as books). The movements of the bed help both

with medical tasks (e.g. periodic visit, wound dressing, etc.) and quality of life, allowing the patient to interact with family, friends and bed mates and to gain a certain amount of independence for tasks such as taking medicine, dressing one-self, eating and so on. The tracking system which contains biomedical sensors (e.g. pulse, temperature, blood oxygenation and pressure, EKG/EEG) and a motion tracking device (e.g. Microsoft Kinect), as well as the composite material proposed are not presented here, but are included in the concept). The innovative character of the product resides both in the individual functions and the ways in which they address specific challenges from the hospital environment, and the combination of all of them into one single unit, which makes it easier to produce, to maintain and to operate in real working conditions.

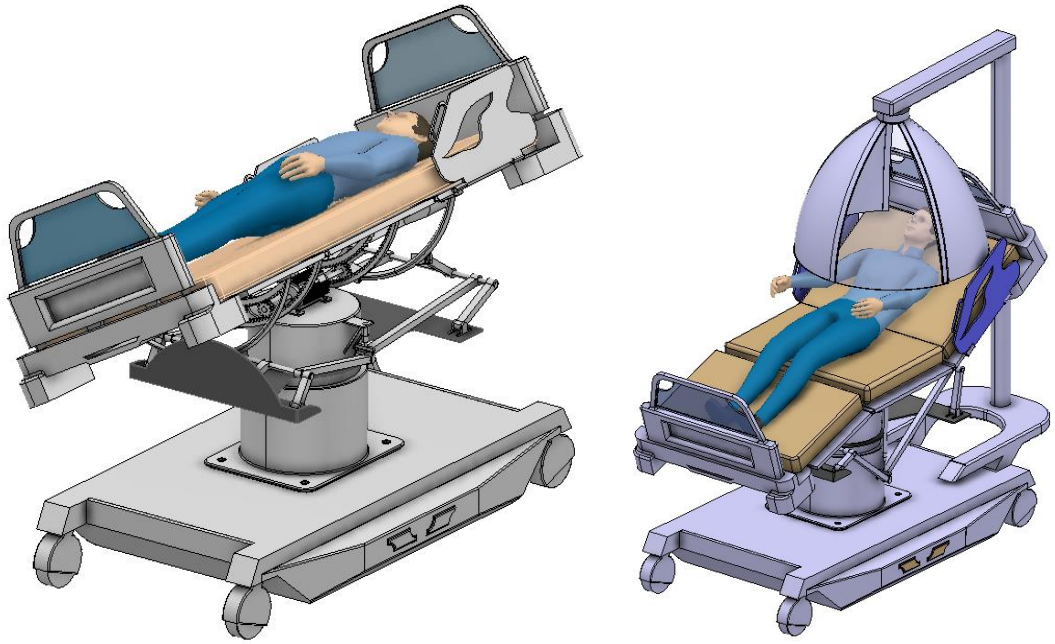


Fig. 2.12 - Main features of the smart hospital bed (Dragomir, et al., 2016)

The mechanical engineering and product engineering elements have been designed and modeled in the 3D environment using the CATIA V5R21 software package. Beside the capability to create and assemble the conceptual product, the software package can use the DMU Kinematics functions to simulate the functioning of the mechanisms as a whole. Together with the FEA capabilities and the related software DELMIA, this environment from Dassault Systèmes permits a complete evaluation of the product in the virtual environment, thus ensuring rapid development, in line with the PLM concept.

Using the software, and ergonomic simulation with the first-person point of view can be performed and offers important details about the interactions of the patients with the products. Fig. 2.13 shows this perspective and the way in which the movements of the mechanisms can be controlled and adjusted to improve the patient comfort during the active life of the bed.

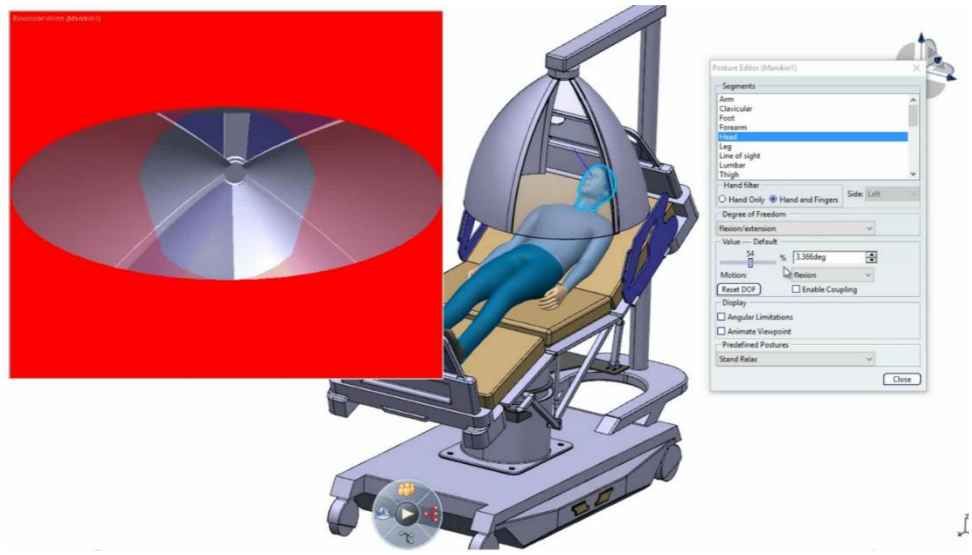


Fig. 2.13 - Simulation of the bed and the isolation cupola (Dragomir, et al., 2016)

The mechanical properties of the main mechanism of the smart bed are presented in the paper (Neamtu, et al., 2016), with the principal benefit being the obtaining of the folding motion from the bed position to the armchair position using a single actuator. The bed structure is made from three segments which are connected to a 6-bar mechanism with two ends fixed, two ends free and two 3-bar joints (Fig. 2.14). The actuator is placed in the central point (denoted with v in the figure) and creates the folding motion by transmitting a translation to the bar structure. The bed position can vary from completely flat (180-degree angles in both segment joints) to upright with two 90-degree angles (one positive and one negative). There is work currently being performed to add the roll motion from side to side and the vertical motion (on the z axis of the entire bed) within this mechanism.

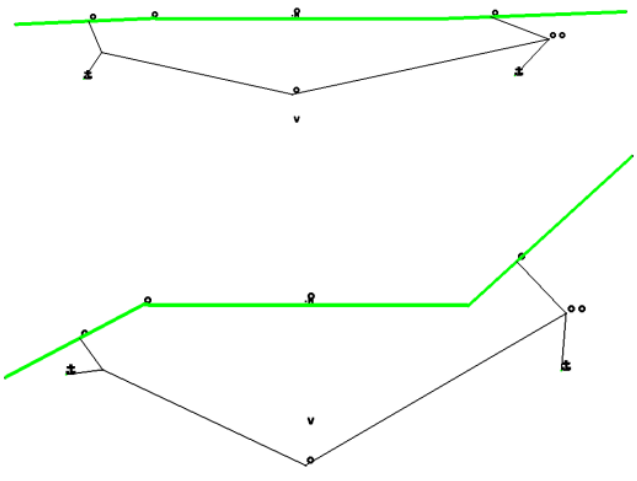


Fig. 2.14 - Folding mechanism of the smart bed (Neamtu, et al., 2016)

The structural bed frame uses composite materials containing on silver ions which can be manufactured for the prototype stage in the facilities of TUCN. Silver based nanomaterials are known to reduce the spread of harmful germs with 90% to 99.9% (Adepu & Khandelwa, 2018),

and this effect is further complemented by the strength-flexibility combination of the parts that are made from this composite, which can greatly improve the working conditions of the orderlies. The proposed solution has been tested in CATIA - the FEA module, replicating the most unfavorable scenario, and has been validated for manufacturing (Fig. 2.15).

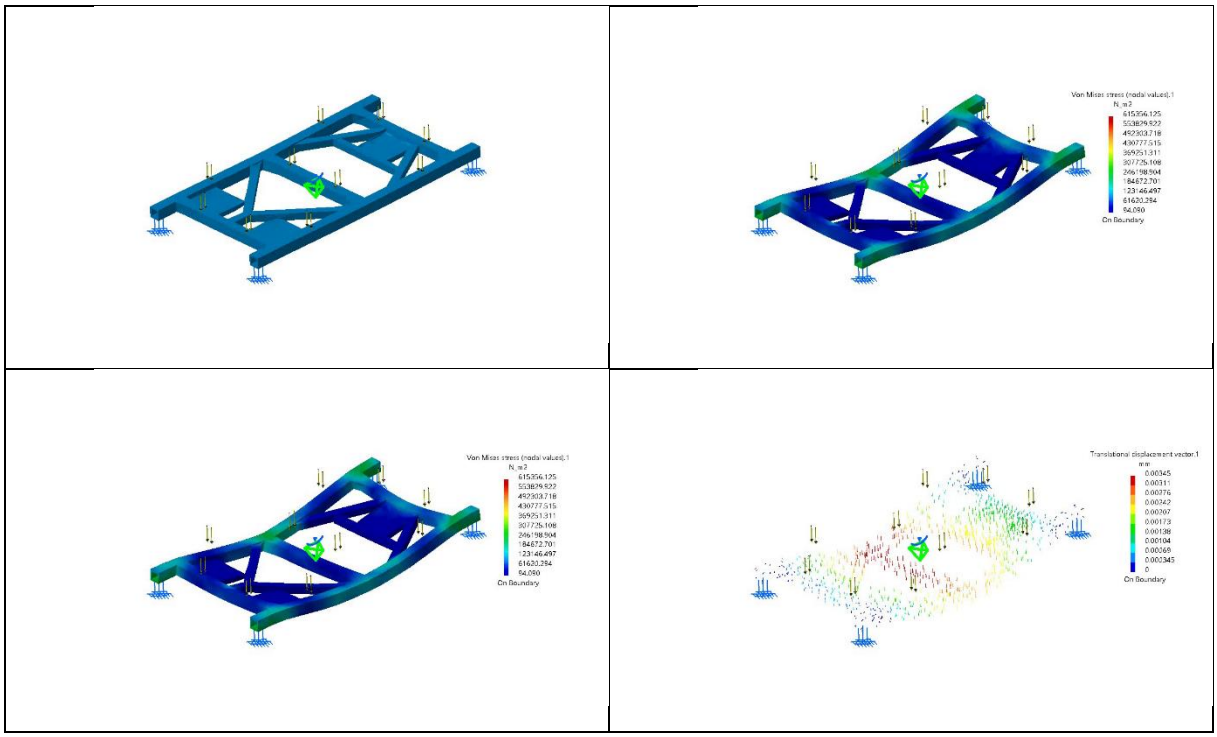


Fig. 2.15 - FEA analysis of the bed frame (Dragomir, 2016a)

The simulations performed have been focused upon ensuring the main functionalities of the product in line with the identified requirements of the stakeholders and the initially proposed technical characteristics. After the prototype is built and the product reaches TRL 4, additional detail related simulations will be performed to ensure the streamlining of the design and the elimination of any unnecessary features. This is very important from the point of view of economic viability of the product and also for its image that can be used for marketing purposes and need to project trust and robustness to the possible institutional customers.

For the situations in which new solutions have been required that go above and beyond the current market available products, the method used combined innovation based on technical conflicts (where the requirements of the users, buyers and beneficiaries conflict with each other or where the realization possibilities are antagonistic) and innovation based on free-form brainstorming. If the latter has been exemplified with the actuation mechanisms discussed above, the former merits additional attention.

The instrument employed was TRIZ (Theory of inventive problem solving) which converts the studied technical conflicts into generalizations for which there are known solutions in the theory (the so-called 40 inventive principles), which are then re-adapted to the problem at hand. Rather than settling for a trade-off of functions or attempting numerous trial-and-error approaches, TRIZ circumvents the issue by making use of an established and validated

knowledge base. The difficulty and „art" of applying this tool consists in making the correct generalization and then the correct customization. In our case, we present a few of the situations that were addresses during the product development process and that were solved using the online platform TRIZ40 by SolidCreativity (http://www.triz40.com/TRIZ_GB.php).

Table 2.1 - Application of TRIZ for smart bed innovation

Conflicting traits (HOpE product)	**Contradictions** (SolidCreativity)	**Principles** (SolidCreativity)	**Customized options (HOpE product)**
Flexibility in administering care (movements, patient interaction, accessibility) Standardized dimensions for hospital beds, wards and medical procedures)	2 Weight of stationary vs. 12 Shape	13 The other way around 14 Spheroidality - Curvature	Wheeled platform, support column, actuation, casing integrated into one basis Modular components and subsystems (sensors, selfcare, personal space) that rotate into place
Patient independence and ability to change position is useful for the health outcome Medical staff must be able to perform regular and emergency procedures	13 Stability of the object vs. 14 Strength	15 Dynamics 17 Another dimension	Movable superstructure with innovative mechanism added on top of the common basis Composite materials using carbon fibers with required mechanical properties at low weight
Existing solutions employ one actuator - one motion (degree of freedom) model The beds must be prepared for quick turnaround and low operational expenses	20 Use of energy by stationary vs. 39 Productivity	1 Segmentation 6 Universality	The product's modular structure is reflected in manufacturing, operation and maintenance The main functionality is to use the superstructure in two main positions and other intermediary ones
Hospitals usually opt for one type of bed to reduce maintenance issues and ensure interchangeability Both the patients and the medical staff have to be able to operate the respective bed functions with minimal training	27 Reliability vs. 33 Ease of operation	17 Another dimension 40 Composite materials	The interface paradigm uses touchscreens and simple command software, with additional functions for nurses The main bed structure is made from a carbon fiber sandwich structure, while exterior panels and fittings are light and cheap items
The bed should facilitate the work of the staff and the implementation of their indications The functionalities should be able to be integrated and customized by the patient themselves	33 Ease of operation vs. 35 Adaptability or versatility	1 Segmentation 15 Dynamics	Operational independence is built into the subsystems and operating software The staff and the patients have different levels of access and a hierarchical structure ensures accountability

Conflicting traits (HOpE product)	**Contradictions** (SolidCreativity)	**Principles** (SolidCreativity)	**Customized options (HOpE product)**
All the components and subsystems must have a long operational life The manufacturing process can be performed with existing technologies and capabilities	16 Durability of non-moving object vs. 32 Ease of manufacture	10 Preliminary action 35 Parameter changes	The hospital bed concept can use the production infrastructure available and ready-made electronics Operating software is a one-time expense, can be outsourced

The final step that has been accomplished so far involved creating the first scale prototype of the main part of the product at a Romanian company from Satu Mare.

Development of innovative furniture

As the last case study, an innovative NPD approach to office furniture is presented. Within the POSCCE project mentioned at the start of the chapter, a complex product development process has taken place in support of the startup company Smart Furniture SRL, which was the beneficiary. A team of over 20 people, with varying degrees of workload, has been involved in this process for 18 months, while the company has considerably developed its production base with up to date equipment. The goal of the project was to develop a mature NPD process, to establish an intellectual property base for the company (patents for innovative products), to train and retain some R&D personnel and to publish the results of these activities.

As it can be seen, transforming regular products in smart products and taking advantage of the capabilities of modern technology is an important concern worldwide (Figure 2.16) and implementing it also was the main driver of the presented demarche. The development was structured with the help of a steering committee made up of the company CEO, the research project director and head of R&D (the undersigned) and an experienced architect. Weekly meetings between this committee and the engineers and researchers helped keep the project on schedule and on budget and in the end the results have been well received by the company owners, the customers of the company and the financing agency, with most of the key project indicators being overpassed.

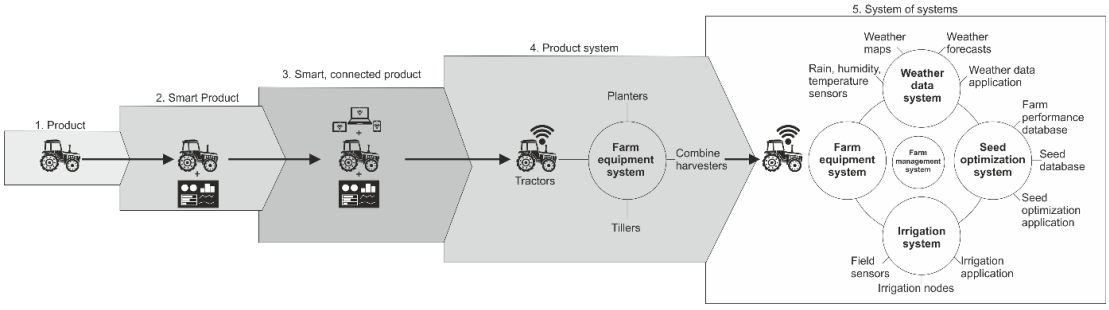


Fig. 2.16 - Conceptual approach to smart product development (Porter & Heppelmann, 2014)

The backbone of the approach was an innovation strategy developed by the steering team, with valuable input from Prof. Chin-Yin Huang from Tunghai University in Taiwan and Prof. Sorin Popescu from the Technical University of Cluj-Napoca. The roadmap proposed in this

configuration and followed for the NPD process involved three different stages of smart furniture development for office use:

- Stage 1 - regular modern furniture, but with multi-functionalities that expand its uses and space related efficiency;
- Stage 2 - regular modern furniture or multi-functional furniture (from stage I) enhanced with IT&C equipment and functions that correspond to the present life and work styles;
- Stage 3 - advanced adaptive furniture that includes sensors, actuators and software to process interactions with the user and anticipate their needs.

In the following, we will provide a walkthrough of the most important achievements, accompanied by descriptions and a discussion relating to the implementation of the strategy.

Stage I - Multifunctional furniture

The main objectives in this stage of smart furniture development were to offer additional options for small companies with small office spaces and to diversify and combine functions that belonged to the professional and social areas. The first examples is of a living or conference room table with adjustable height, that can be used either for supporting professional meetings or for receiving visitors and guests, as it doubles as a coffee table. The table relies on a double crown mechanism, with two circular features connected through spherical joints to three vertical rods each. The two crowns can move independently, the inner one within the outer one to generate a vertical lifting and descending motion of the actual table horizontal piece. The mechanism also allows intermediary positions and locking into place. In the figures, one can see the original concept and the detailed design which was used for the patent application.

Fig. 2.17 - Table with adjustable height (Dragomir, 2016b)

The invention was prototyped by the company and it is part of their offering to the customers, while at the same time it was presented at the Proinvent Invention Salon in 2016 where it obtained an excellence diploma and a gold medal. Also, it was included in the presentation delivered by the undersigned to the Entrepreneurial Discovery Process organized in Oradea by the Regional Development Agency.

A similar example, also in the status of patent application being filed to the Romanian Patent Office is a multi-functional coffee table that can offer support for small meetings, storage space for small objects like mobile devices and accessories and an incorporate outlet connector to provide a quick way to charge these devices. Basically, it performs similar functions as the previous example but in reverse, as it could help in the establishment of small home based offices. The invention was presented at the Inventica Invention Salon in Iași and obtained a gold medal. In the figure below are visible the 3D model, the first viable prototype and the obtained award.

Fig. 2.18 - Multi-functional coffee table (Dragomir, 2016b)

Stage II - IT&C enabled furniture

In this stage of smart office furniture development, the attention of the NPD team has been focused upon the merger of stage 1 furniture with advanced IT&C devices and technology, to provide exciting functionalities that could integrate with the requirements of modern office activities.

The first example device submitted for patent application that obtained at the Proinvent Invention Salon 2016 two awards: an excellence diploma with gold medal from the organizers and Special prize from the University Lucian Blaga Sibiu. It describes a simple and light device that can be incorporated in desks and other furniture objects and has three main functionalities dedicated to smartphones: support with enhanced adherence, induction charging and USB connection, integrated into an elegant and modern looking gadget.

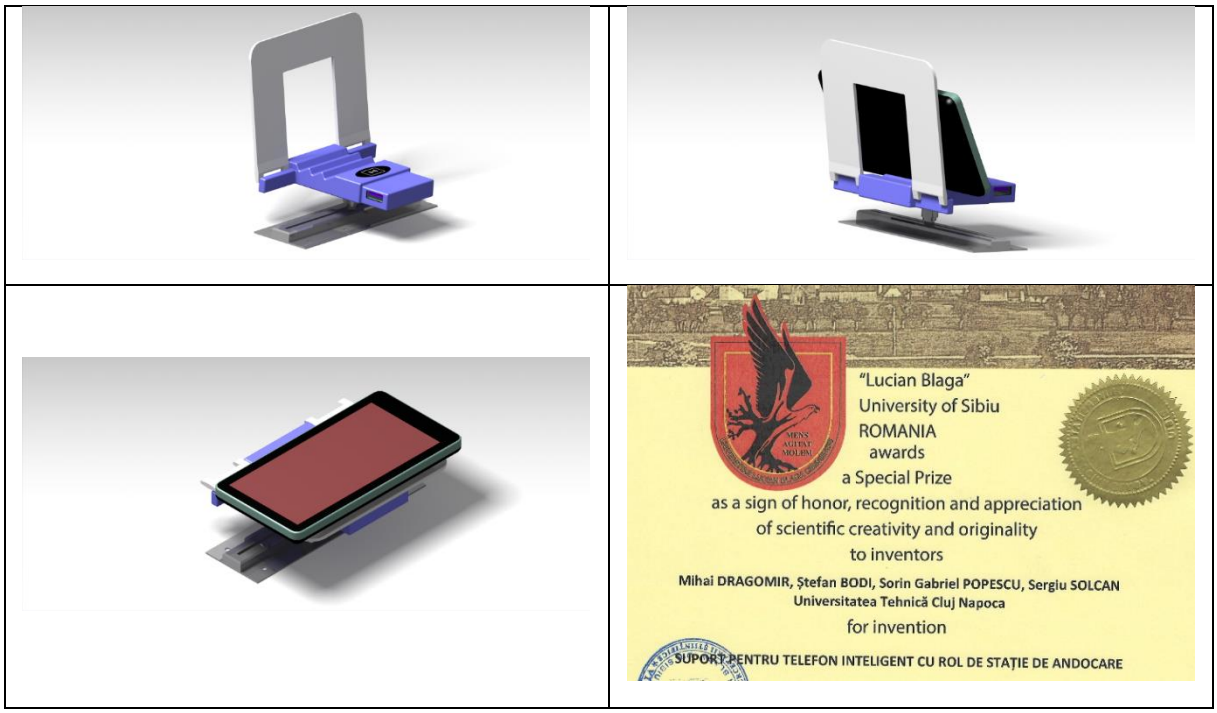


Fig. 2.19 - Smartphone docking station with induction charging (Dragomir, 2016b)

Another example deals with a complete desk solution for smart offices, with a significant number of IT devices bringing smart functionalities for an office user. On a regular type of work office, the proposed concept integrates the following functionalities:

- docking station providing laptop integration and functionalities such as transfer, charging, ventilation and cooling, etc.;
- bluetooth omnidirectional speakers, for supporting video-calls, web-conferencing and ambient music;
- scanner for digitizing paper-based documents;
- wi-fi smart clock with weather station and bio-parameter monitoring;
- light sensitive lamp, with adaptability to outdoor conditions and time of day.

This list is not exhaustive and can be extended with additional functionalities and equipment. The proposal was developed and analyzed for effectiveness using morphological charts, and the main challenge observed was reducing the dependence on cables for power and data transfer, using as much as possible wireless solutions.

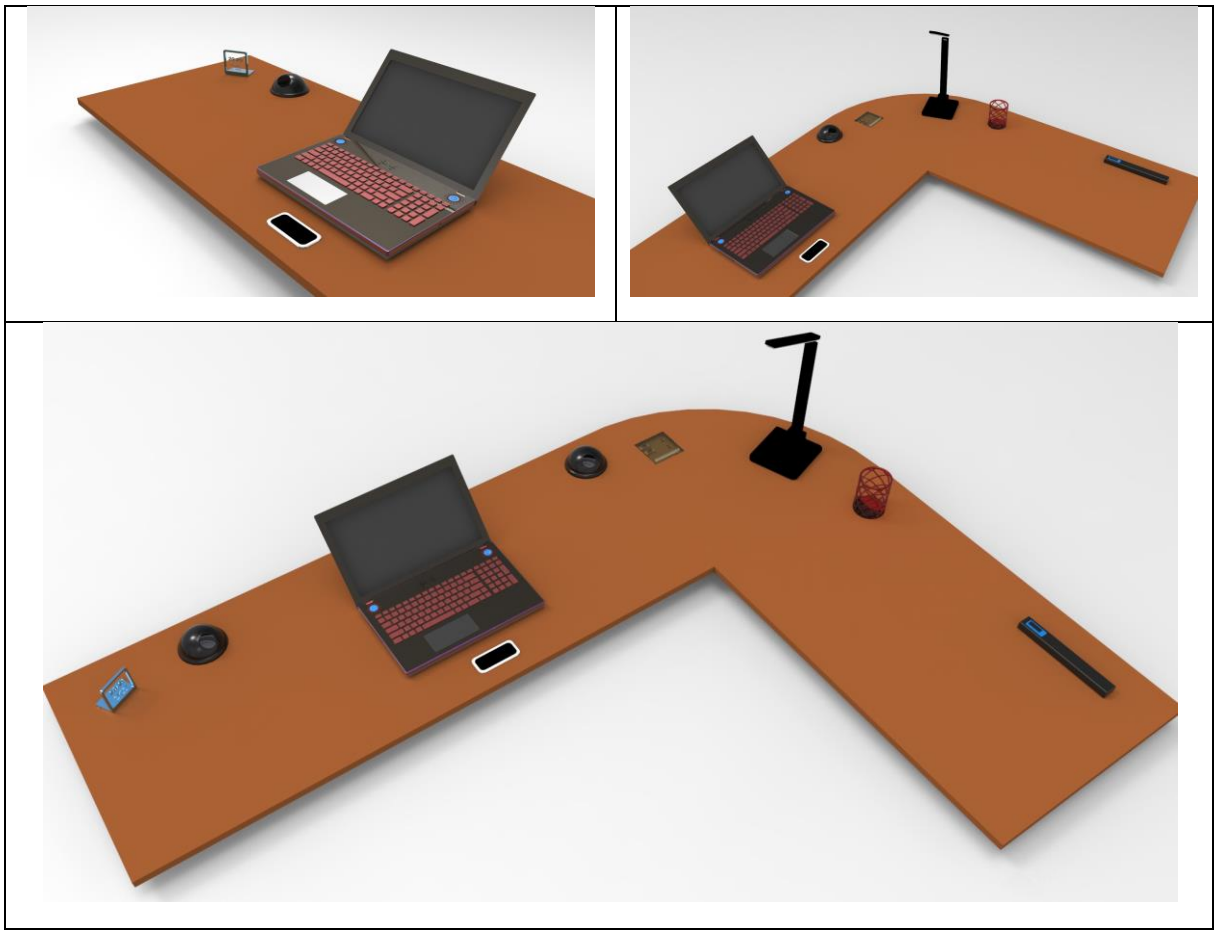


Fig. 2.20 - IT&C equipment integrated for a smart workplace (Dragomir, 2016b)

Stage 3 - Adaptive furniture

This is the most complete and complex stage of development reached by the NPD team. Each product developed for this level requires its own project as the requirements engineering step, the 3D modelling and the prototyping, each require a considerable effort and significant resources. In our case, the first example presented in this chapter (due to its detailed nature), the HoPE enhanced hospital bed is an excellent example of the possibilities that can be achieved when smart furniture is employed in a creative way.

The bed has the ability to adapt to the needs of each patient that uses it and at the same time it serves the needs of the medical professionals delivering the treatment. In this way, it generates more effective medical care and quick turnover in the beds, thus becoming also a sensible investment on the part of the hospital.

2.2 Quality and innovation management practices

2.2.1 Contributions

Category	Involvement and obtained results
Academic experience	**Faculty in charge of the courses in the area Quality and integrated management systems at bachelor and master level starting with 2007** **Reviewer** for IWA World Water Congress 2016, The International Spectator, IETEC-BRCEBE 2015, ICPR-AEM & QIEM 2014, 2016, 2018 **Director of the Department for University Management of TUCN** (2018) **Operational manager** of the team for preparing the external evaluation of academic quality at institutional level (2018) **Manager of the Danube Innovation and Technology Transfer Center Office at TUCN (since 2012)** Member of the working group for strategic planning of TUCN (2016)
Practical experience	**Coordinator or consultant for over 30 management system implementations** Industrial contracts 2013 **Continental Automotive Timișoara, Training in the field of measurement uncertainty, Contract co-director; 2012 Leoni Wiring Systems Bistrița, Training in the field of quality control, Contract co-director (budget 2850 lei); 2010 MMM Autoparts SRL Turda, Consultancy and assistance for designing and implementing the environmental management system**, Member of the project team. **Member** in the council of the Design eng. and robotics Dept. (since 2012) **Member** in the council of the Faculty of Machine Building (since 2012) **Member** of the organizing committee for the QIEM (Quality and Innovation in Engineering and Management) 2011, 2012 and ICPR-AEM (AEM) & QIEM 2014, 2016, 2018 conferences in Cluj-Napoca **Trainer** for a BEST Cluj-Napoca summer course (2006), speaker at BEST Days (2009), juror for the local EBEC 2015 contest **Member** of the organizing committee for 2 scientific sessions for TUCN PhD students (2012-2013)
Supporting projects	2013-2016 EU Prog. "Capacities", FP7-INCO-2013-9 R2I-ENP, project no. 609531, **Knowledge Transfer Community to bridge the gap between research, innovation and business creation - NoGAP, Project responsible for TUCN (TUCN budget 94.166 €)** 2011-2013 EU, Leonardo da Vinci - Transfer of Innovation, 2011-1-PL1-LEO05-19870, **MUVOT - Blended learning course on Measurement Uncertainty for advanced vocational training**, Member of the project team, and Industrial contract 2014 Emerson SRL Cluj-Napoca, **Measurement uncertainty course in blended learning format - from the Leonardo da Vinci project MUVOT, Contract co-director (budget 2455 €)** 2010-2013 European Social Fund, Call for proposals 88 „Doctoral scholarships", POSDRU/88/1.5/S/60078, **Doctoral studies in engineering sciences for the development of the knowledge based society - SIDOC, Member of the management team (Operations coordinator) (budget 20.937.700 lei)** 2010-2013 European Social Fund, Call for proposals 107 „Doctoral scholarships", POSDRU/107/1.5/S/78534, **Q-DOC - Increasing the quality of doctoral studies in engineering sciences for supporting the development of the knowledge based society**, Member of the project team 2009-2011 European Social Fund, Call for proposals 18 „University for the labor market", POSDRU/18/1.2/G/9136, **Designing and implementing a**

Category	Involvement and obtained results
	Bologna-type master study program, with international outreach, in the field of Quality Management and Engineering, aligned with the requirements of the labor market, Member of the management team (Assistant project manager) (budget 740.000 lei)
Research articles	Popescu, S., **Dragomir, M.**, Pitic, D., Brad, E., **Method for competitive environmental planning**, Environmental Engineering and Management Journal, ISSN 1582-9596, 11(4), 2012, pp. 823-828 S. Popescu, M. Drăgan, **M. Dragomir**, D. Pitic, **From Organisational Business Performance to an Environmental Excellence Framework**, Journal of Environmental Protection and Ecology, 14(4), 2013, pp. 1711-1718, ISSN 1311-5065 **Mihai Dragomir**, Grigore Pop, Diana Dragomir, **ISO 9001 from the 2008 to the 2015 version. Understanding the changes to gain perspective**, 5th RMEE Conference, Cluj-Napoca, 22-24 September 2016, ISSN 2247-8639, pp. 283-289 **Dragomir, M.**, Popescu, S., Neamțu, C., Dragomir, D., Bodi, Ș., **Seeing the Immaterial: A New Instrument for Evaluating Integrated Management Systems' Maturity**, Sustainability, vol. 9, issue 9, 2017, ISSN 2071-1050, journal ranked by ISI Web of knowledge, Q2 quartile F. Iliescu, S. Popescu, **M. Dragomir,** D. Dragomir, **Public-Private Partnership in the Water Sector in Romania: Success or Failure?**, Water Science and Technology: Water Supply, 13(5), 2013, pp. 1249-1256, ISSN 1606-9749 F. Iliescu, S. Popescu, **M. Dragomir**, D. Dragomir, **Stakeholder driven improvement of water and sewerage services**, IWA World Water Congress, Lisbon, Portugal, 21-26 September 2014 Diana Rusu, **Mihai Dragomir**, Diana Dragomir, Daniela Chiran, **Exploring innovation practices in the renewable energy sector in countries from the Eastern Partnership**, Proceedings of the 2016 ICPR - AEM and 4th QIEM, Cluj-Napoca, 25-30 July 2016, ISBN 978-606-737-180-2, pp. 141-144 **M. Dragomir**, O. Iamandi, Ș. Bodi, **Designing a roadmap for performance indicators in integrated management systems**, 6th International Conference Managerial Challenges of the Contemporary Society, 7-8 June 2013, Cluj-Napoca, published in vol. 5, 2013, pp. 91-95, ISSN 2069-4229 **Dragomir Mihai,** Neamțu Călin, Popescu Sorin, Popescu Daniela, With the trio of standards now complete, what does the future hold for integrated management systems?, Proceedings of the International Symposium for Production Research 2018, 28-31 August, Vienna, pp. 769-778, Springer, ISBN 978-3-319-92266-9 **M. Dragomir**, D. Dragomir, S. Popescu, Ș. Bodi, **Case study regarding teaching Design for quality at graduate level**, IETEC-BRCEBE Conference, Sibiu, Romania, November 1-4, 2015, ISBN 978-0-646-94781-5, pp. 78-86 **Dragomir, M.**, Popescu, S., Płowucha, W., Marxer, M., **Blended Learning in the field of Measurement Uncertainty. Experiences from the MUVOT project**, 2nd International Conference Quality and Innovation in Engineering and Management, Cluj-Napoca, Romania, 22-24 November 2012, Published in a special issue of Quality - Access to Success, vol. 13, no. SUPPL. 5, pp. 127-130, ISSN 1582-2559 Călin Neamţu, Dan Hurgoiu, Sorin Popescu, **Mihai Dragomir**, Herbert Osanna, **Training in Coordinate Measurement Using 3D Virtual Instruments,** Measurement, Volume 45, Issue 10, December 2012, pp. 2346-2358 (available online 8 October 2011), ISSN 0263-2241

Category	Involvement and obtained results
	Mihai Dragomir, Diana Dragomir, Diana Rusu, **Setting up a training and managerial improvement plan for a measurement laboratory**, 12th ISC Coordinate Measuring Technique, 18 - 20 April 2016, Bielsko-Biala, Poland
Teaching materials	Mihai Dragomir, **Design, implementation and continual improvement of integrated management systems,** ISBN 978-606-543-360-1, MEGA Publishing house, Cluj-Napoca, 2013 (157 pages) (Romanian) **Mihai Dragomir**, Sorin Popescu, **Quality management in industrial enterprises. University textbook**, ISBN 978-606-543-362-5, MEGA Publishing house, Cluj-Napoca, 2013 (157 pages) (Romanian) Sorin Popescu, **Mihai Dragomir**, **Quality management** Chapter, pp. 499-517, in the monography Lungu Florin (coord.), **Management and engineering for business - Qualification manual**, ISBN 978-973-662-579-4, UT PRESS Publishing house, Cluj-Napoca, 2010 (Romanian) Călin Neamţu, **Mihai Dragomir**, Daniela Popescu, Rareş Ghinea, **Virtual laboratory** Chapter, pp. 45-55, in the monography Wojciech Płowucha (ed.) et al., **Didactics in coordinate metrology**, ISBN 978-83-63713-30-0, University of Bielsko-Biała, Bielsko-Biała, Poland, 2012 (English)

2.2.2 Case studies and results

Advanced quality and process management in R&D

Quality management systems and, by extension, integrated management systems with three components, quality-environment-occupational health and safety, have formed the main line of research for the undersigned ever since starting my PhD program in 2004. I have presented and finalized my doctoral thesis on this topic in 2010 and have continued to work in the area of standardized management systems as an academic and as a consultant. In this sub-chapter, there will be presented some of the new developments that I had the opportunity to work on. The thematic of the research in this field has shifted towards uncovering the mechanisms of process management especially in the relation to companies or initiatives aimed at innovation or the creation of new products. The case studies included are derived from manufacturing and the renewable energy sector.

First, the implementation of a full-fledged NPD process for the furniture industry, already mentioned, has included the need to set up a process network that could deliver the expected results while operating with the infrastructure and personnel of a small start-up company. Beside this obvious challenge, the process chain had to be able to provide the answers required by the stakeholders and the documentation required by the financing agency.

The figure below presents the processes required by the R&D project structured in an ISO 9001 compliant map, including principal, support and management processes.

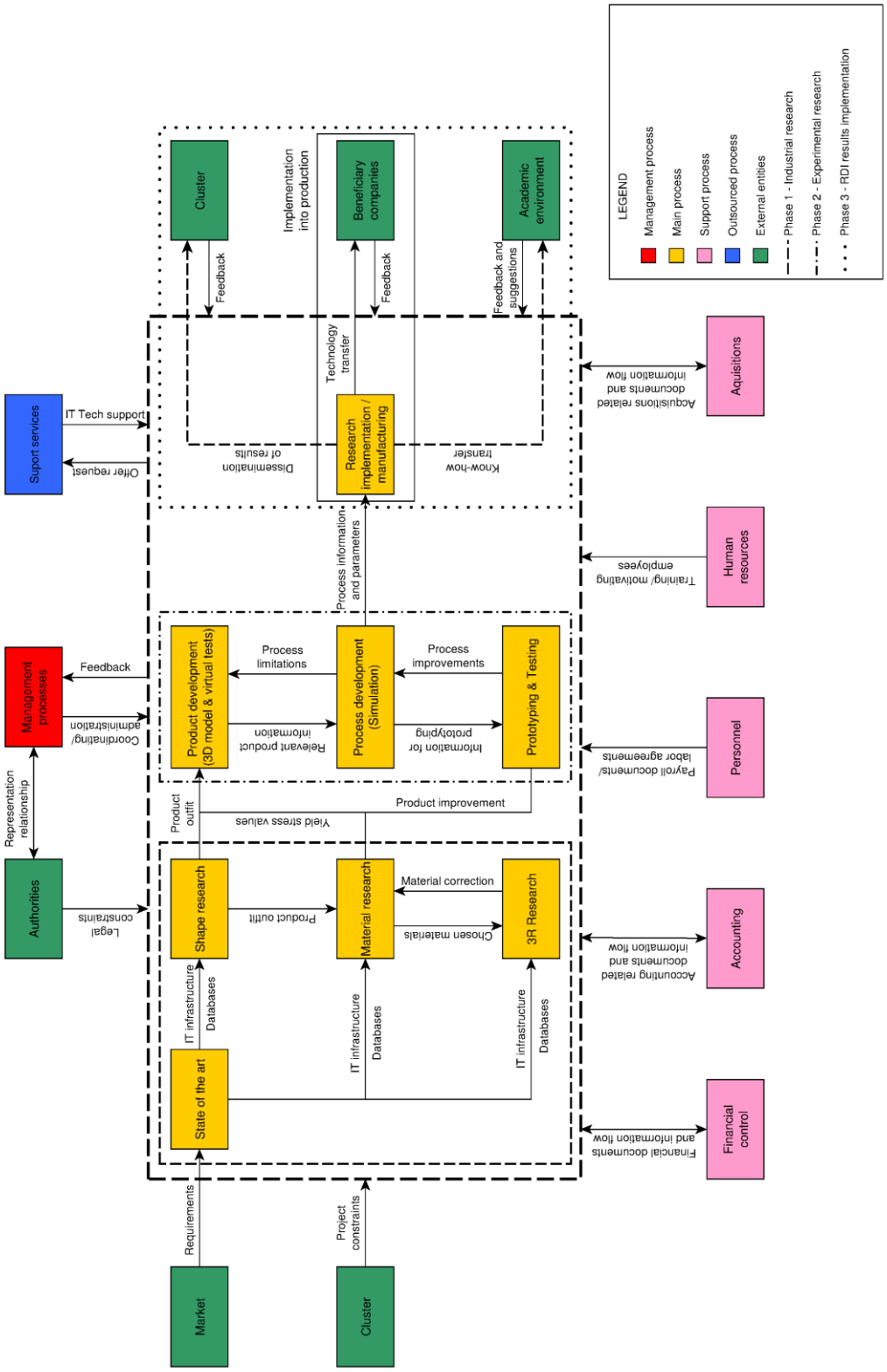


Fig. 2.21 - Process map of a R&D project (Dragomir, et al., 2014)

This map has been used as blueprint for a full-scale simulation performed with the help of the SigmaFlow Modeler software. This program has the capability to assist the user in creating a model of the process network based on flowcharting and then to insert real process data into its calculation model to obtain a detailed picture of the behavior that a future or current process will have. The characteristics of the process that have been used in our case included the available personnel resources, which was based on the organizational chart of the startup, the pattern of use of these personnel across various activities, the time to achieve each of the steps of the process map and an estimation of the variability for each of them, in terms of statistical distribution type and features. The staff included in the simulation is composed of 1 Research manager, 5 design engineers, 3 industrial designers and 3 production specialists (for a total of 12 people).

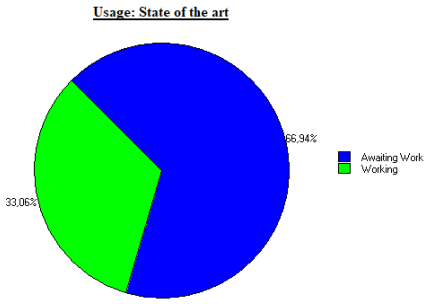
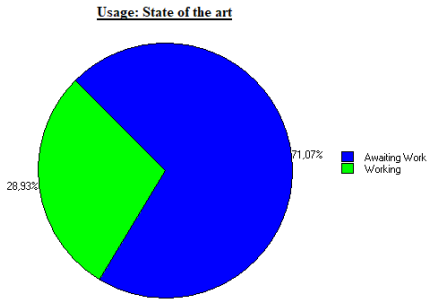
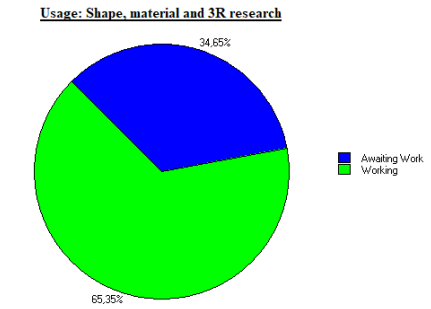
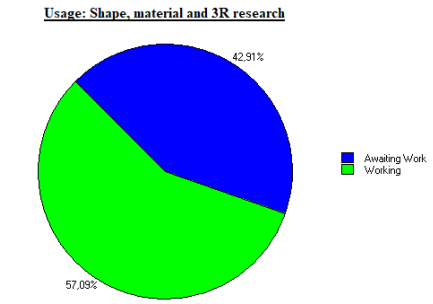
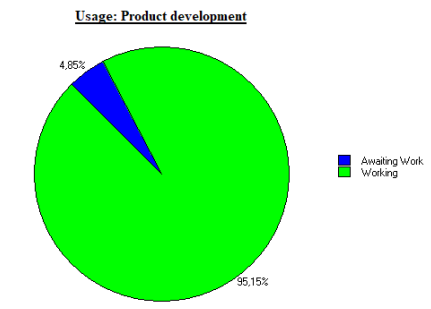
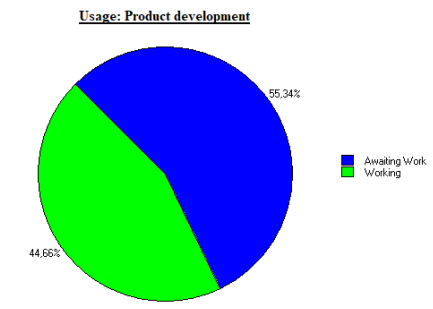
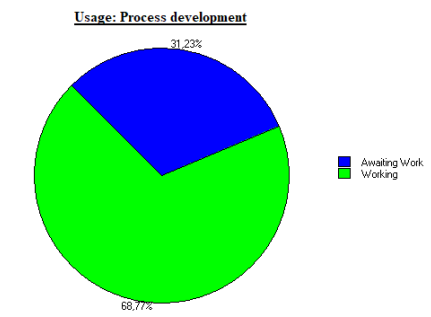
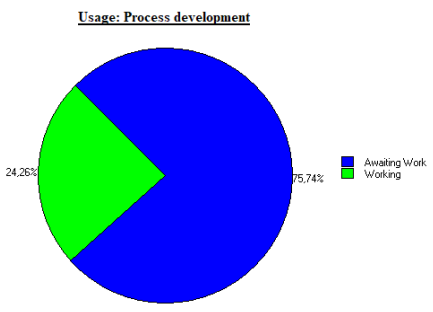
Once this preparatory stage was completed, the simulation was run with a focus on effectiveness, thus percentages were used instead of time units. The results showed that 86% percent of the input data (feasible product development ideas) can be converted into useable results (product prototypes, scientific articles or patent applications). Since this was considered improvable, a set of measures has been proposed and implemented at the level of the research and development team. The Research manager was given flexibility in selecting and organizing the staff he is working with, which lead to the creation of two different teams of employees, one for industrial research and one for experimental development. These team were independent of each other, but had people with interchangeable skills within them, thus engineering and design were no longer separated, but could share work time thus eliminating a significant cause of variability and unproductive phases. The production stage was left as it was, due to the fact that these people were working on the shop floor and could be made to share their time and tasks as easily as the ones that worked in the offices. Additionally, training was provided to help the process of compatibilization of the two types of resources and the process steps themselves have been made more clear and leaner with the help of operational procedures.

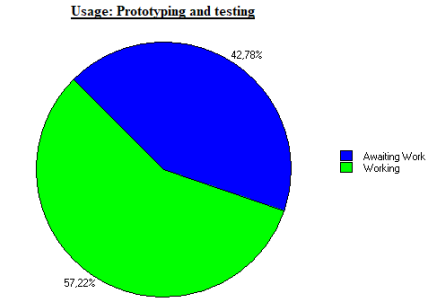
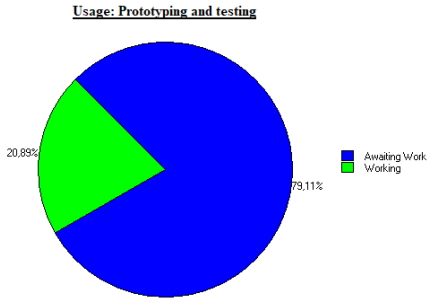
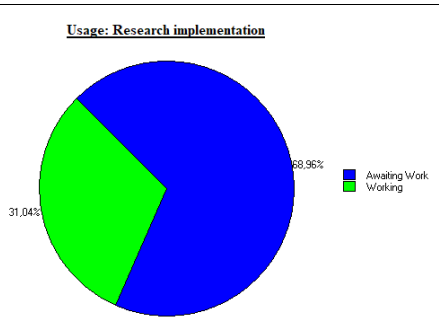
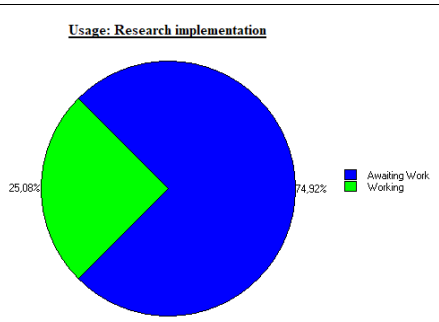
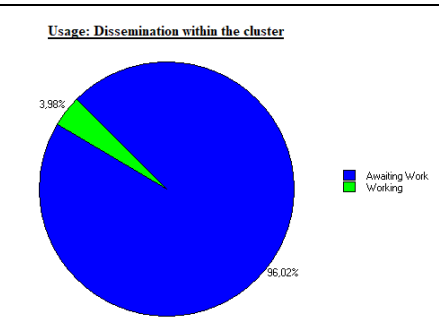
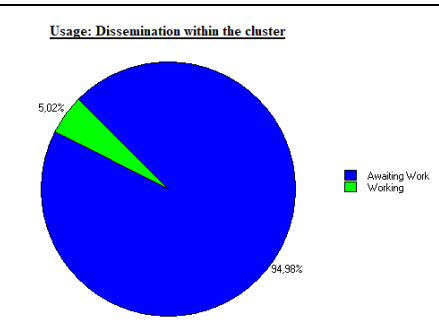
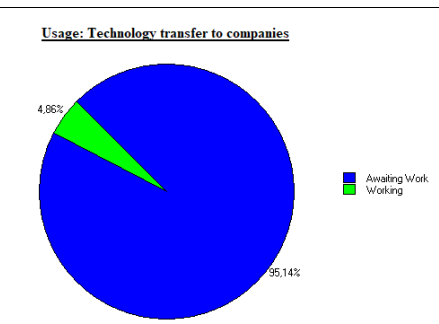
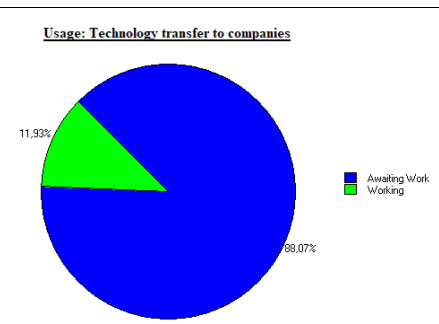
With this action plan approved by company management and implemented, the situation changed for the better and the simulation results showed this fact. The effectiveness of the process increased to 98%, while the workload became more even among the members of the team and some capacity was even freed. This means that additional work could be taken on, and by keeping the same percentage of success, the total work results in absolute terms could be increased by a factor of cca. 1,5. However, additional improvements are needed at the level of individual process steps, since some of them are already close to the maximum capacity, while other have considerable room left for this (see Table 2.2).

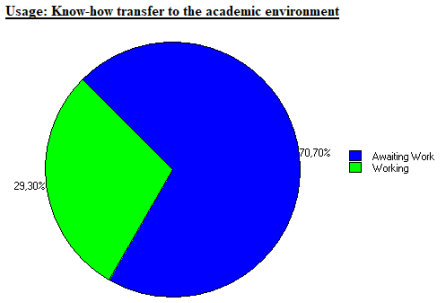
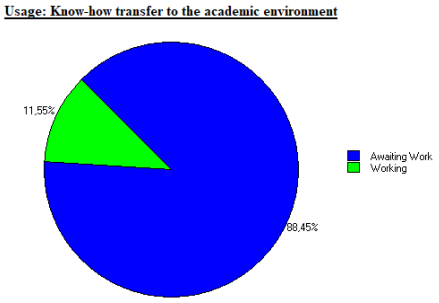
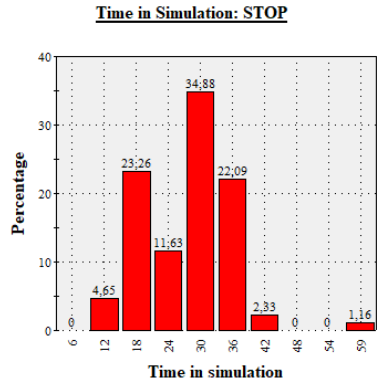
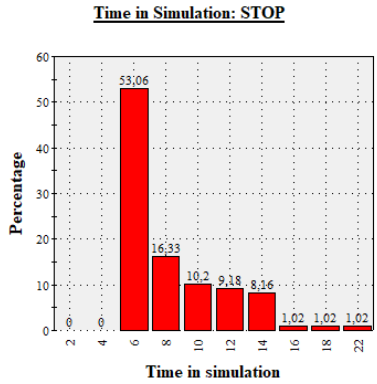
Another sources of development and improvement that has not been tapped yet is the possibility to change the process map of the R&D project itself (which is not based on the stage-gate or waterfall philosophy), by adopting a different organizational structure (e.g. a matrix structure based in each product related subproject), a different management approach (e.g. agile

development with teams and scrums), or by subcontracting some of the support processes, reducing costs and hiring new personnel in the stages where capacity is almost maximized.

Table 2.2 - Step by step process improvement visualized with SigmaFlow

Regular process	Improved process
	
	
	
	

Regular process	Improved process
	
	
	
	

Regular process	Improved process
	
	

Beside the comparisons for each step which speaks for itself and shows that by exacting relatively small changes the company can achieve a significant boost in effectiveness (12%) and efficiency (cca. 43% or even more with additional changes), it is important to understand the final graph generated by the software. It can be seen that the initial process was in a natural state, with a normal (Gaussian) distribution with two “humps”, generated probably by the two relatively independent activities or departments, while the improved process is far from this kind of distribution.

Over 55% of the results are achieved in very short time, which is good for product development because it allows short times to market, and the rest could be relegated to non-product result types of outputs (e.g. patents which take longer). Still, since this is a Poisson-type distribution, the possibility exists that the processes will revert to their natural behavior and squander the results of the changes made, so the entire process network must now be kept under a tighter control, through managerial and technical means. These aspects have been discussed with the management of the startup company, especially since the process is to be completely taken over by them, with no external consultancy. Among the items they are currently considering to increase the level of process control there are:

- employing a modern CAD platform that allows sharing and progress monitoring;
- periodic meetings of the two work teams to exchange best practices and solutions;

- co-development project with clients or partner companies.

The second part of the case study presents a risk analysis achieved in order to set up a laboratory in the field of quality control and industrial metrology (measurements), as part of the larger development and interest towards research of the furniture cluster in our city. The main directions for analysis established through discussions are:

- *Skills of the personnel* represent a critical asset, which needs to be continuously addressed (Werner & Weckenmann, 2012), (Frota & Finkelstein, 2013), the focus in our case being on developing future members of the team, which should go through training;
- *Documentation* of activities should be improved in the laboratory to ensure better traceability, improved completion of tasks and enhanced communication with the stakeholders;
- The *maintenance* of the measuring equipment is vital to maintain the measuring properties of the machines and their working order and availability for use in research projects or contracts;
- *Accreditation* is important to ensure improved recognition and usability of the results delivered, beyond the current situation where a quality management system is running, but is not specific for laboratories;
- The direction of *relationships* concerns both the way the laboratory is functioning within the university and the direct cooperation with various related laboratories;
- In our case, *automation* refers to the possibility of automating various managerial and administration tasks, which, although necessary, can cut into the research or practical measurement time;
- *Internationalization* refers to maintain the current state or to extend the network of collaboration with universities, research institutes and companies from the European Union, in order to become a competitive participant in the field.

In the Table 2.3 below, the main risks identified for each direction are presented, evaluated and their mitigation is proposed with the help of the Failure Modes and Effects Analysis (FMEA) method. As usual, the cut-off score for intervention is 125 RPN (Risk Priority Number). It can be seen that, beside the improvement direction towards developing and enhancing the skills of the personnel, a considerable proportion of the identified risk reduction measures are also concerning the personnel. In consequence, we propose that combination of technical and managerial trainings and courses, that could cover most of the topics resulting from the previous analyses, is required. As the value of virtual based education has already been demonstrated in the field of coordinate metrology (Maresca, et al., 2013), (Neamtu, et al., 2012), (Bauer, et al., 2015) this approach should feel natural and prove effectiveness for training the new members of the team.

There is also revealed through the FMEA deployment the need for more managerial support instruments: planning tools, communication tools, sharing and collaborative working tools, etc., which can also be implemented electronically and online.

Table 2.3 - FMEA risk analysis for setting up a quality control laboratory

Development direction	Failure modes	Possible effects	Probable causes	Current controls	S	O	D	RPN	Recommended action for mitigation
Skills	Personnel retention difficulties	Missed opportunities Ineffectiveness Inefficiency of resource use	Unpredictability of financial resources	Periodic evaluations	7	6	5	210	Specific tools for financial management Specialized personnel for project proposals
	Slow learning curve of the new personnel		Complexity of topics	Periodic evaluations Monitoring	7	4	4	112	Not necessary
	Mismatching requirements of stakeholders	Errors and complaints	Scientific trends Market trends	Literature/ market reviews	8	6	3	144	Participation in conferences and professional events
Internationa-lization	Lack of financing / projects	Diverging preoccupations No contact	Failed proposals Lack of cont. communication Complicated financial manag.	Due diligence Proposal cross-evaluation	8	5	8	320	Use of virtual meetings and instruments Specialized personnel for project proposals
	Responsiveness in relation with companies	Complaints Failure to re-contract	Bureaucracy Didactic load	Customer feedback Bill payment	7	4	2	56	Not necessary
Relationships	New financial and operational regulations	Bottlenecks Inefficiency of resource use Complaints	External or internal regulatory processes	Communicat. process control	6	6	1	36	Not necessary
	Unbalanced workload		Insufficient planning	Monitoring	6	7	3	126	Use of management planning tools
Maintenance	Difficulties to communicate with manufacturers	Machines unavailable Errors and complaints	Distance to closest office Engagements	Communicat. process control	8	4	1	32	Not necessary
	Inadequate personnel and procedures		Not own personnel or knowledge	Testing and validation	8	6	3	144	Specialized personnel for maintenance
Accreditation	Failed accreditation audit	Limited usability of results	Insufficient preparation or investment	The audit itself	8	2	1	16	Not necessary

The actual planning has been performed with the help of an X matrix that is presented in Fig. 2.22 below (valid for the first year of the time interval). This instrument comes from the Hoshi kanri strategic management approach and helps correlate the strategic intent with the operational objectives in a traceable and measurable manner. The corners of the matrix are used to establish and then follow proper correlations during implementation. The matrix can also include a resource allocation section, which has been omitted here because of space reasons. In the case of our laboratory, the three strategic goals deal with the number and qualification of new personnel, the independent management performance of experienced personnel and the validation of activities through accreditation. These are then translated into four objectives for the year 2016-2017, which are more concrete in nature and make use of previous results obtained by teams: the SAM-EMU (Popescu, et al., 2009) and MUVOT (Gröschl, et al., 2015) projects related to Measurement Uncertainty and the GPS&V Toolbox (Plowucha, et al., 2014) project related to Geometrical Product Specification and Verification. Also, the expertise we have already gained in implementing quality management systems has been considered an asset to be capitalized in the management plan.

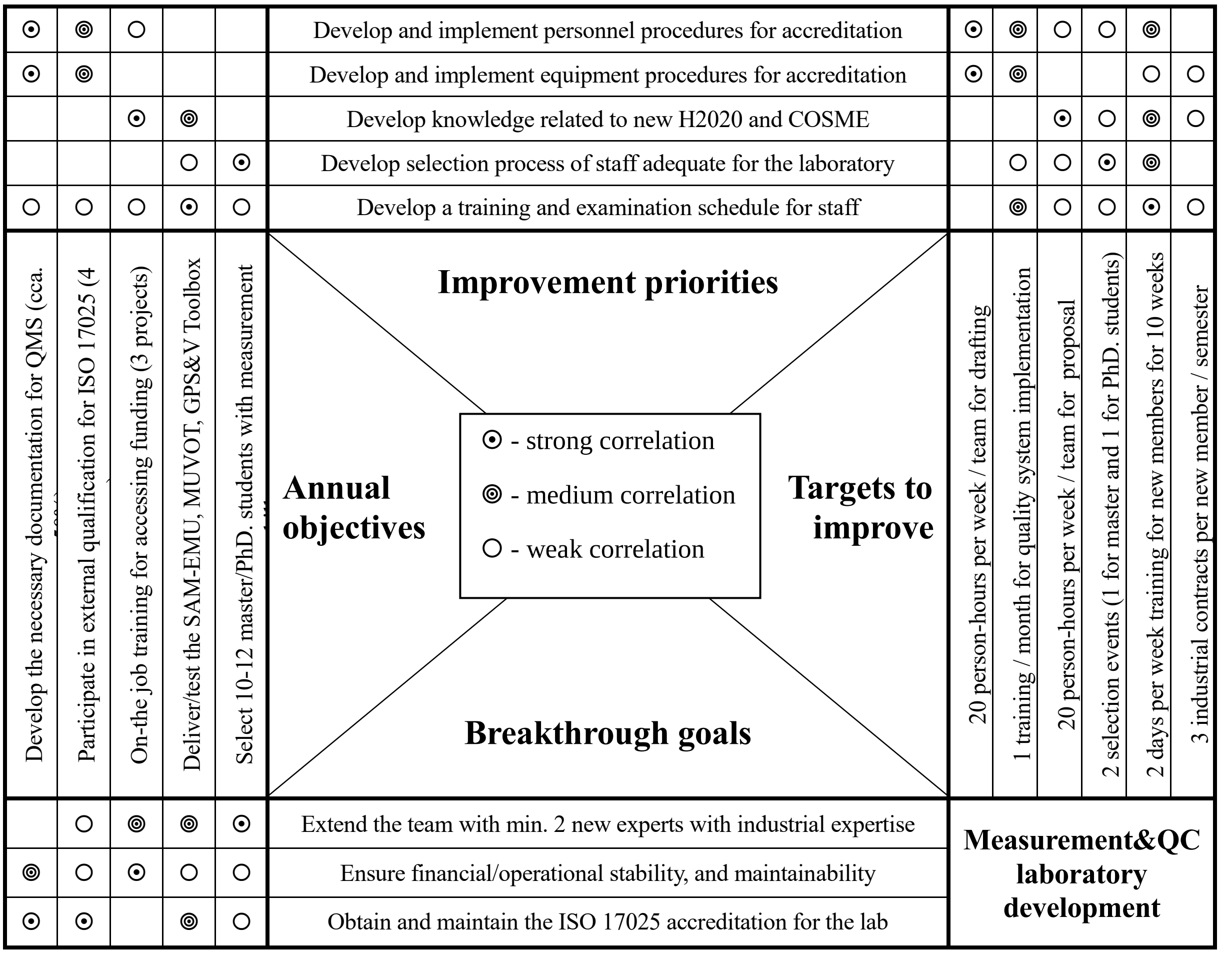


Fig. 2.22 - Hoshin kanri X matrix for planning the development of the laboratory

The next two steps of the method describe the priorities and targets to be followed in implementing the plan: the main types of procedures required to control the activities within the laboratory with a proper quality management system, a new direction to apply for project calls

that are specific for R&D and NPD, and a detailed process to select, train and test future personnel. The final step is used to establish numeric targets for the tasks and events necessary to implement the provisions of the development and management plan conceived.

Innovation capability audits for the renewable energy sector

The purpose of the present audit program was to assess the innovation maturity degree of organizations activating in the field of Renewable Energy and Energy Efficiency, and in connected areas, in Belarus, Georgia and Ukraine, as part of the FP7-NoGAP project forming the basis of Deliverable 3.6. For this purpose, 8 organizations from Belarus, 8 from Georgia and 10 from Ukraine have participated as auditees in the period between November 2014 and December 2015. The discussions were conducted around a questionnaire where the questions were grouped by into main categories with 5 questions for each, as follows:

- Innovation Culture - addresses the soft skills and the formal and informal "modus operandi" of the organization with respect to innovation;
- Innovation Capability - investigates mechanisms and approaches to transform intentions into workable activities and outcomes;
- Innovation Processes - discusses the internal structural and operational elements that can be used to deliver the results expected by the market;
- Innovative Products - evaluates the adequacy of technical aspects that contribute to the achievement of successful outputs of the innovation processes;
- Marketing Innovation - addresses the necessary strategies to open up the channels needed to bring the products on the relevant markets;
- Innovation Support - is focused upon backing external entities and knowledge.

The respondents were asked to evaluate the level of the innovation measures, actions, initiatives and strategies in their organizations on a scale from 1 to 5, where: 1 - very low, 2 - low, 3 - moderate, 4 - high and 5 - very high. The questionnaire combined a self-evaluation approach with assessment by members of the NoGAP team based on previous knowledge or audit responses and evidence. In some cases, where clarification has been deemed necessary by either party, additional remarks have been collected within the questionnaire to improve the qualitative aspect of the evaluation.

The Innovation Audit activity of the NoGAP project has proved a valuable instrument in discovering and analyzing the potential of stakeholders working within the societal challenge "secure, clean and efficient energy" in the EaP countries to improve their competitiveness and performance. This exercise has brought forward lessons to be learned for all the parties involved: project partners from EU countries, especially UTC-N, which has piloted this task, project partners from the EaP countries which have expanded upon the initial know-how to deliver a wide range of experiences, audited participants which have gained an interesting and important outlook upon their innovation potential and the way it is being materialized. We believe that, through this report, the general public will also gain an insider's point of view

upon the accomplishments and challenges of the organizations that work in this field in Belarus, Georgia and Ukraine.

Some interesting insights can be formulated, both about the innovation function existent in these companies and the process of evaluating and improving this organizational feature. As it can be seen, overall, the strongest chapter that is revealed from the analysis is the one referring to Products (or services) of the studied organizations. The authors believe that this situation is generated by an unmanaged and opportunistic approach to innovation. That means that in certain cases, when conditions are right, the natural creativity of the employees is channeled and transformed into sporadic successes. However, considerable work needs to be done on other two internal dimensions audited, the innovation Culture and innovation Capability. Without strengthening these two and making them work in a continuous manner, the success of the Products vanishes very quickly and might not ever be reproduced. These require the commitment of management and the dedication to effect changes within the modus operandi of the company, involving the transformation of its workforce into an innovation-minded one.

Among the external factors that affect the performance of the company, the Market relation registers rather good scores, but, for sure, the involvement of the Supporting organizations needs to be enhanced considerably. With few exceptions, the studied entities had little success to report on this direction. As innovation and technology transfer offices started to appear and to perform in the EaP countries in the past decades, there is a need to "bridge the gap" between them and the companies seeking innovation support. The organizations that come into contact with the market are pressured to innovate, especially if they intend to go abroad, and the supporting agencies have the required knowledge, or are in the process of gaining it. These ideas have been validated within NoGAP project activities and in many other initiatives and studies. We consider that the future focus of similar projects should be on achieving the necessary matches, nationally and internationally, across the EU and the EaP, and accelerating the results' generation process.

In general, the research units have noted some collaboration with national private companies for developing innovative technologies which can be also easily commercialized. Often, the collaboration implies also patent developments and publishing in scientific journals. One interesting stakeholder audited is a big research unit which has maintained contacts with universities from the USA, Germany and the Netherlands, recognizing the importance of international cooperation.

As it can be found out from most of the discussions, the strategies of the companies are very much depending on their customers' demands. From the observations made, the stakeholders' main initiative is to reduce operating and production costs, leading therefore to increased profits. This is also the reason behind using innovative technologies in production processes. We have identified one business stakeholder whose strategy implies developing internal innovations, quality controls, and permanent market monitoring and customer's

satisfaction evaluation. They are also promoting an organizational culture oriented towards innovative ideas, which is a relatively new practice in their country.

Regarding the marketing aspects, no original methods were discovered. The stakeholders are usually promoting their products through their own webpage, social media, blogs, seminars, conferences and mass media. The most common way for disseminating the technological results and more often to get in touch with new ideas and customers or partners is by attending national exhibitions.

A problem for most of the stakeholders is how to attract external funding. In strong correlation with this would be also the reduced collaborations with international partners. There are few examples of external financial support, and most of them are in the case of research institutes which are used to these mechanisms. Apart from here, the research focus is on inexpensive technologies, easy to be implemented and used by SMEs with their own funds. An interesting point to discuss is hence the possibility to find European partners and the potential of accessing funds from the programmes of the European Union.

In Belarus, most organizations presented a balanced innovation footprint. It is true, there are different levels of performance, which are usually correlated with the size and scope of the stakeholder, but most of them appear to be following the improvement cycle established by the six pillars of the audit template. There seems to be a preference among the organizations in Belarus towards marketing innovations, which could be explained by their need to be connected to the external markets in order to make their already developed products known internationally. The main drawback encountered was in the relationship of the studied stakeholders with the supporting environment, both national and international, which needs to be addressed in the future, as it is an important source of know-how, motivation and market leads for any type of organization, and especially for the ones looking for export markets.

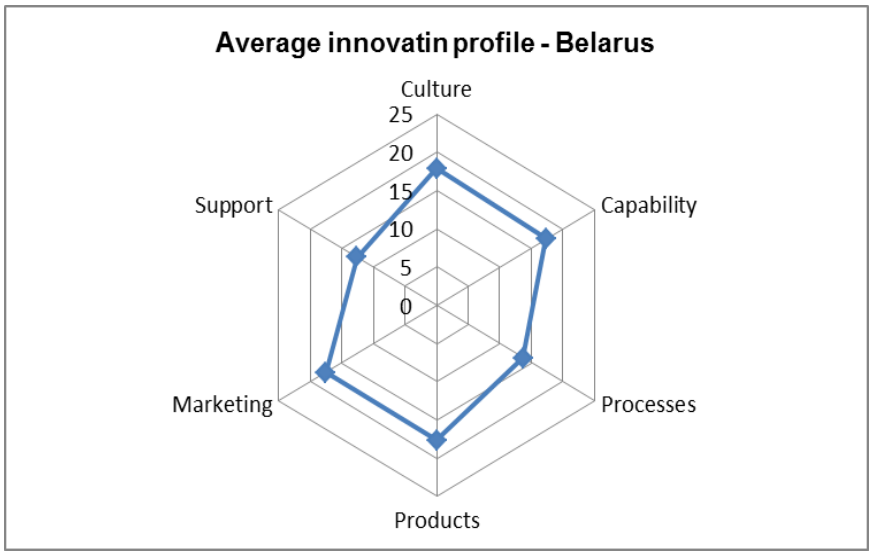


Fig. 2.23 - Average innovation profile - Belarus

In this country, there is a strong presence of the state sector, both in the academic environment and the economic one, but private enterprise is also under development. Any approach to raise the innovativeness level of energy stakeholders in Belarus should seek the support of the central administration (i.e. ministries) while at the same time addressing the needs of the organizations themselves. The following figure depicts the average situation of the audited stakeholders:

Georgia displays a dynamic and active landscape in the field of energy, with all types of organizations active, showing different profiles among the interviewed stakeholders. A large number of NGOs and small companies fill different niches in the market, ranging from energy audit services to consultancy for strategic development of the sector. This comes to show that a good market economy is forming and this will help the companies in the energy sector to become more competitive in the future. Among the interviewed organizations there have been also a significant number of energy consumers, with special interest towards energy efficiency in industry, which opens up new business opportunities. The axes of our model oriented towards Products and Marketing, and to a lesser extent Culture, scored high during the audits, and we can say all these domains constitute strong points on the market. The country enjoys a very good geo-strategic position in between Europe and Asia and the valuation of these strong points by the organizations in Georgia could transform them into suppliers of products, services or know-how for a large geographical area. Also, the entities in this country obtained a low overall score on the Support axis, which means that here also, projects like NoGAP could have a considerable contribution to bring towards the development of the sector. The figure below shows the average country innovation profile:

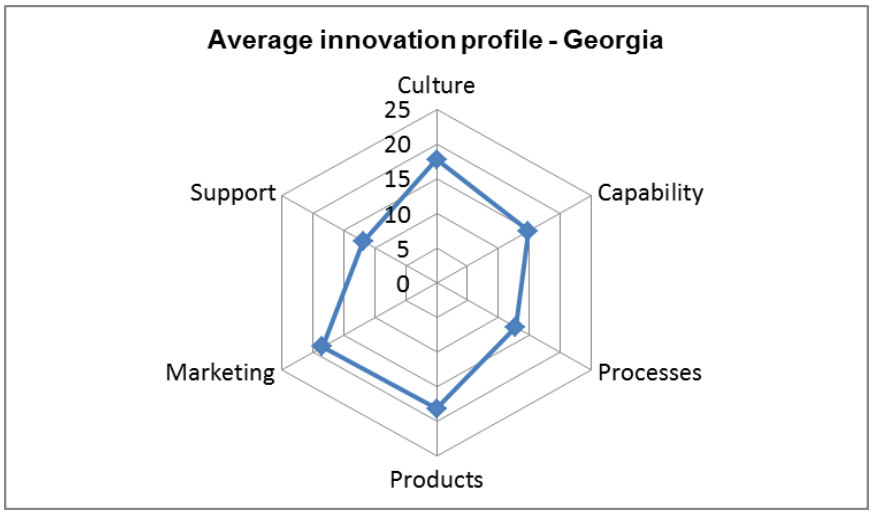


Fig. 2.24 - Average innovation profile - Georgia

In Ukraine, many of the stakeholders that we have met are actually research units working in the fields of renewable energy and energy efficiency. Some of them have a large size and a considerable track record of accomplishments in the field. This is very promising for this sector in Ukraine, however most of their activity is focused on carrying out state funded research. We believe that the human capital, as well as the capabilities they possess, could be better supported

if the effort would be made to secure international or national private funding. This would open up the possibility for innovations developed in Ukraine to be exported out of the country and is underlined by the fact that the best scores have been obtained during our audits on the Products scale. Of course, the education dimension, which is traditional in universities and departments performing research on renewable energy and energy efficiency, is also very developed and could constitute and advantage in the future, for training personnel and enhancing their competencies. Here also, the Support scale is among the ones getting a low score, but the lowest is achieved by the Process scale, which means that instability in the country and the diminishing resources are affecting innovation performance also. Anyhow, Ukraine, overall, enjoys a very good position among the three analyzed EaP states, as it can be seen in the figure below.

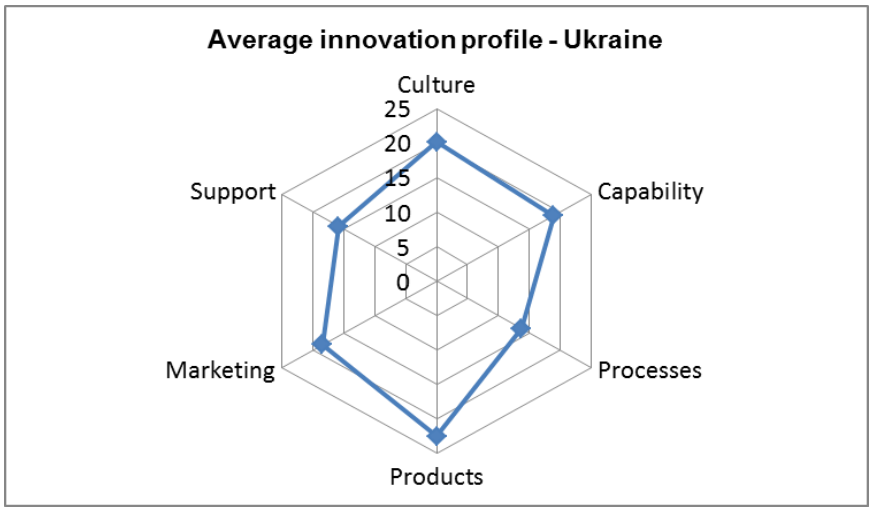


Fig. 2.25 - Average innovation profile - Ukraine

As it can be seen in the three figures above, the analyzed countries show similar average profiles (especially Belarus and Georgia), but also have some specific elements. We consider that this situation is due to their shared history and values. All of them demonstrate an understanding of the importance of innovation in doing business on competitive international markets, such as the EU, and are in the process of developing and implementing innovation related strategies, for which they could benefit from the support of the European Neighborhood Policy instrument.

In conclusion, we consider that the field of renewable energy in the Eastern Partnership should be of major interest for Romanian and EU based companies to expand and invest, in order to face the competition and the ever-increasing demand. At the same time, a major constrain should be observed in the form of the emerging concept of the water-energy-food nexus (Fig. 2.26), that might bring limitations to investment projects, and for which working in this area of Europe might prove very valuable, due to the abundance of all three resources.

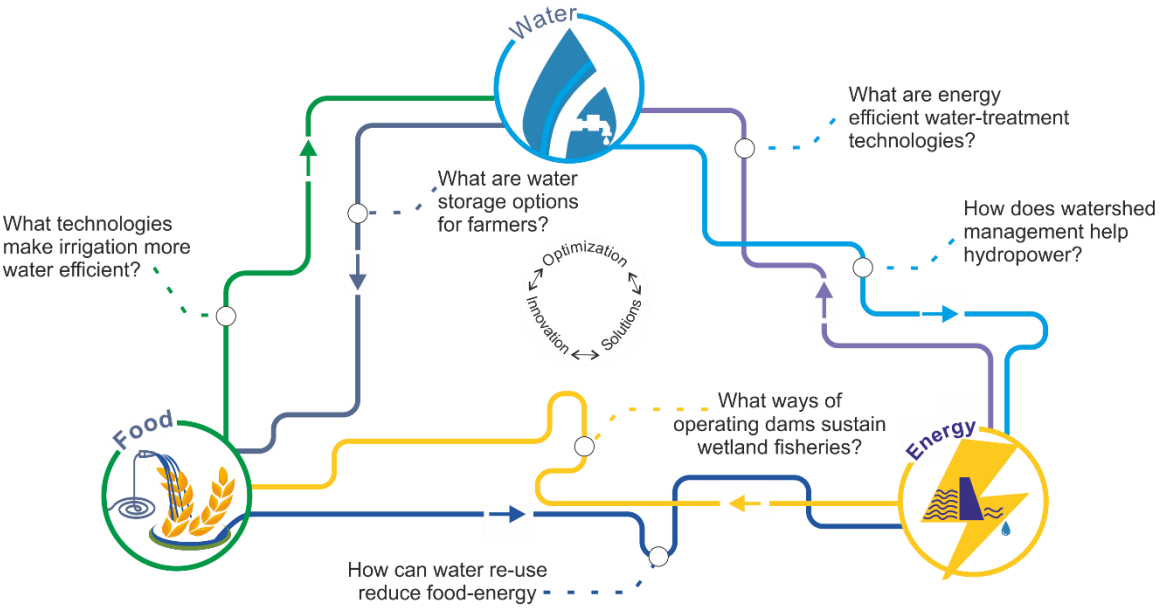


Fig. 2.26 - Nexus approach to water-energy-food (IUCN Water Knowledge Platform, 2013)

Partnership development for collaborative research

The contribution described in this case study was prepared for a Romanian manufacturing company that sought to develop specific know-how in order to improve its competitiveness on the global market of power equipment, by increasing its ability to conceive, design and prepare for the execution of a range of Air-Air (CA-CA) and Air-Water (CA-CW) cooling systems used in the motors of large electric generators.

One of the targeted features of the electrical generators is the energy dissipated as heat which, at high power levels, becomes a critical element of the generator's functioning. Under these conditions, cooling the generator is a major technical problem, its effectiveness having a major impact on its performance reliability and efficiency.

The technical requirements regarding the cooling equipment mentioned above are ever-growing, considering the fact that the new technical solutions are being concerned with both the effectiveness regarding their primary function of cooling, as well as with improving their energy efficiency, their noise during operation, their gauge, weight and integration in the generator's construction and the manufacturing costs. A research targeting the improvement of these equipment is undoubtedly one of pronounced complexity and interdisciplinary.

As a response to our clients' demands, the studied and assisted company has begun a thorough study of this field, in order to fulfill the demands of the market, reaching the conclusion that significant investment is required in research and development in order to be able to deliver on the market of energy equipment a competitive range of products. As a result, the company is planning a development approach to its capability of design, dimensioning / calculation and execution of such coolers, as well as their full equipping, testing and delivery. The present research aims to determine the necessary demands for the creation of a software

able to size, calculate and design the entire cooling system, and to design and execute a trial stand for the finished products, in order to test them prior to their delivery to the client.

According to a report developed by JRC (Joint Research Centre Europe) and IE (Institute for Energy Europe), European Union is facing "a constant growth in electricity demand" (L'Abbate, et al., 2008, p. 13).

Rising energy requirements need larger electric generators which should be capable of providing the required energy into the grid. The need to design effective and reliable industrial generators, that have a low impact on the environment, has grown exponentially over the past few years. Often, in relation to these concerns, particularly interesting research topics arise concerning systems analysis and modeling (Jurca, et al., 2008) or even their design and construction (Okabe, et al., 2003), (Polikarpova, et al., 2011).

There are many methods used to achieve an acceptable temperature of the generators, the most common being air-based or water-based cooling systems. The water-based cooling system has a low cost of implementation and is much more efficient in terms of heat than an air-based cooling system (Parker Hannifin, 2011). However, there are many disadvantages to be considered, such as (Parker Hannifin, 2011):

- the ratio between the size (weight) / produced energy is far greater than in the case of air-cooled systems, and the heated water should be dissipated over a larger area in order for it to cool down rapidly;
- the risk of a short circuit is higher because the water has the property of electrical conductivity, and in case of a leakage the consequences can be disastrous and expensive;
- if the generator is located outside, in areas where the temperature drops below 0° C, the water will freeze; adding additives will solve the problem but will also reduce the cooling capacity of the water.

Among other methods used one can mention also the hydrogen cooling system. Unlike the air-cooled systems, the hydrogen has a low viscosity, therefore, the friction between the hydrogen and the rotor is lower and the efficiency is higher, however the performance of this type of cooling system is strongly dependent on the purity of hydrogen (Smith, 2002). There are also hybrid cooling systems that use both water and hydrogen (Okabe, et al., 2003).

An innovative cooling system is the one based on refrigerant. In this case, the components are similar to those of a water-based system, but instead of water another type of coolant is used, which has the ability to evaporate when coming into contact with heated elements, thus resulting a release of temperature of 2 to 4 times higher than the transfer of heat between the heated part and the liquid (Parker Hannifin, 2011).

At the present time there are companies that produce coolers for industrial purposes. These are catalogue products that cover a very wide range of applications. The Sweden company "Luvata produces air warming units and air-cooling units that serve all warming or

cooling demands, for example in factories, warehouses, shops, stores, hallways, garages or supermarkets. High efficiency coils, aluminum casings and low energy consumption fans are standard issue for all our coolers. All the units are in conformity with EU regulations regarding Equipment Safety, MD2006/42/EG. All units are designed and produced according to the Pressure Equipment Directive 9723 EG" (Luvata, pp. General, para. 1-4). The Dutch company "VDL Klima develops and produces all its products through self-production. The equipment has a wide range of applications. *VDL Klima* develops and sells air-water coolers, air-air coolers, cooling boxes, axial fans" (VDL Klima, p. para. 4). On the European market, the companies that produce coolers are mainly situated in the Northern part of Europe (in countries such as Sweden, Finland, Netherlands, Denmark). As a result, prices for the coolers are high. On the Romanian market there are no companies that produce such coolers, while there are enterprises in Romania that buy these products from the European market. Also, the big companies that produce electric motors and generators (General Electric, Cummins etc.) use these types of coolers. "The GE Power Conversion company offers a wide range of motors and generators that serve our clients and their processes in a wide range of applications. Characteristics and benefits: air or water cooling, good starting capacity, efficiency and cost reduction, low maintenance, high reliability, flexibility (horizontal or vertical disposition available etc.)" (GE Power Conversion, pp. para 1, 2). The problems for these companies mainly consists in the difficulty of finding suppliers that can offer products suited to their exact demands.

The aim the partnership is targeting is creating a more competitive product, better adapted to the demands of the market, with lower production costs. Consequently, the company shall develop and produce the entire cooling system, based upon the characteristics defined by the final producer, for different applications. In order to create this cooling system the company shall undertake an optimized dimensioning process leading to reduced production costs by avoiding to oversize the coolers. At the same time, a cost lowering measure will consist in the choice of materials and manufacturing technology used, by selecting materials adapted to the working environment (costly materials will not be used, such as copper or stainless steel, where it is not necessary). The design of the entire system shall be optimized by using simulation software in order to create a product with maximum efficiency. A secondary outcome of the use of dimensional calculation and the simulation of design would be a significant decrease of the overall noise relative to the weight of the generator. Through this project, the consortium shall make a study of solutions taking into account the operating conditions, we shall be able to size the exchange surface as precisely as possible, the prototype shall be verified while in operation on the trial stand, simulating operating conditions.

The partnership concept (Fig. 2.27) is conceived as an important step in the evolution of the Romanian industry in the field, achieving the following goals:

- Raising competitiveness of the industrial partner by gaining the ability to make present-day solutions available on the market, in the field of cooling and noise reduction for big

electric generators, thus considerably influencing the impact that these systems have in different fields: energy production, constructions, transportation, tourism, etc.;

- Establishing a partnership between the industrial and academic environment, meant to complementarily harness the research, development, innovation and technological transfer potential.

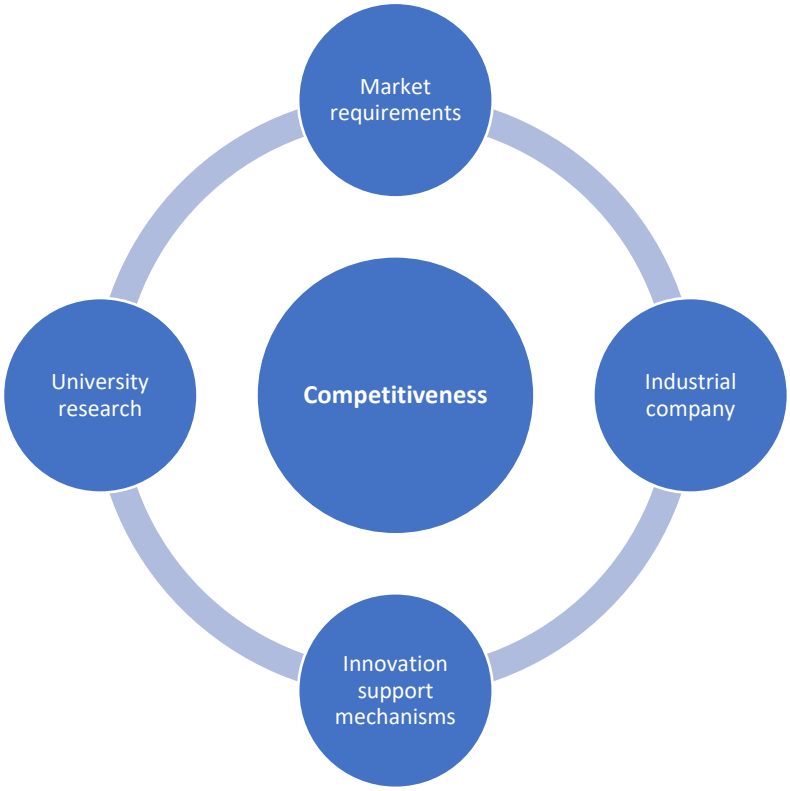


Fig. 2.27 - Concept for collaborative industrial research partnership

In this context, the objectives of the collaboration are meant to meet with the most important demands concerning the cooling systems for big electric generators and the way in which they are built:

- Energetic efficiency, by obtaining a yield as good as possible for the heat transfer at Air-Air cooling for big electric generators. We can achieve this through detailed calculation of the necessary cooling surface and proposing and testing in the virtual environment of different combinations of size, structure and form of the cooling surface;
- Noise reduction during operation, through the design and realization of some components with innovative design and functionality that should be incorporated in the product, aiming to: reduce the number of components, replace conventional gears, use of modern materials, etc.;
- Economic efficiency through production, with the aim of an optimized implementation within the production process, by reducing the number of operations, an advanced

configuration of production equipment, use of materials and raw materials of high quality and low impact over the environment.

Practically, the company, in partnership with the University, would obtain the ability to be competitive in the field of product innovation, in addition to the advantages that it already has, regarding the quality of the execution and the labor cost. By continuing this cooperation, and also developing a main axis of collaboration in the field of research, development and innovation regarding cooling systems for big electric generators, it gives way to further collaborations in fields such as: new products creation in the category of Air-Air or Air-Water cooling systems for big electric generators, services of calculation of heat and noise transfer during operation and for other categories of products and industrial equipment, development of commercial software solutions in the field, which could be offered on the market, training maintenance mechanics for this type of systems for other companies, too, etc.

From a scientific point of view, the new products will be based on the development of an original algorithms for calculating the cooling surfaces and on the results of studies concerning the performances and the innovation potential of the possible product and manufacturing systems' configuration. Noise reduction shall be realized through a flow of the fluid that is as optimal and easy as possible, thus avoiding the sounds made by the air being forced through the cooler and also eliminating vibrations. For this, a fluid flow simulation plug-in shall be developed. This plug-in will also simulate the cooling capability of the system in order to guarantee the sizing calculations.

Economic efficiency can be reached through adequate manufacturing technology, focused on the topic and placement of the cooler. A significant change in the manufacturing technology shall be the process of mandrelling the pipes onto the case and not welding them, which will lead to a reduction of time and raw materials used. The use of materials specific to the field of use and the environment (the use of carbon steel and aluminum instead of stainless steel and copper in the areas that do not necessarily need these materials which are more costly) makes the final price of the cooler to be extremely competitive. These aspects will be addressed through research concerning the optimization of the production system. By integrating the product in the complete cooling system designed to improve the flow and reduce operation noise, the competitiveness on the market rises.

Within the collaboration, the following significant connections shall be made between scientific fields, necessary for reaching the set objectives:

- Development of calculation algorithms for sizing and designing: electrical engineering, thermotechnics, environmental engineering;
- Elaboration of software for calculating the heat transfer and cooling system: thermotechnics, design engineering, software development;
- Elaboration of plug-in software for product simulation and solution validation: design engineering, quality engineering, software development;

- Development of experimental stand for research and solution validation: design engineering, quality engineering;
- Specialized studies regarding the product and manufacturing process performances: design engineering, production engineering, and marketing.

A significant contribution to reaching the goals will be held by the handling of issues concerning intellectual property (software copyright, patent requests for methodologies and experimental stand) and dissemination of scientific results in publications.

The use of these products has vast applications, in more fields of activity, mainly in wind energy, electric power plants with gas turbine, nautical field, oil & gas, mining or construction / urban development field. In the last years we have observed a growth of the drilling sector, for gas and oil in offshore areas. This growth has a direct effect upon the demand of motors and generators, action and leading systems, and also upon the demand of cooling systems for these products. Through the creation of the entire cooling system we could obtain a growth in performance of the generator, as well as the reduction of the noise level of the equipment, improving the work conditions of the staff using it, and also of the people in the vicinity of the equipment. With a low energetic consumption, the work regime of the electric generator improves, which leads to the reduction of contaminants and fuel consumption, through the placement of the fans directly on the axis of the rotor, eliminating an extra consumer. This leads to the reduction of own energy consumption. Low creation costs in the manufacturing process will be obtained through the use of clean materials and manufacturing technologies - laser cutting, mandrelling of the pipes, electrostatic field painting with low impact upon the environment. All these lead to an improved quality/price ratio. Directly, the results of the development shall benefit:

- present and potential clients of the company, who shall be able to buy products with higher reliability, competitive price, and will have a broader and more diversified range of products to choose from;
- the Romanian industrial partner, which will be able to diversify the manufacturing process, will raise the activity volume and, implicitly, create stability for the staff of the company, which will lead to improved professional perspectives.

Indirectly, the results of the project will be beneficial to local and regional authorities, through the contribution to the growth of regional PIB, the creation of new jobs and attraction of specialists with different qualifications: engineers, electronics engineers, operators, etc., as well as the growth in employment rates.

The cooperative research follows the methodology described below. The team shall appeal to knowledge of thermotechnics, geometry and manufacturing engineering in order to come up with the best solutions. The main parameters of these solutions will target the type of exchange surfaces used (for example, pipes or tiles), their placement and form, as well as performances, processability and the cost of materials that will potentially be used. With the

help of available software packages, we will study comparatively the performances of these solutions, but also the calculation mode dedicated to it. The team will propose possible configurations fit for the targeted applications and will consider innovative solutions that increase efficiency or decrease costs or dimensions of the cooling systems. Also, we will consider the design particularities that can be introduced by the special conditions in which certain applications take place.

The consortium aims for the enhancement on the equipment's performances, concerning the functionality, noise reduction during operation, as well as the optimization of the product in relation to its components (for example, reduction in material used on creating the case, improving the resistance of welds etc.). After this stage, will follow develop and propose innovative solutions with patent potential which will be incorporated in one's own model of a cooling system. The improvements, optimizations and innovations at product level shall also be accompanied by re-engineering proposals at level of creation processes, through an optimal configuration of the work equipment, reduction of energy consumption, the growth of execution precision and operators' level of training. The software technology will include all the knowledge previously acquired and will be operable with the proposed innovations. The programme will be able to calculate and estimate the performances of the system depending on the parameters chosen by the designer (cooling surface, functional model, components and materials) and will be able to estimate and simulate the performances of the cooling system in the desired application. At this stage, the project will also aim the development of specific plug-ins for 3D CAD software, so that data obtained by calculation and simulation can be transferred to the design software systems.

A comparative study will be performed on the technical and economic performances achieved in the design and execution of cooling systems using classical and software assisted method. The main parameters to be pursued are listed as follows: speed of development of the solution with projection on the market launch moment, heat exchange efficiency and speed of the cooling process, the degree of adaptability obtained compared to generators/applications required by customers, cost, time and other resource savings calculated for expected execution at the partner's site. Within the final stage, there will be created an automated testing stand, for the testing of the cooling systems. This will be adequately equipped with sensors in order to collect all relevant signals for the product development objectives (noise, vibrations, heat dispersion, mechanical stress etc.), and the read parameters will be compared to the results obtained through simulation and with the requested performances. The stand will be executed at the company and will be capable of being interfaced with the software development.

3. EMERGING RESEARCH DIRECTIONS

3.1 Technical entrepreneurship and bio-economy

3.1.1 Contributions

Category	Involvement and obtained results
Academic experience	**Fulbright-RAF (Romanian-American Foundation) scholarship** (4 months) at the University of Rochester, USA, Ain Center for Entrepreneurship (2017) - project "Sustainability related approaches in new product development and manufacturing to support the development of industrial entrepreneurship in Romania" **Reviewer** for the Regional Innovation Smart Specialization Strategy developed by The North-West Regional Development Agency Romania (2016) **Reviewer and consultant** (as well as work package leader) for the implementation of the Training program required by the Made in Danube Interreg DTP project and implemented by the Budapest Chamber of Commerce and Industry, Hungary
Practical experience	**Entrepreneurial advisor** for the business plan developed by the team A. Petruș, L. Marina, F. Stroia, M. Muț, in the framework of the TREPAN project (POSDRU/9/3.1/S/6), which won 1st prize nationally, 2011 **Entrepreneur and manager** in 3 different companies since 2001 in the fields of telecommunication services, management consultancy and applied research **Executive manager** of the TUCN team developing the **Danube Transnational Innovation Cooperation e-tool** (within the Made in Danube Interreg DTP project) and the www.dtcnetwork.eu portal (coordination Prof. Sorin Popescu, programmer Eng. Marcel Beldean, team members Lect. Ștefan Bodi, Lect. Emilia Câmpean)
Supporting projects	2018-2021 Interreg - Danube Transnational Programme, DTP2-012-1.2, **Danube Chance 2.0 - Embracing failure to facilitate second-chance entrepreneurship in the Danube region, Project responsible for the partner TUCN (TUCN budget 144.450 €)** 2018 National Council for Financing of Higher Education, CNFIS-FDI-2018-0438, **TUCN Students - Entrepreneurs in the digital world (SALT), Mentor** 2010-2013 European Social Fund, Call for proposals 92 „Be an entrepreneur", POSDRU/92/3.1/S/62459, **Training and assistance in the managerial-entrepreneurial domain for small and future entrepreneurs, managers and employees of SMEs in the North-East, North-West, Center and South-East regions, Member of the project team (Assistant regional manager) (TUCN budget 800.000 lei)** 2017-2019 Interreg - Danube Transnational Programme, DTP1-1-072-1.1, **Transnational Cooperation to transform knowledge into marketable products and services for the Danubian sustainable society of tomorrow - Made in Danube (MiD), Partner communication manager (TUCN budget 100.500 €)**
Research articles	E. Câmpean, **M. Dragomir**, M. Beldean, D. Chiran, I. Ambroš, **On-line support for bio-economy actors through the "Made in Danube" project**, 2018 ICPR - AEM and 5th QIEM, Cluj-Napoca, 25-26 July 2018, ISBN 978-606-737-309-7, pp. 42-46

Category	Involvement and obtained results
	E. Câmpean, M. Beldean, **M. Dragomir**, G. Vlăduț, **Developing an innovation and technology transfer e-tool in the field of bio-economy**, 2018 ICPR - AEM and 5th QIEM, Cluj-Napoca, 25-26 July 2018, ISBN 978-606-737-309-7, pp. 139-142 A. Badiu, I. Badiu, **M. Dragomir**, **Studies regarding the use of reclaimed wood in the manufacture of modern furniture - Part I**, Acta Technica Napocensis Series: Applied mathematics, mechanics, and engineering, Vol. 58, No. 2, 2015, pp. 225-230, ISSN 1221-5872 A. Badiu, I. Badiu, **M. Dragomir**, **Studies regarding the use of reclaimed wood in the manufacture of modern furniture - Part II**, Acta Technica Napocensis Series: Applied mathematics, mechanics, and engineering, Vol. 58, No. 2, 2015, pp. 231-238, ISSN 1221-5872
Teaching materials	**M. Dragomir,** O. Iamandi, **Handbook for services in IPR and Innovation Management,** NoGAP project deliverable no. 2.3, online at http://no-gap.eu/_media/D2.3_-_Handbook_IPR_final_v2.pdf, 2014 **M. Dragomir, Technology Transfer Environmental Analysis Report**, NoGAP project deliverable no. 3.3, online at http://no-gap.eu/_media/D3.3_TT_Environment_Report_FINAL.pdf, 2015

3.1.2 Case studies and results

Analyzing the entrepreneurial landscape

Starting with the Strategic plan 2016-2020, TUCN has developed and has committed to a strong entrepreneurial component within its mission. According to it, one of the main directions of action will be „Entrepreneurial behavior supplemented by responsible resource management" (Technical University of Cluj-Napoca, 2016, p. 5) and „in the leadership of the university at all management levels initiative and the entrepreneurial spirit are encouraged as facilitators of the development of the institution" (Technical University of Cluj-Napoca, 2016, p. 6). In 2017 within the university, a Compartment for Relations with the Socio-Economic Environment has started its activities and has contributed to a better orientation of the institution towards the needs of the regional industry. Also, it has become involved in initiatives related to entrepreneurship such as Innovation Labs and the Entrepreneurial University.

According to the Ministerial Order 3262/2017 from the Ministry of National Education, in Romanian higher education institutions there will be organized Student Entrepreneurial Companies to foster entrepreneurial initiatives and facilitate economic development through start-ups and/or the better employment of graduates. UTCN has developed the regulatory framework for this type of company which has entered into force starting with October 2017. In the next period, the operational issues related to the functioning of this structure will be approached in order to ensure the generation of the expected results, through a project for funding institutional development, FDI-SALT (TUCN Students - Entrepreneurs in the digital world), for which I contribute as a mentor and member of the implementation team.

The following paragraphs form the basis of the scanning of the entrepreneurial eco-system developing around TUCN in the past year, as it could be identified from online sources.

Student entrepreneurial activities are in the incipient stages, but a number of events and programs have been taking place in the past years and there is a growing interest for the topic. Some of these elements include:

- The Start-Up training and practical education program, the FASTTRACK / Kaufmann Foundation programs, and the student competition "Company of the year", from Junior Achievement (2013-2017);
- The „Today a student, tomorrow an entrepreneur" workshop organized by the Center for Organizational Initiation and Development in preparation for the national program Start-Up Nation (2017);
- The success of the Innovation Labs competition (2017-2018).

Co-curricular activities are also in the early stages of development, some of these activities are presented below:

- The Student Entrepreneurship Festival event organized by the Center for Organizational Initiation and Development (2012);
- The Conference Series "Entrepreneurship, the business sector and sustainable development" organized by the Center for Promoting Entrepreneurship for Sustainable Development (2011-2017);
- The event organized by the Entrepreneurial Platform for Good Packaging Management in the Circular Economy, TUCN being represented by the Center for Promoting Entrepreneurship for Sustainable Development (2016);
- POSDRU (Human Resource Development) projects financed by EU funds in the field of entrepreneurship which have included co-curricular activities (see the chapter beginning for a list of projects in which the author has contributed).

The technology transfer function is well developed in TUCN and is considered a key part of the university's relationship with industry. Over 100 patent applications have been submitted in the past 5 years. Also, TUCN currently has a portfolio of 43 granted patents (42 Romanian and 1 European). Technology transfer is carried out through three specific structures: the Technology Transfer Office of TUCN, the TUCN Office of the Danube Innovation and Technology Transfer Centre Cluj-Napoca which is member of a European network centered on the Danube Region fostered by Steinbeis Europa Zentrum, the Technology Information Center at Baia Mare North University Centre and the well-known and very active Enterprise Europe Network Regional office. Most of the times technology transfer takes place through common projects and contracts.

The ecosystem centered upon TUCN is undergoing growth and expansion at the moment and it contains the following institutions/organizations/initiatives supporting startups:

- The Digital Incubator of the TETAPOLIS Science and Technology Park. Key features (tetapolis.com): first of its kind in Romania, focused on digital economy, support for entrepreneurs/innovators in emerging technologies such as cloud computing, Internet of Things, drones or robotics, Machine-to-Machine (M2M), big data and analytics, predictive analysis, cyber security, mobility and wearable solutions, e-commerce, and telecommunications services;
- Cluj-Napoca has been home for 4 years to SPHERIK® Accelerator - „the first accelerator launched in Romania whose mission was to connect startups with strategic resources and support the growth of the local ecosystem" (spherikaccelerator.com) which was created through a partnership between Liberty Technology Park® Cluj, Banca Transilvania, the Technical University of Cluj-Napoca and Babeș-Bolyai University. The website of the accelerator lists 24 successful alumni start-ups.
- The regional office of OSIM (Romanian Patent Office) for Transylvania called the Regional Center PATLIB CLUJ which is hosted by TUCN.

The national and local innovation and entrepreneurial landscape is evolving rapidly supported by a number of private and public programs. This can be seen in the very well-publicized case of the first Romanian "unicorn", and IT start-up from Bucharest working in business process automation, called UiPath that crossed 1 billion dollars in valuation. The first local/regional venture capital fund started activity less than two years ago in Cluj-Napoca and is called Risky Business, and was positively received by the market. Also, in more extensively the past two years, but also some 7-8 years before, there is a strong supports in the area of entrepreneurship from the European Union through European Structural Funds (personal involvement of the author in this area is listed in the beginning of the chapter) and from the Romanian Government through national funds. There is a complex network of initiatives running at the moment under the umbrella of the Startup Nation program:

- Startup Nation, with Romanian funding, targeted directly towards small scale investors (44.000 euros grants);
- Startup Plus, with structural funding, targeted in large scale projects for organizations with regional impact that train entrepreneurs and then distribute second level grants of cca. 40000 euros;
- Startup Diaspora, which is funded by the Government and intended to attract Romanians living in Europe to come back home and start business;
- Startup Danube which is a policy support direction being implemented through European Interred - Danube Transnational Programme projects to which Romania is participating.

Two other important landmarks in this are the Governmental Agency for SME that runs many small grant programs for micro-industrialization, crafts, internationalization support, women entrepreneurship and so on and the Sectoral Operational Programme for Human Capital which just this year introduced new competitions (calls for project proposals) oriented towards

the concept of student-entrepreneur at all study levels (bachelor, master, PhD) even extending towards high school student involvement. Of course, the results of this projects will take some years to be manifested.

In this context, the question may arise „Isn't it enough that we have to teach the students, do research and contribute to the development of the university?" In my opinion, the answer should be "No, it is not" and some of the reasons identified with the help of TUCN students and faculty are listed below:

- Learning by doing is recognized as one of the best forms of developing competencies and skills
- The economy of the 21st century is characterized by flexibility, volatility and disruptiveness
- There are less and less classic 9-5, 40-year long jobs
- Value creation is done mostly in the area of innovation and new product development
- Much of the results of academic RDI and IP sits on shelfs or in between books/magazines covers
- Extreme challenges await: climate change, conquering space, eradicating poverty & disease, etc.

The ecosystem around TUCN is only just beginning to develop and long-term viability is not yet validated for many of the participants (see figure 3.1). Linkages and synergy are at very early stages and a complete and evolving mapping is still needed. Many individual and helpful initiatives appear constantly in various areas and intense learning is taking place at each entity - the know-how is developing in the area.

Fig. 3.1 - Birds-eye view of the I&E eco-system in Cluj-Napoca (around TUCN)

Concerning figure 3.1, the last cell (bottom right) refers to the first two graduates of the Fulbright-Romanian American Foundation program on technical entrepreneurship that spent 4 months at the Ain Center for Entrepreneurship at the University of Rochester, USA (Lect. Flaviu Turcu - UBB and Assoc.prof. Mihai Dragomir - TUCN). This team is getting larger as we speak, with two other academics being in the US right now (Lect. Veronica Maier and Lect. Ştefan Bodi, from TUCN).

The mission of TUCN within this context could be to „become a focal point and an enabler for a healthy, ambitious, proactive and impactful entrepreneurial ecosystem in Cluj-Napoca and its surroundings". The table below presents a brief SWOT analysis related to achieving this mission:

Table 3.1 - SWOT analysis for entrepreneurial development at TUCN

Strengths	**Weaknesses**
University's mission promotes e-ship E-ship master programs and centers Faculty involved in e-ship education projects Geographically spread structure Good collaborations with industry	Faculty know-how is basic & non-practical Students are typical engineers State based administrative systems Dedicated infrastructure is reduced Self-confidence needs a considerable boost
Opportunities	**Threats**
Funding opp. for training, SME, etc. New laws for incubators, PPP, taxes, etc. Good dynamic of angels, VC, accelerators Growing interest for e-ship in Romania Cluj-Napoca has a vibrant IT sector	Eco-system is sparse and incipient Significant cultural differences US - RO Pressure from FF to get a job Faculty is evaluated based on research Young people are leaving the country

The current situation regarding the implementation of this strategy presents the following interesting elements, showing that the approaches to entrepreneurship are developing at a good pace: 2 master programs in Entrepreneurship: Technical entrepreneurship - School of Industrial Engineering, Entrepreneurship for sustainable development - School of Materials and Environmental Engineering, and 11 courses in various schools in the field of Innovation and Entrepreneurship. Also, successful cooperation is growing with Romanian-American Foundation, Junior Achievement, HEInnovate (preliminary results of the June 2018 meeting and assessment visit were very encouraging), etc.

A new maker space has been created within the Department of Design Engineering and Robotics by the staff of the Design engineering bachelor and master study programs (Prof. Călin

Neamțu, Lect. Radu Comes and their colleagues). This is available to all students on the Bd. Muncii campus and if financial resources could be found, the model can be generalized within the university. The undersigned contributed with infrastructure development, student involvement and lab strategy development (figure 3.2).

Fig. 3.2 - "DI Makerspace" overview and logo (© Radu Comes, 2018)

In partnership with the Alumni relations Department and the association of TUCN alumni, we are now planning the introduction of the "Entrepreneur in residence" position to create a focus point in space and content for student entrepreneurship. Beside practical skills, this will also allow for the development of the entrepreneurial mindset in the academic community. Within the FDI-SALT project a pre-implementation of this concept will take place, by creating office space and hours for students to meet with a legal, a financing and an IP consultant and work on their business plans.

An important aspect in the long run will be to establish a city-wide approach in partnership with the other universities, especially since both TUCN and UBB have been involved in the Fulbright-RAF program. Existing centers and programs, as well as networks such as DTC Cluj-Napoca can form the back-bone of such a development. In this way, both student entrepreneurship and technology commercialization for faculty can grow in a synergic way, using many different types of resources an achieving a multiplication effect in terms of impact and image. The most realistic way to start such a cooperation is to prepare and implement, if successful, common financing projects for themes within this area (e.g. business incubators, excellence clusters, scientific parks, etc.).

Web platform for supporting bio-economy

This case-study presents the contribution towards online support for technology transfer and innovation based on the DTIC web-platform. DTC Network is based on a PA8 (EUSDR) initiative targeting to develop a transnational network of Innovation and Technology Transfer centers that facilitates and accelerates the knowledge circulation between academic and economic environments and fosters the transnational knowledge sharing in the Danube Region. Being in development, DTCN already has 10 centers in 8 countries of the macro region and met a strong need for tools to support its activity. The focus is on the mapping and matching of the knowledge needs and existing knowledge potential, which is necessary both for ITT activities and for macro-regional transnational cooperation, but the DTCN has similar developments in the works concerning a training platform (elearning system) and mobile solutions for ITT specialists.

Realizing the wide utility of such a tool, DTC Cluj-Napoca has started with own resources to develop the Transnational Innovation Network, a web instrument intended to support the acquisition of the mentioned information in a wide database having adequate interfaces, security and processing tools. TIN reached a demonstrator stage between 2014 and 2016, in an in-house project lead by Prof. Sorin Popescu and staffed by Assoc.prof. Mihai Dragomir, PhD student Ștefan Bodi and programmer MEng. Marcel Beldean. TIN contributed to the mapping the knowledge potential of competence centers working in specific fields of the Danube Strategy (environment, energy, water, etc.) as well as the knowledge needs existing in companies (especially SMEs) and has facilitated an accelerated knowledge transfer for: cooperation within projects, innovation support and vocational training.

In order to make the results of the project available for the entire DTC network and their partners, considerably advancing their innovation and technology transfer support capabilities within their home areas and also transnationally, the TIN portal was included within the scope of the Interreg-Danube Transnational Program project “Made in Danube”. With continued effort from members of the DTC network and with the involvement of the targeted stakeholders, the instrument grew to provide considerable opportunities for collaboration between industry and academia, thus contributing to the knowledge-based competitiveness of the Danube Region. It is now used in the Danube Region by ITT centers, companies, research centers and institutions that need information about the existing knowledge needs & potential as well as about the availability of partners in a certain field. This far exceeds the DTC Network utilization, supporting the fast identification in the Danube Region of the organizations, groups and persons connected with knowledge creation, transfer and utilization and that may have a relevant cooperation within a certain local, regional or transnational initiative.

The demonstrator TIN portal (prepared before the project on a voluntary basis, with limited functionality) was adapted to the specific, the objectives and the requirements of the Made in Danube project and transformed into the Danube Transnational Innovation Cooperation (DTIC) e-tool. In the following we will present the main features of the platform

based on the Factsheet of the project output no. 4.2 submitted to the Joint secretariat of the programme. We must note that the development has been oriented to making the DTIC adequate for the use of actors in the field of bio-economy as part of their sustainability approaches in line with the latest trends in the field set forth by the EU (see figure 3.3).

Fig. 3.3 - The link between bio-economy and sustainability (European Commission, 2012)

The current functionality and features of the DTIC e-Tool (available here http://www.muri.utcluj.ro/tin-etool/index.php?page=login) include the following elements:

- Account creation for any users
- User management options
- Profile administration options
- A new partnership option to create groups
- A new notification system similar to social media platforms
- New detailed and precise geographical identification
- Graphical map visualization and tree structure
- New bio-economy specific section with information from the project and Local Action Pilot description
- New section for registering developed products and services by LAPs
- Extended user records including photo gallery
- Extended privacy settings from fully private to fully public
- Extended searching and matching possibilities

- Data stream integration from three public European sources
- Integration with other project tools developed by the partners
- Completely new module for bio-economy with project activity integration
- Completely new audio and chat communication tool with community approach
- A fully functional project management system for ITT
- A detailed help and contextual system
- Implemented legal provisions for data protection and licensing
- Open access implementation for interested developers
- Implementation of modern web programming technologies
- Improved file structure and better security
- Mobile device accessibility and responsiveness
- New server and software support architecture

The DTIC platform is available to all potential stakeholders of the project within the Danube Region and the bio-economy field. The foreseen dissemination is to start with the project consortium members and then their collaborators within and outside of the project and to move outwards in concentric circles for the future use of the e-tool. Any company, university, research institution, technology transfer office, public authority or other stakeholder in the area will have the possibility to access the tool and create profile, offers or requests for knowledge. Based on these and on their partnership and confidentiality preferences they will have the capability to initiate new partnerships, projects, and contracts. These collaborations can be made either for research, innovation, product development or capacity building purposes.

The transnational impact is the main advantage of the DTIC e-tool and will be facilitated by its functions and the dissemination and communication activities of the Made in Danube project. The DTIC e-tool covers the entire geographical are of the Danube Region. Being an online instrument, it can be used by ay stakeholder in this zone. There are no physical limitations and the instrument has been designed to foster collaboration in the region and impact the speed and effectiveness of cooperation in a significant way. In the beginning the countries involved in the project through partners will be involved, but the results can be transferred for the entire Danube Region. Direct technology transfer can take place more easily between knowledge providers and generators and knowledge users, for the benefit of markets and consumers. Also, consortiums and projects based on shared interested and complementary competences can be established in a more direct way, allowing the users of the platform to be more competitive when applying for financing and working upon innovative product ideas. The time to market should become shorter and the adequacy of the matching of partners is intended to improve also.

The e-tool will be fully functional and extended with new modules by the end of the Made in Danube project. Its future sustainability is part of the sustainability strategy of the entire consortium. The plan is to keep using and expanding its capabilities. Institutional sustainability will be ensured by the DTC network that will keep administering and promoting the platform,

while financial sustainability will be ensured through continued use of its facilities for setting up and managing new financing projects and direct contracts between users. Due to its focalization on bio-economy, the potential results that will be obtained by using this platform will be at the forefront of the new economy of the EU and will contribute to a better cohesion between East and West, within the Danube Region. Innovative products and services, project consortium and other types of collaboration will be established with more ease and will produce better and faster results through the use of the system, thus supporting social and economic development in the respective countries.

The following section briefly describes the main capabilities of the DTIC e-Tool, which can also be tested online at any time in real work conditions. In the figure below one can see the main login screen, containing or pointing to, beside the usual fields for ID, password and new account creation, also important other information such as: the Interreg-DTP financing program, the "Made in Danube" copyright notice and links to its webpage and social media pages, and the Creative Commons license conditions for third party developers, which have to provide "attribution" to the consortium, must use the platform code in a "no commercial" way and must "share alike" their own work based on it.

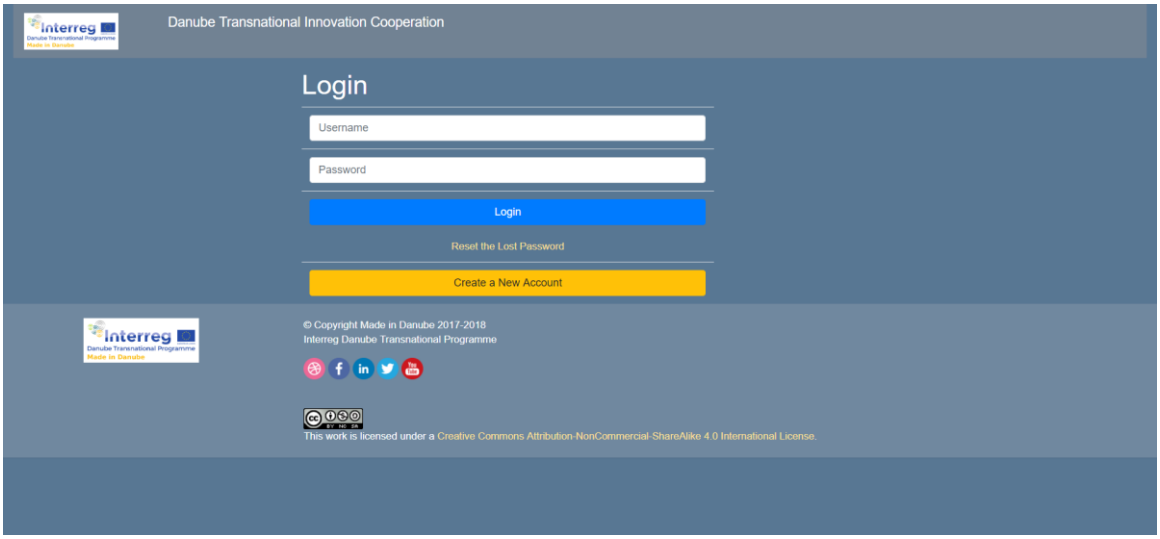


Fig. 3.4 - DTIC login screen

The next image presents the main screen of the e-Tool, which can be accessed immediately after login. The main feature here is the dynamic map of Europe on which the cities are highlighted from where organizations are using the portal. Also, the first three menu options, with multiple functionalities in their turn, are visible: own account and profile administration, access to help and support and the three possible options for giving open access to the code of the platform. The last one was a specific conditions of obtaining public European funds for supporting the development of the platform. Also, the provisions for privacy are visible in the form of a page accessible from the main one.

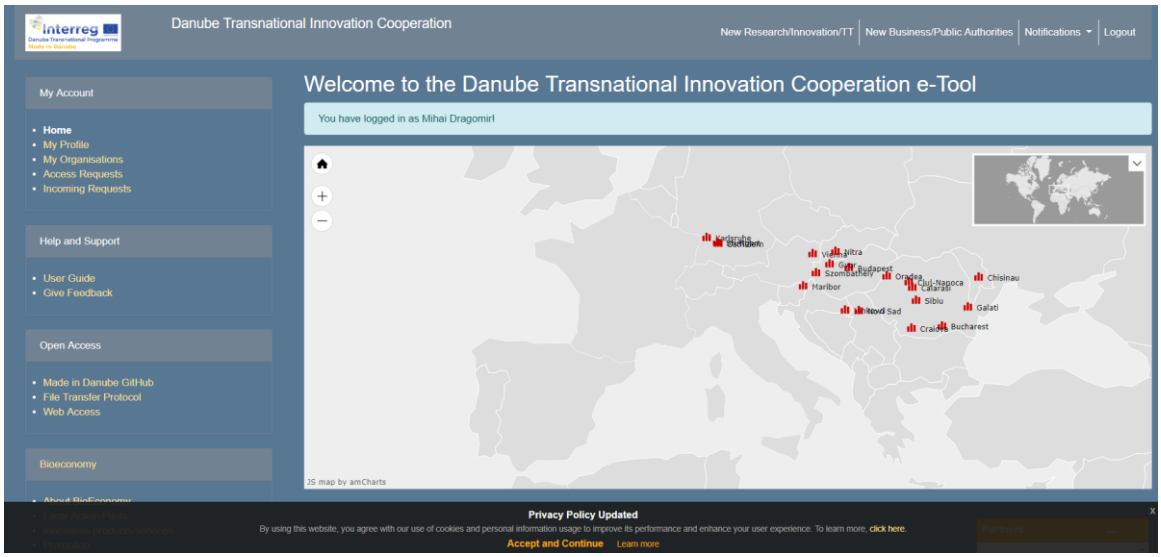


Fig. 3.4 - Main interface of the e-Tool

The platform is built around the mapping and matching concept mentioned already. Users create profiles and then have the option to add one or more organizations or organizational units in one of two categories: research and innovation providers and businesses or public authorities as beneficiaries of technology transfer. Each type can add information about the organization, previous experiences and results, and offers or request for collaboration in direct contracts or project consortia. Figure 3.5 shows the first screen that comes up for adding organizational data on the side of knowledge providers.

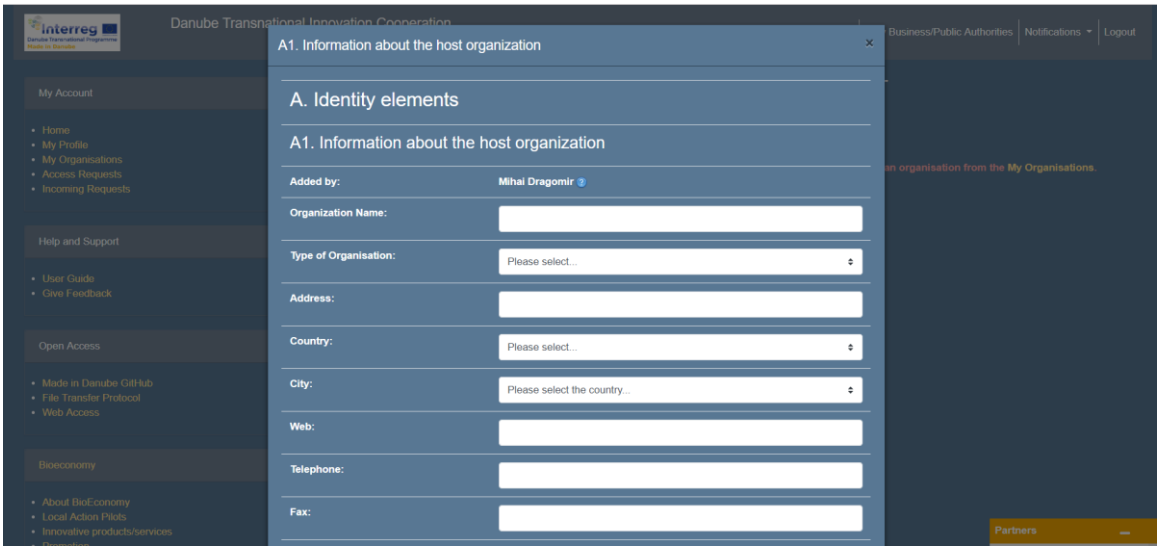


Fig. 3.5 - Adding a research unit in the platform

Once their data is saved in the confidential and encrypted database (the organizations having control upon what is visible to others), the organizations of the users can be searched for and "matched" based on standardized keywords relating to their interests (figure 3.6).

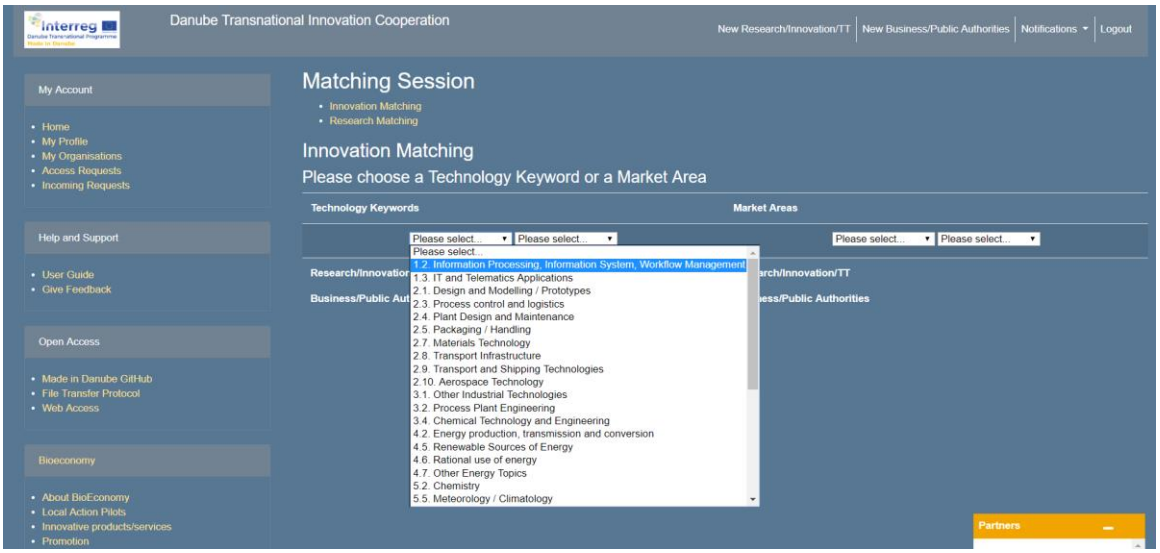


Fig. 3.6 - The function for innovation matching of providers and beneficiaries

A special module has been dedicated to bio-economy per the needs of the project. It provides general and project specific information and it permits the documentation of the project results (innovative products or services) in a database, as well as their promotion on the web through customer relevant information and a QR code for mobile usage (figure 3.7).

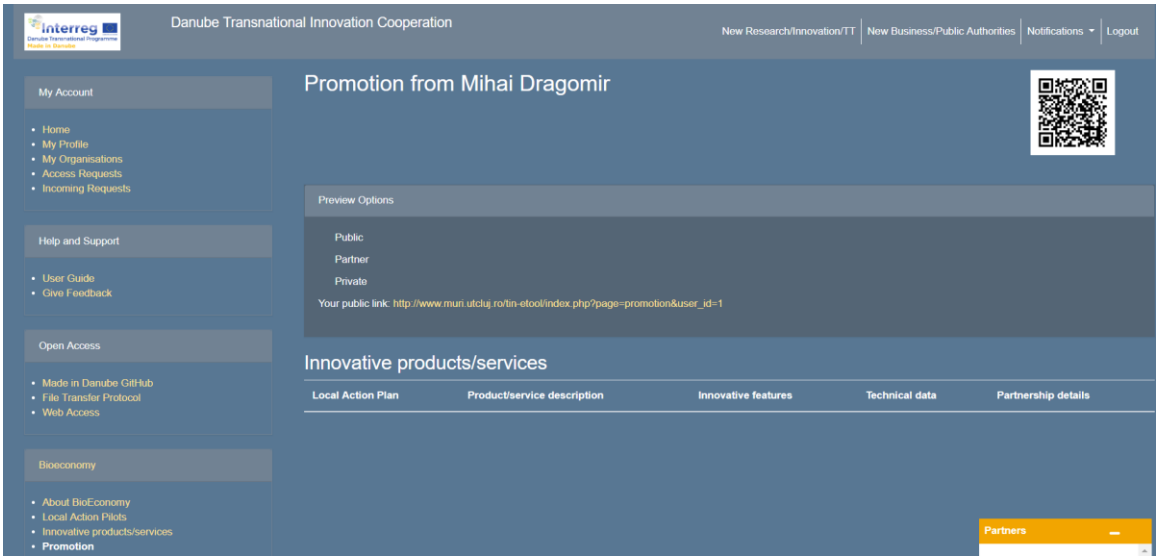


Fig. 3.7 - Generating the promotional page for an innovative result

Another module specifically created within “Made in Danube” is a tool for communication designed to work within the platform and facilitate communication among matched users to develop their partnership. It has the capability to host peer to peer exchange of information in the form of audio and text. It works in tandem with the chat feature which is also visible in figure 3.8 (bottom right corner).

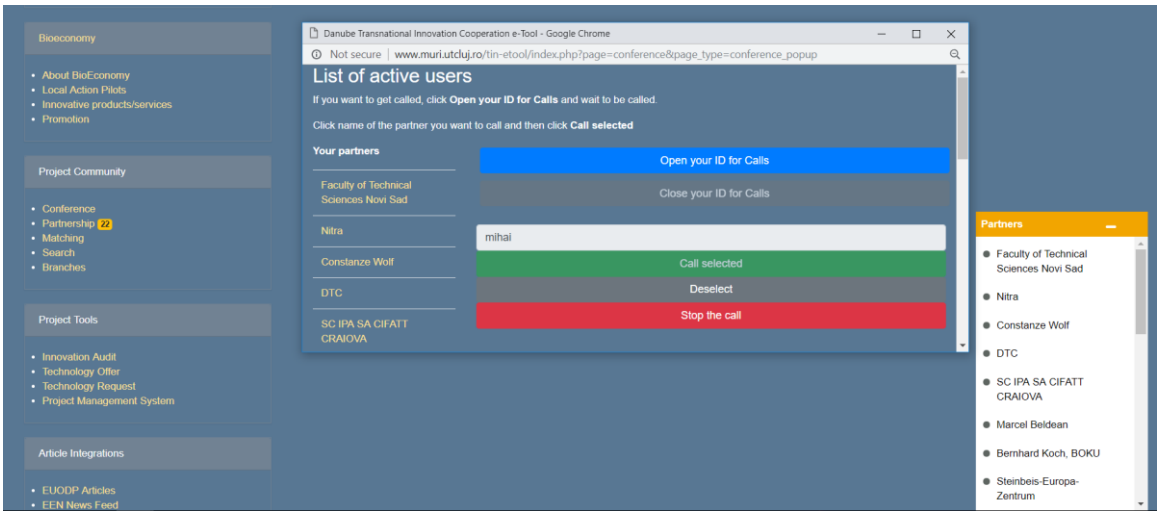


Fig. 3.7 - Generating the promotional page for an innovative result

The third specially designed module is a project management systems, run separately, but integrated within the DTIC platform. The screen in figure 3.8 displays the Add project screen, which is the start for creating a new project in the dashboard of the system. The tool has the capability to manage tasks, priorities, and milestones, to create Gantt charts and to perform resource administration, including emailing the members of the project team. Also, there is a dedicated function to document the results of the project for future creation of deliverables. It is designed to be useful for the platform users, especially when used in conjunction with the tools already presented above.

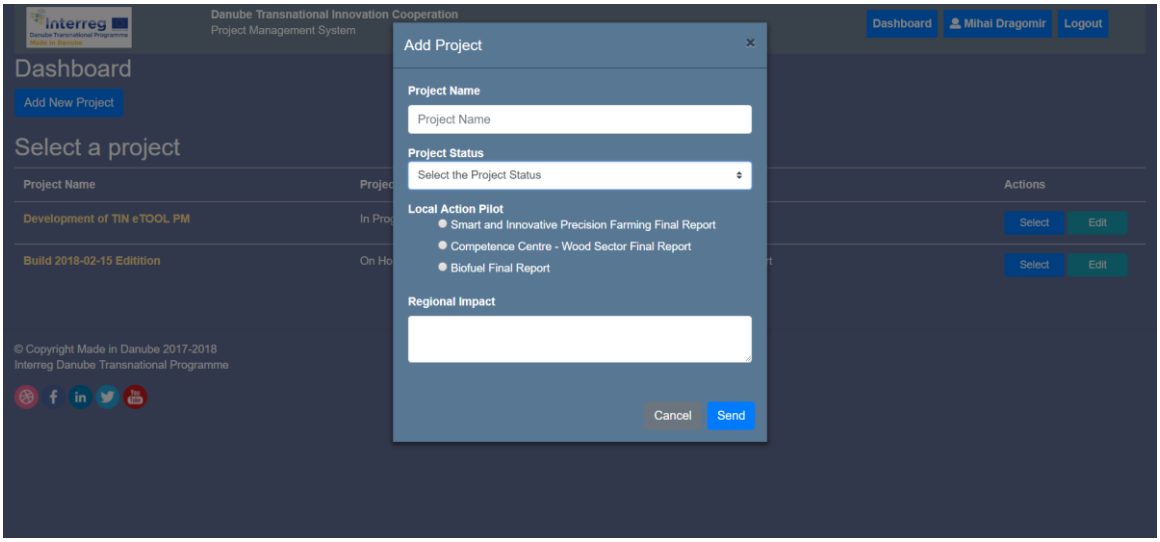


Fig. 3.8 - The project management system for ITT collaborations

In order to keep the DTIC users up to date with relevant information to the field of bio-economy, a feature has been implemented to connect with and display three data streams from free of charge European sources. In this way, information is continually added to the platform

that might help them in their efforts to find new partners and develop collaborations to solve the challenges they are confronted with. The figure below presents the news coming in from the EU Open Data Portal.

Fig. 3.9 - Data stream available within the platform

The DTIC platform is in full promotional process, and the number of users is growing. Its development will continue during the sustainability phase of the "Made in Danube" project and after that, in line with the stakeholders' interest.

3.2 Digital humanities and interactive culture

3.2.1 Contributions

Category	Involvement and obtained results
Academic experience	**Editorial team** member of the Journal of Ancient History and Archaeology in charge with journal indexing (since 2015) **Member of the scientific committee**: IETEC & BRCEBE, Sibiu, 2015 & 2017, 12th CMT Bielsko-Biala, 2016 Invited talk **VR/AR for All: Applications from Product Development to Cultural Heritage and Beyond.** Lehigh University, Bethlehem, Pennsylvania, USA. Co-authors: Călin Neamţu, Radu Comes (2017).
Practical experience	2010 MMM Autoparts SRL Turda, **Consultancy and assistance for designing and implementing the environmental management system**, Member of the project team
Supporting projects	2018-2020 Romanian Government, Executive Unit for Financing RDI, National Research Plan III, 53PCCDI/2018, **The elaboration of complex methodologies for the attribution and authentication of medieval and premodern paintings from the national patrimony**, Member of the research team of P1 and P3 component projects 2014-2016 Romanian Government, Executive Unit for Financing RDI, National Research Plan II, PN-II-PT-PCCA-2013-4-1882, **The multi-disciplinary evaluation of imperial gates from churches from the XV-XIX centuries in order to conserve and restore them through classical and digital methods for ensuring community viability - ASTERCRIG**, Member of the project team
Research articles	C. Neamțu, V.C. Măruțoiu, I. Bratu, O.F. Măruțoiu, C. Măruțoiu, I. Chirilă, **M. Dragomir**, D. Popescu, **Multidisciplinary Investigation of the Imperial Gates of the 17th Century Wooden Church in Sălișca, Cluj County, Romania**, Sustainability, vol. 10, issue 5, 2018, ISSN 2071-1050, Q2 quartile O.F. Măruțoiu, I. Bratu, C. Măruțoiu, D.L. Postolache, **M. Dragomir**, C. Tănăselia, S. Garabagiu, **Scientific investigations of the Imperial Gates from the Petrindu wooden church, Sălaj County, Romania**, X-Ray Spectrometry, 2018, volume 47, pp. 176-185, Q3 quartile Călin Neamţu, **Dragomir Mihai**, Răzvan Mateescu, Paul Pupeză, **Dacians in the virtual era**, International Colloquium from Târgu-Mureș: Iron Age Rites and Rituals in the Carpathian Basin, 7-9 October 2011, invited paper
Teaching materials	**Information session** "Cultural heritage projects - international financing sources and opportunities for collaboration" (in Romanian) (with Diana Dragomir) during the International Symposium 3D Technology and Cultural Heritage, 5-6 August 2016, Cluj-Napoca

3.2.2 Case studies and results

Concept for cultural heritage interactivity

Archaeological exploration has always been a meticulous and work-intensive process, that involved access to difficult archaeological sites, timely availability of experts and considerable care in labeling, handling and transporting artifacts, in order to produce accurate results that obey the historical truth and offer the possibility for scientists to study real and

complex issues about previous civilizations, while at the same time giving the general public the feel of being „immersed" in the life of the past. Traditionally, engineering was not one of the disciplines that was called very often to the aid of historians when exploring various sites, only maybe in instances where the mechanisms of realizing monumental buildings were under scrutiny. However, in the past 10-15 years, the great speed of development in the fields of 3D scanning, 3D printing, virtual reality (VR), augmented reality (AR) and other related fields, have brought engineering solutions closer to archaeological research, offering the possibility to recreate precise and exciting virtual worlds that can be explored and studied over the Internet.

The approach of this case study is based on the principles of the „Digital Agenda for Europe" (European Commission, 2010a) and "Europe 2020 Flagship Initiative - Innovation Union" (European Commission, 2010b), overseen by the European Commission, and intends to develop an instrument for supporting innovation and collaboration in digital cultural environments. The envisioned system will use an augmented reality head mounted display (ARHMD) as a communication tool, as a remote assistance instrument using virtual colocation and as a means for data acquisition. Many of the existing applications in the field of AR are dedicated to one idea in particular or are made „just for fun". Current developments in the field of AR for archaeology include the following systems and solutions:

- MixAR is reported by (Narciso, et al., 2015) to focus on visualization of archaeological sites by achieving a mixed reality of the physical environment with digital reconstructed elements;
- Venus, presented by (Haydar, et al., 2011), is dedicated to submerged sites, has achieved demonstrator stage and proposes a set of exploration tools;
- a smartphone app that enhances the value of the information provided by a site presentation brochure with 3D models, which is described by (Battini, 2015);
- the open ARFA approach for employing mobile technologies to help generate and use augmented reality scenarios, presented by (Deliyiannis & Papaioannou, 2014).

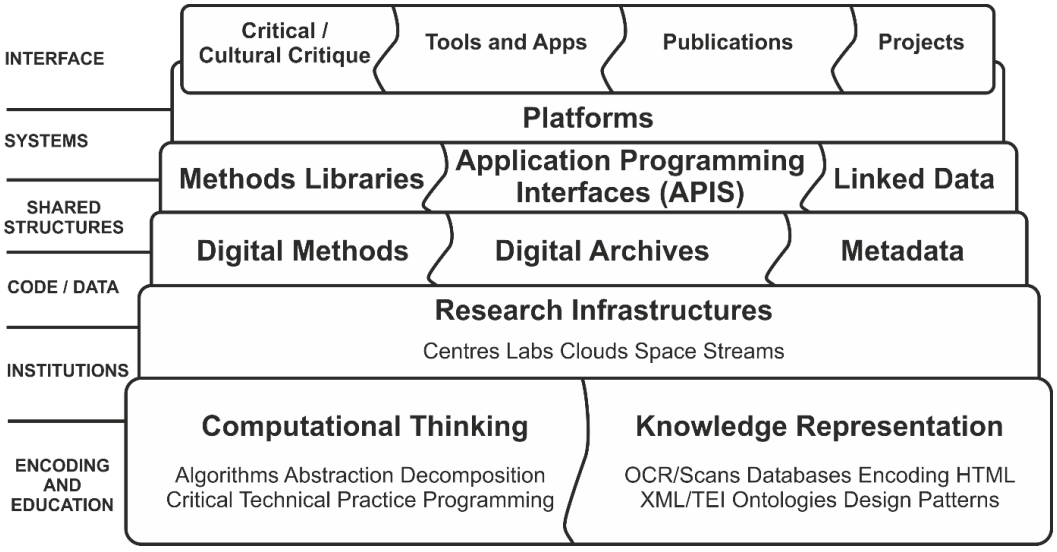


Fig. 3.10 - Digital humanities approach - "The Stack" (Berry & Fagerjord, 2017, p. 18)

Like most initiatives in the field of digital humanities, this approach also tries to take into account changes and development at the levels of intervention required for success in the field (see "The Stack" of Berry & Fagerjord in figure 3.10): interface philosophy, digital platform, apps/tools, data management, institutional support and impact.

We can identify among the limitations of research and innovation in this field, the limited number of implementations and the relatively small-scale demonstrators attempted so far. Most publications in the field agree upon the potential and opportunities that AR technology brings to archeological exploration, but the road from conceptual development to viable practical implementations is a complex one. Most of these contributions propose limited ways of interacting with the created reality and the focus is mostly on its entertainment and novelty value, not on its capability to support scientific research. The proposed approach will add upon these functions tools specific for the scientists in the field, sensor capabilities and access to a growing knowledge base which could help both the researchers and the tourists interested in using this system. The user will be able to interact with the environment in real time and in a collaborative way, he or she will be able to exchange information using voice, video, 3D and other formats. The remote assistance in archaeology achieves a different level of complexity compared to existing solutions, by using ARHMD in combination with the web platform and a Knowledge Sharing System. Using 3D models on ARHMD, the user will be able to interact directly with the content for playing, learning or research.

The main goal of the team I am part of is to promote access to digital archaeological resources through the development of applications and tools for the use of scientific collections, archives, museums, libraries and archaeological sites. This research undertaking is aimed at developing and demonstrating a new and original instrument for making archaeological sites more enriched and attractive for both the scientists and the general public. In order to achieve this, a complex hardware-software system for virtual HMD based interaction with cultural heritage has been conceived, as a communication system for dynamic interaction with archaeological sites.

A considerable amount of time and expenses could be saved when performing archaeological work and the results of the expeditions could be of higher quality (with less errors and imprecisions) and more transparent (factoring in the implication of the public). It is our belief that a continuous scientific dialogue could mean quicker and better debates upon important topics, which would bring to light new discoveries of significance for our common past. Also, the process of scientific publishing would get a boost, as the ideas and interpretations proposed will have been already peer reviewed in some way. Moreover, the system is a demonstration of a powerful new technology that will allow scientists, and people in general, to bring closer their creativity and motivation and work together to achieve new and significant results in any domain of life.

Beside its obvious attraction for non-expert users, the system will allow archaeologist to greatly improve the quality and quantity of the work they perform on-site. The ability to connect

with experts from across the country or the continent will determine the meeting of scientific challenges encountered in the field with the proper experts, at the proper time, and with the possibility of continued feedback. This will permit the testing of various hypothesis online, the avoidance of mistakes or misinterpretations and will reduce the cost of bringing experts to the dig site. The three digital archaeology tools included will further this demarche even when expert knowledge might not be available at one or the other of the ends of the communication system. More persons could serve as explorer with minimal training if they are able to quickly digitize, properly tag and catalogue artefacts and monuments and if they can situate them in context on an accurate geographical and historical map. Coupled with access to video-recordings and stored VR-AR simulations from the knowledge base, this will significantly extend the capability to contribute to the advancement of archaeological research.

Such a system will be used as a tool for three main areas of interest:

- **scientific research in cultural heritage** area: A user (in situ specialist) that is equipped with a mobile augmented reality system wants to visit an archaeological site. In real time he can access the HUB Knowledge Sharing system and receive information on particular areas of the site or artefacts discovered. He will be able to view the reconstructed models of the various components from the site. In the same time, using an instrument from the HUB service systems, with his consent, he will be able to contribute to the site documentation by transmitting images and video recordings. Meanwhile, other user (remote expert), that have a multimedia streaming connection with the former one, and that is equipped with a VR setup and may share a virtual replica of the accessed real historical site with other remote experts, may assist the former user in his experience by giving him hints/annotations, by asking him to obtain supplementary in situ information. In this mixed environment, several hypotheses may be validated (or not) and thus, the research activities' results may be disseminated for scientific community, or for the public.
- **learning area**: Massive open online course - MOOCs. The system prototype includes support for online courses through open access (via the web), for virtually unlimited (theoretically) participation of remote learners. The remote learners will benefit from all the capabilities the system provides, with respect to the accessibility, tools and visualization of digital content in the archaeology and cultural domain. To facilitate such a system feature, a special focus will be on the design of system modules that implement the best means for easy integration with existent MOOCs systems.
- **edutainment area:** This kind of application, that can be used with the help of the augmented reality (mobile) device (ARHMD, tablets/smartphones or even desktop) could allow the development of some guided virtual tours through any museum or archaeological site and the information could be shown in real time on the (mobile) device's display and correlated with the surrounding environment by processing the data collected from the positioning sensors incorporated into the (mobile) devices.

The HUB (Open web platform) is an innovative technological platform that introduces the augmented virtual colocation concept as a main instrument of collaboration in archaeological exploration. Augmented virtual colocation is a concept similar to the one used in IT&C (for describing the virtualization of systems) and supposes the connection of two or more points using specific augmented reality hardware equipment (see chapter 2.1.2 for a practical implementation). Thus, using a pair of the latest augmented reality glasses (ARHMD), that use the Android operating system and a wide range of sensors, like VGA camera, GPS, Gyroscope, Accelerometer and Microphone, a real-time communication system will be created, with the help of images and sounds acquired from the sensors that are incorporated into the glasses.

Using ARHMD (Augmented Reality Head Mounted Display) and smart devices (phones and tablets) a new way for communication and interaction with digital cultural content will be developed with capability for real time interaction in dynamic environments. The system developed in the project will facilitate the interaction between people and between people and a knowledge database with cultural heritage content using mobile devices connected to the internet. There are many producers of ARHMD on the world market and each of them announced and launched some applications, but our project is the first that intends to use them as an integrated part of one complex system. The proposed system will use ARHMD as part of a communication tool, as a remote assistance tool using virtual co-location and as tool for data acquisition. More of the existing applications for ARHMD are dedicated to displaying information such as messages, navigation system or movies, we intend to overpass this barrier in an innovative way.

As such, the user will be able to interact in real time in a collaborative way, he or she will be able to exchange information using voice, video, 3D and other formats using the web platform. The remote assistance in cultural heritage achieves another level of complexity compared to present solutions, by using ARHMD in combination with web platform and Knowledge Sharing System. Using 3D models on ARHMD, the user will be able to interact in a group directly with the content for playing, learning or research activity.

Based on the proposed concept, developed a team together with Lect. Radu Comes and Prof. Călin Neamțu, the two colleagues proceeded further with detailed design and prototype execution, and published their results with support from a POSSCCE project for innovative plastic parts development that could be manufactured by companies from Cluj-Napoca to become more competitive on international markets (Fig. 3.11).

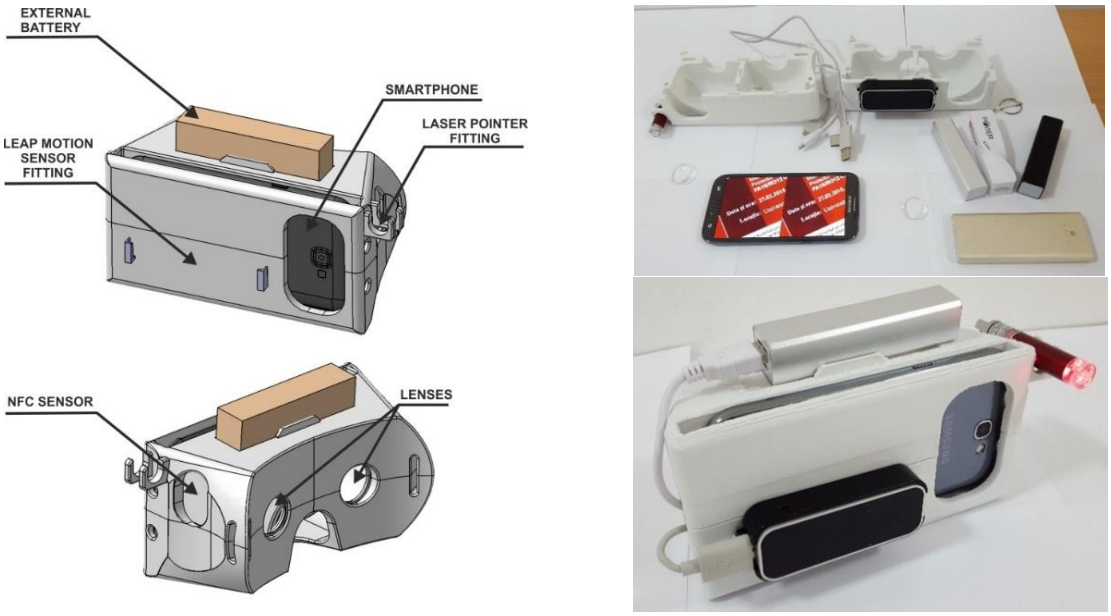


Fig. 3.11 - Design and prototype of the ARHMD device (Comes & Neamţu, 2015)

Additionally, the involvement of high-tech solutions, such as 3D content and sensor data, will bring about a new, more detailed, way of representing and analyzing archaeological findings, meaning that discoveries and conclusions will be closer to the former historical realities.

The system is not necessarily oriented towards a specific market, but it is rather a contribution to the development of the European identity and in this way it provides a social service which is hard to evaluate in monetary terms. We can say in this case, that the project was focused on delivering a form of social innovation, considering that the system is a "means to an end" for the scientists in this field and, at the same time, it is a thrilling way of spending time and learning for any citizen of Europe, and especially the children.

Technical support for digital humanities and interdisciplinary perspectives

Better solutions in the domain of cultural heritage digitization are needed all the time as digitalization and enhanced interaction of the user and the virtual objects constitute some of the best modern ways not only to save the significant pieces for future generations and make them universally available via the internet, but also to present them in their original form and location, thus enabling perfected restauration projects and advanced historical research, which might otherwise not be possible due to the lack of historical information or the fragility and estimated value of the studied objects. Romanian cultural patrimony will be better protected and safeguarded if fast and accurate solutions to digitize 3D artifacts (ranging from jewelry, to pottery, to buildings and sculptures and even to entire citadels) could be studied by more researchers from all over the world and if the general public (from Romania, Europe and across the globe) can see them virtually and then come to the country for a more in-depth look, which also stimulates tourism and can bring about new business and development models for the communities that host such places (e.g. virtual-real tour operators, customized souvenir shops, digitally enhanced museum or related infrastructure development).

The current demarche is focused on the sharing of good practices related to the impact of the digital world upon the quality, precision and availability of restored, reconstructed and virtualized cultural heritage, which is an emerging and valuable field of interest for creating a sense of European identity. Successful developments in this area require a multi-disciplinary approach that involves historians, cultural experts, engineers, media specialists, programmers and many more.

The solutions for scanning and 3D processing of cloud points are complementary to the virtual/augmented reality visualization and contextualization solutions. Together, future initiatives could yield improved techniques and technologies for interacting with patrimony objects. In his way, the ideas developed will have an increased degree of innovativeness, as well as managerial maturity, which will increase their chances of being selected for financing in the future. From a scientific and technical point of view, the topic under current consideration will deal with the software, hardware and methodology elements necessary to achieve precise item reconstruction within the constraints of a given location and time.

The main benefits of such a system will be its ability to provide new ways of doing two important things:

- on site research, analysis and assessment, by combining the "hands on" approach with access to existing knowledge and even, peer review, thus ensuring better interpretations and wider, interdisciplinary, approaches for art and cultural pieces;
- interaction between the European citizens and their culture, by removing or diminishing the need to travel long distances to places that might be hard to access in order to experience it and by providing a higher level of excitement and connectivity in exploring their heritage and present contributions.

The use of technology in the field of humanities, be it related to cultural heritage preservation, increasing public accessibility, or to studying and understanding issues related to archaeology, visual and plastic arts or even anthropology is deeply connected and dependent upon interdisciplinary integration both with the host domains and with the expectations of the academics and the public. I have so far had the opportunity to work in projects related to digitally reconstructing the past which has brought me in contact with historian, archaeologists and other enthusiasts like numismatists, cultural experts and mountaineers, as well as in projects related to religious and laic art, which has brought me in contacts with theologians, chemists, physicists, restoration experts and ethnographers. Some of the examples of how work from these fields can be integrated with digitalization, reverse engineering and 3D modeling for VR or AR are presented below, based on publications I have co-authored (Fig. 3.12-3.14).

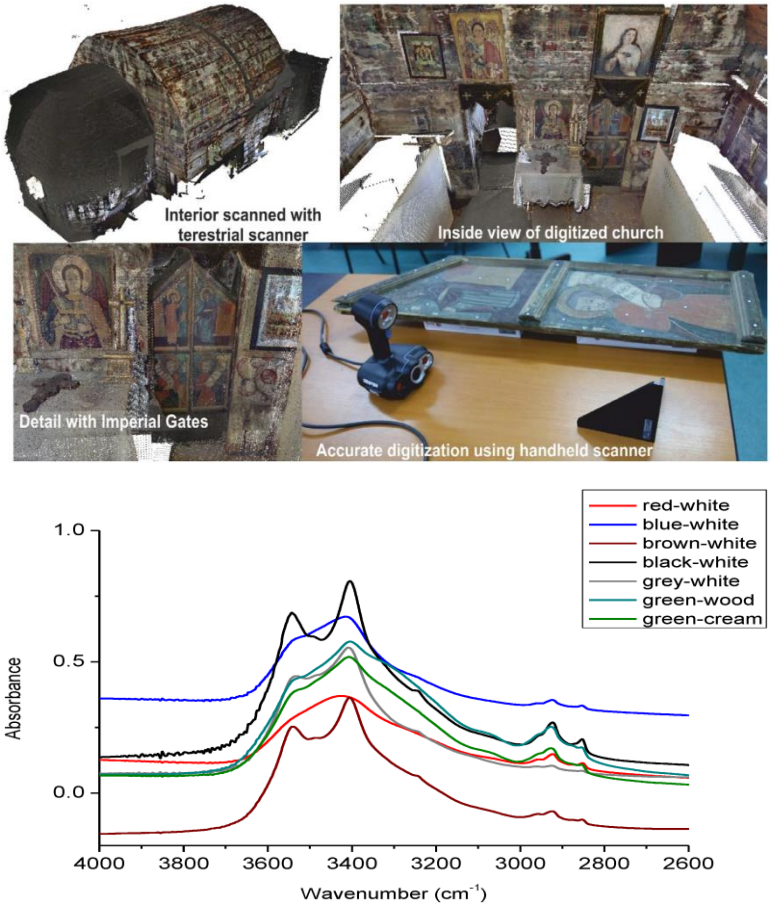


Fig. 3.12 - Combining 3D scans and spectroscopy (Neamtu, et al., 2018)

The figure above presents the way in which scientific collaboration contributed to the analyzing the status of deteriorated wood painted imperial gates and then to their restoration in the real and virtual environments.

	XRF		mg/kg (ppm)	Fe	Cu	As	Hg	Pb
A	Red border	Set I (3 segment doors)	Right side	1,100	<LOD	11,400	21,000	57,000
B	Green border	Set I (3 segment doors)	Right side	1,700	38,700	24,000	LOD*	200
C	Red middle	Set I (3 segment doors)	Right side	9,300	50	100	20	70
D	Green middle	Set I (3 segment doors)	Right side	700	13,000	8,500	100	100
E	Black	Set I (3 segment doors)	Right side	1,700	50	400	400	400

Fig. 3.13 - Using x-ray fluorescence to support digital restoration (Marutoiu, et al., 2018)

In Fig. 3.13, it is observable how the results of x-ray fluorescence, combined with spectroscopy, scanning and image processing, has been used to support a digital restoration and dissemination project.

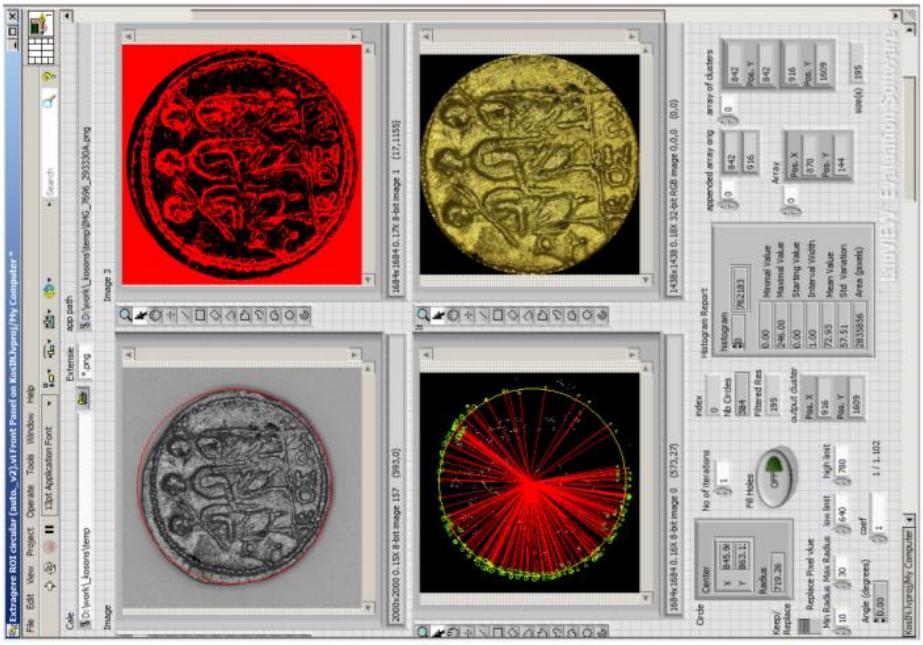


Fig. 3.14 - Combining image processing and numismatic analysis (Tompa, et al., 2017)

In the last figure, one can observe the way in which engineering analyses in the form of image processing and numismatic interpretation are used for determining the characteristics and historical context of ancient coins.

The field of digital humanities open up a very interesting and diverse world where engineering knowledge and the preoccupations for sustainability of culture and history in the very fast-paced modern society, can come together to deliver innovative solutions and new ways of experiencing the creative greatness of the human spirit. It is also a domain that provides multiple directions for studies and research and as such is very adequate for new PhD students and their academic pursuits that I intend to mentor.

4. ACADEMIC CAREER DEVELOPMENT

Developing on the long-term the didactic component requires that some exploratory directions explorers are be followed by the entire team, as greater impact means more uncertainty that must be tackled collectively. In this regard I will propose the development of new study programs that are required by the economic environment and the long-term goals of the university. Within these projects, we could develop new curricula, new educational content, new platforms for electronic learning and new partnerships for educational purposes (e.g. for offering double degrees), as well as new ways of combining teaching-learning with industry practice etc.

From a teaching practice point of view, I intend in the coming years to focus on advancing the teaching materials in my area to a new level of complexity and practicality. Concerning the teaching methods, the discipline group industrial engineering is highly practical and for this reason for effective transmission of knowledge close relations with companies in the area are critical. Some of the possible aspects I will try to work upon are: use of mobile and internet enabled learning, use of simulation games and software, the implementation of the concept of a „flipped course" that I have seen in the US. To address these issues, I will make use of the contacts with industry to develop collaborative framework agreements, especially with big companies in the area. I will also pursue attracting and involving domain-specific actors in the educational process of (e.g. professional associations), as well as alumni of the existing study programs.

I believe that high-tech industries (aerospace, automotive, internet-of-things, bio/nano-tech, etc.) form one of the most dynamic and demanding economic sectors in terms of production engineering and are important for both teaching and research. A number of close collaborations with companies in these industries helped me to understand their applied know-how needs and the challenges they face to be successful in the long run while at the same time seamlessly integrating in the community and environment. In my view, the ability to control and continuously improve all processes, but mostly development, design and production processes, constitutes the main competitiveness factor for these companies. Effective and efficient processes, with low variability and high productivity can ensure their success with respect to price, time-to-market and product performance. Among the defining characteristics of these industries, that I aim to study in order to develop possible answers about interchangeable business and engineering methods, I can mention the following aspects:

- High level of requirements pertaining to quality, reliability and safety for products and processes, many times the companies competing on a global level, directly or indirectly;
- The production processes are very well defined and controlled through managerial and technical methods and means (Statistical process control, Measurement system analysis, Gauge R&R, 8D problem solving, APQP, PPAP, Business plans, Supply chain management, etc.);

- High production volumes with intensive resource and energy uses, and with the need to conform to strict environmental and occupational health and safety regulations;
- Lean Six Sigma, Kaizen or similar approaches are implemented to reduce the volume and the cost of non-conformities and to eliminate waste, scrap and variability.

These research challenges are important and currently interesting for the scientists working in this domain, as a brief literature overview can show. For example, (Müller & Pfleger, 2014) argue that the push towards integrating sustainability into the strategic demarche of a company should take the form of a relentless and replicable process driven by the values of the company and its possible economic impacts. Initiating this process and carrying it to maturity are issues that are also discusses by the mentioned authors, together with a decision-making model for selecting the best actions to take.

Even closer to industrial themes, in the article published by (Chen, et al., 2012) there is proposed a model to integrate in the factory planning process, the interfaces between sustainability issues and the physical components of the future factory, which can be considered one of the possible approaches to take sustainability into consideration since the earliest conceptual stages for product and process development. The authors (Eastwood & Haapala, 2015) demonstrate the use of a methodology for evaluating product sustainability through the impact generated within the processes that are required for creating that product, thus enabling the study of alternative designs. Similarly, (Hallsted, et al., 2015) put forward a complex method for sustainability evaluation in the incipient stages of new product development that combines the customer perspective with the social aspects and the ecological assessment. An interesting outlook can also be gained by studying the various reported studies that deal with certain industries and/or countries and the challenges and results obtained when tackling the issues of sustainability from a process or organizational perspective: e.g. forest products industry in Finland (Husgafvel, et al., 2013), gold mining industry in the United States (Finnie, et al., 2009), automotive industry (Mayyas, et al., 2012), etc.

The main axis for research that I propose aims towards assessing the collaboration potential for adapting the design and production processes in high-tech manufacturing industries to the complex requirements of the market, such as:

- How to optimize the products/processes for obtaining low scrap rates at high production volumes?
- What are the means and the ways to intervene within the processes to reduce or eliminate negative environmental impact (less waste, less raw materials, less energy consumption)?
- How can one intervene upon processes to ensure a working environment with a high degree of employee safety, health and satisfaction (high ergonomics, few incidents / accidents)?
- What is the specific difference among companies operating in Japan and companies operating in Romania in terms of practices, relation with the authorities, and relation

with the social setting and organizational culture and how these aspects influence their performances?

The research demarche will target four main stages in an international and industrially relevant framework that values competitiveness through sustainability:

1. Determination and quantification of the main issues or opportunities for sustainability related improvements in high-tech industrial companies. If possible, preference will be given to automotive and aerospace companies to ensure the proper understanding of the relevant issues and the determination of the specific differences generated by each industrial branch.
2. Modelling and simulation using 3D simulation tools and conceptual process simulation tools of these situations and studying them in detail to uncover practical mechanisms of competitiveness through sustainability within the studied industries. On the computer models, various successful scenarios can be tested for customization through successive runs.
3. Develop appropriate solutions for transferring the lessons learned, using tools of competitive engineering, quality engineering, environmental engineering and risk management and customize their implementation for application in Romania. The primary focus will be on adapting the main tools used for these tasks, namely Quality Function Deployment and Failure Modes and Effects Analysis, and the main models used in process improvement, namely ISO 9001/9004 and Lean Six Sigma, to the specific needs of the high-tech industries.
4. Validation (using the Delphi method and similar approaches) within the experts' community of the host institution and partner companies, as well as on-line with the experts and partners back home. The applications and case studies developed at the previous step will be assessed using face to face interviews as well as online instruments, to perfect and develop them, with the final aim of publishing the results for making them available to both scientists and industrial specialists.

The challenges brought by these issues are complex and fluid in nature, and possible solutions will harmoniously combine specific engineering elements (production engineering, statistical process control, design of experiments, tools and techniques for competitive development), management systems elements (standardized management systems and related mechanisms, life cycle management of products / processes / technologies, knowledge management) in an approach that will be supported also by software tools (available at the home and the host universities). The results of the research demarche presented above are projected to include the following usable and publishable elements:

- methods / best practices for the reorganization of processes in terms of resources involved and activities performed,
- developments of existing instruments (e.g. extensions of the FMEA and QFD methods) used in product and process management,

- specific adaptations of consecrated process improvement methodologies (ISO 9001/9004, Lean Six Sigma),
- recommendations for public policies to support the industrial development of Romanian companies, that can be partners for European and US companies, on their road to excellence in manufacturing.

I believe this direction will ensure consistent publication and patenting patterns and significant impact in the industrial environment for myself and the future team of young researchers I intend to build as PhD advisor. A very important component of my research work will be the strategy for the dissemination of results. I propose a plan focused on the following coordinates rapid presentation of interim results and working concepts at international conferences, to ensure their visibility and contribute to the development of their maturity; publication of the final results of research in journals with indexing in Scopus, IEEE, INSPEC or other similar databases, making them available to a broad audience and increasing their chances to be known and cited; publication of exceptional of results or research in journals indexed and ranked by Clarivate Analytics reaching high impact factors, for a consistent international presence and visibility of my host institution. In order to ensure international prestige, and national applicability of the results, I propose a plan focused on the following coordinates:

- rapid presentation of interim results and working concepts at international conferences with Thomson Reuters CPCI (ISI Proceedings) indexing, to ensure their visibility and contribute to their maturity development; I may also consider for this category conferences that have partnered with different scientific journals, which allow for the evolution and development of ideas between the successive stages of evaluation;
- publication of the final results of research in journals with indexing in Scopus, IEEE, INSPEC or other similar databases, making them available to a broad audience and increasing their chances to be known and cited;
- publication of exceptional of results or research / studies in journals indexed and ranked by Thomson Reuters reaching impact factors as high as possible, for a consistent presence in the international scientific world and visibility of my host institution;
- publication of the aggregate results of research conducted over several years in more specialized books, preferably at prestigious publishing houses.

Due to the possible innovation potential of working in industrial engineering, an important factor for the development of the activity will be the recognition of contributions by patenting activity outcomes, nationally, or internationally. In this way, scientific results obtained will be applied directly by partner companies and the collective contribution of the undersigned and the team I belong to will be duly recognized. Also, I consider to be very important, particularly for establishing a bridge between academia and society and for the university prestige, the activity of organizing internationally recognized scientific events (conferences, workshops, trainings, etc.), as well as the integration of the team I will lead into

networks and professional associations of academic or industrial nature, individually or institutionally, for permanent contact with the latest developments in the field in which we operate and for increased international visibility.

Starting from these goals, through close collaboration in the work team, with a careful balance between experience and enthusiasm, I believe that I can contribute to a successful future for the school I am part of and for its older or newer members.

5. CONCLUSIONS

By analyzing the body of work presented, as well as the proposals for future developments, we can conclude that there is a great potential for research and educational results in the field of Engineering and Management. Also, if we frame this within the large context of changes that appear in the capabilities and uses of engineering and managerial tools in a multitude of fields (from bio-based industries to space exploration and from nano-manufacturing to data science), it becomes even more apparent that there is a significant need for highly trained people, and for habilitated professors to train them, for investment in state-of-the-art research infrastructure and for improved academic management approaches. I express the expectation that my contributions so far, as described in this thesis, are a valid reason to consider that I can do even more by leading a team of young researchers, by advising PhD students and by approaching challenging and useful research topics that are both interesting for publication and readily implementable in Romania.

Due to the opportunities that have appeared during my career so far, I think I have managed to establish a complex and diverse professional profile, that covers many of the topics which are included in the field Engineering and Management, both in Romania and abroad: quality engineering and management, industrial metrology and 3D scanning, Computer Aided Design (and in general, Computer Aided Engineering), technology transfer and innovation management and support, product development and process improvement. Of course, there are also wider connections in my research output to environmental engineering and management and digital archaeology and humanities, as well as considerable experience in project management and research and educational management. However, since there are many other topics to cover (e.g. optimization, scheduling, logistics, manufacturing technologies, etc.), I believe I have managed to constrain my interests into the areas that are relevant for the area that the Technical University of Cluj-Napoca serves, and I intend to focus even better if I should be given the opportunity to become a PhD advisor. Excellence level competence in recognition in a field is usually associated with how narrow it is, and the three active research direction mentioned in Chapter 3 should provide enough opportunities to construct a solid base and coach new researchers for immediate and decisive needs of the industrial sector. Moreover, the connections among them allow for the possibility to achieve inter-disciplinarily fast in order to access prestigious scientific outlet, journals and conferences.

As the three previous directions mentioned are already rather mature, most of the activity and knowledge developed for them can move it the educational area and into the professional side of improving management practices in companies and universities and research labs. That is not to say that interesting research can’t still be performed for these axes, but the global economic and technological trends will favor developments that can lead quickly to new competitive ventures that are able to employ smart and innovative processes to generate

likewise products in fields that are deeply connected to the needs of the environment and the society and make massive use of digital technologies. By creating proficient entrepreneurs, with a healthy appreciation for risk-taking and interested to achieve harmony with the surrounding world and solve some of the challenges of rapid human expansion and development, out mission as educators and our institution's mission as a higher education provider will be successfully adapted to the needs of the future.

This develop plan must be permanently correlated with the strategies of the university and department that I belong to, as well as with the opportunities, especially financing opportunities and human resources selection and training, that exist in Romania, the EU or even further. Also, an important role in creating the adequate fundament for the research vision will be the need to align my future team's work with the trends and policies that are promoted on an international scale. In my case, I am fortunate to already be in contact or working with some of the most relevant international networks in the area of engineering and management: the Danube Transfer Center Network (in its turn connected with the Steinbeis Network of Technology Transfer Centers), the Fraunhofer Network (through its Fraunhofer IAO Joint Office with TUCN), the International Foundation for Production Research and The European Organization for Quality (through the Romanian Association for Quality). By working with the professionals belonging to these organizations and by getting involved in their initiatives and projects, I am confident I will be capable to integrate my work and the work of my future team of PhD students into the mainstream of research preoccupations in Engineering and Management. In the same line, I would like to mention some very good bilateral collaborations with renowned institutions that can be further international contact points: Vienna University of Technology, University of Rochester, University of Pittsburgh, Lehigh University, University of Oslo, Kiev Polytechnic Institute, University of Bielsko-Biala, Adnan Menderes University, etc.

In end I would like to express my commitment to make all the presented elements work together, as harmonious as possible, and to put my energy, my creativity and my experience in the services of this demarche. I hope I will be able to look back after some years and be glad that I had the opportunity to focus my career with the help of this habilitation thesis.

6. SUMMARY OF CONTRIBUTIONS

The main scientific contributions of the author since the award of the PhD title in 2010 and presents in the current work can be summarized as follows:

- Project leadership for the FP7 project "NoGAP"
- Project leadership for the POSCCE Furniture cluster R& project
- Project leadership for the Interreg-DTP Danube Chance 2.0 project
- Involvement in project teams and management as mentioned for each chapter
- Publication of 12 ISI papers (7 in journals with impact factor, 3 in the Q2 quartile, the so-called "yellow" zone)
- Publication of 1 book and 1 chapter in international publishing houses
- Contribution to the development of the ARCs colocation system
- Contribution to the development of the HoPE smart hospital bed
- Coordination of the innovation team for smart furniture
- Co-authorship of 4 innovative furniture patent applications
- Developing an advanced quality and process management system for R&D
- Coordinating an innovation audit program in renewable energy in EaP countries
- Participation in the Fulbright-RAF scholarship for technical entrepreneurship
- Analysis and proposal for developing the I&E ecosystem around TUCN
- Contribution to the development of the ITT support Danube Transnational Innovation Cooperation platform for the Danube Region
- Conceptual and methodological support, as well as practical implementations and experimental research, for cultural heritage digitization and digital humanities

These contributions, validated by the academic community nationally and internationally, are completed by an extensive work in the educational area to help in the training of over 200 quality engineering and management specialists, as well as direct consultancy and assistance for over 20 companies. I have also had a major commitment and involvement in the institutional development of TUCN in the form of support for the development of Danube Transfer Innovation and technology Transfer Centre, the leadership of the University Management Department and the executive coordination (under the responsible vice-rector, Prof.dr.ing. Daniela Popescu) of the process for preparing the 2018 external accreditation by ARACIS (Agenția Română pentru Asigurarea Calității în Învățământul Superior – Romanian Agency for Quality Assurance in Higher Education), which was finalized with the "High degree of trust" qualification for the next 5 years.

7. BIBLIOGRAPHY

Adepu, S. & Khandelwa, M., 2018. Broad-spectrum antimicrobial activity of bacterial cellulose silver nanocomposites with sustained release. *Journal of Materials Science*, 53(3), p. 1596–1609.

Battini, C., 2015. *Augmented Reality applied to the archaeological site. A case study in Palazzo Baldini, Florence.* Vienna, Museen der Stadt Wien – Stadtarchäologie, pp. 1-9.

Bauer, J. M. et al., 2015. Telepresence in Education. *IFAC-PapersOnLine*, 48(24), pp. 178-182.

Berry, D. M. & Fagerjord, A., 2017. *Digital Humanities: Knowledge and Critique in a Digital Age.* s.l.:Polity Press.

Chen, D., Heyer, S., Seliger, G. & Kjellberg, T., 2012. Integrating sustainability within the factory planning process. *CIRP Annals - Manufacturing Technology*, 61(1), pp. 463-466.

Comes, R. & Neamţu, C., 2015. Design a low-cost eyewear display adapted to additive manufacturing. *Acta Technica Napocensis - Series: Applied mathematics, Mechanics and Engineering*, 58(4), pp. 563-566.

Deliyiannis, I. & Papaioannou, G., 2014. Augmented reality for archaeological environments on mobile devices: a novel open framework. *Mediterranean Archaeology and Archaeometry*, 14(4), pp. 1-10.

Dragomir, M., 2016a. *Furniture - from tradition to the internet of things.* Cluj-Napoca: s.n.

Dragomir, M., 2016b. *Best practices in RDI in the furniture industry in the North-Western Region*, Oradea: s.n.

Dragomir, M., Bodi, Ș., Iamandi, O. & Dragomir, D., 2014. *Applying SigmaFlow Simulation Software for Improving the Quality of an R&D Project.* Cluj-Napoca, UTPress, pp. 143-147.

Dragomir, M., Popescu, S., Buna, Z. & Zăbală, I., 2016. *Enhanced hospital bed with smart functions.* Cluj-Napoca, UTPRESS, pp. 317-320.

Eastwood, M. D. & Haapala, K. R., 2015. A unit process model based methodology to assist product sustainability assessment during design for manufacturing. *Journal of Cleaner Production*, 108(Part A), pp. 54-64.

European Commission, 2010a. *A Digital Agenda for Europe*, Brussels: s.n.

European Commission, 2010b. *Europe 2020 Flagship Initiative*, Brussels: s.n.

European Commission, 2012. *The Bioeconomy Strategy*, Brussels: s.n.

Finnie, B., Stuart, J., Gibson, L. & Zabriskie, F., 2009. Balancing environmental and industry sustainability: A case study of the US gold mining industry. *Journal of Environmental Management,* 90(12), pp. 3690-3699.

Frota, M. N. & Finkelstein, L., 2013. Thoughts on the education in measurement and instrumentation: A review of requirements. *Measurement,* 46(8), pp. 2978-2982.

GE Power Conversion, n.d. *More than 20,000 MW of installed capacity worldwide.* [Online] Available at: http://www.gepowerconversion.com/product-solutions/induction-motors/large-mv-induction-motors
[Accessed 20 November 2016].

Ghersi, I., Mariño, M. & Teresita, M., 2018. Smart medical beds in patient-care environments of the twenty-first century: a state-of-art survey. *BMC medical informatics and decision making,* 18(1), p. 63.

Gröschl, A. et al., 2015. Measures of Improvement MUVoT, a Blended Learning Course on the Topic of Measurement Uncertainty for Advanced Vocational Training. *Procedia CIRP,* Volume 27, pp. 111-116.

Hallsted, S. I., Bertoni, M. & Isaksson, O., 2015. Assessing sustainability and value of manufacturing processes: a case in the aerospace industry. *Journal of Cleaner Production,* 108(Part A), pp. 169-182.

Haydar, M. et al., 2011. Virtual and augmented reality for cultural computing and heritage: a case study of virtual exploration of underwater archaeological sites. *Virtual Reality,* 15(4), pp. 311-327.

Husgafvel, R., Watkins, G., Linkosalmi, L. & Dahl, O., 2013. Review of sustainability management initiatives within Finnish forest products industry companies—Translating Eu level steering into proactive initiatives. *Resources, Conservation and Recycling,* Volume 76, pp. 1-11.

IUCN Water Knowledge Platform, 2013. *The Water-Energy-Food Security Nexus.* [Online] Available at: http://cmsdata.iucn.org/downloads/nexus_graphic.pdf
[Accessed 31 August 2018].

Jurca, F., Martis, C., Birou, I. & Biro, K., 2008. *Analysis of a Claw-Pole Synchronous Machine for Wind Power Conversion Module.* Vilamoura, Portugal, s.n., pp. 1116-1121.

L'Abbate, A., Fulli, G., Starr, F. & Peteves, S. D., 2008. *Distributed Power Generation in Europe: technical issues for further integration,* Loxembourg: European Commission, JRC, Institute for energy.

Luvata, n.d. *Air Unit Heaters / Air Unit Coolers.* [Online]
Available at: http://www.luvata.com/Products/Heat-Transfer-Solutions/Air-Unit-Heaters-Air-

Unit-Coolers/
[Accessed 2016 29 May].

Maresca, P., Gómez, E., Caja, J. & Barajas, C., 2013. Virtual Environment for the Simulation of a Horizontal Coordinate Measuring Machine in the Teaching of Dimensional Metrology. *Procedia Engineering,* Volume 63, pp. 234-242.

Marutoiu, O. F. et al., 2018. Scientific investigations of the Imperial Gates from the Petrindu wooden church, Salaj County, Romania. *X-Ray Spectrometry,* 47(2), pp. 176-185.

Mayyas, A., Qattawi, A., Omar, M. & Shan, D., 2012. Design for sustainability in automotive industry: A comprehensive review. *Renewable and Sustainable Energy Reviews,* 16(4), pp. 1845-1862.

Müller, A.-L. & Pfleger, R., 2014. Business transformation towards sustainability. *Business Research,* 7(2), pp. 313-350.

Narciso, D. et al., 2015. MixAR Mobile Prototype: Visualizing Virtually Reconstructed Ancient Structures In Situ. *Procedia Computer Science,* Volume 64, pp. 852-861.

Neamtu, C. et al., 2012. Training In Coordinate Measurement Using 3D Virtual Instruments. *Measurement,* 45(10), pp. 2346-2358.

Neamtu, C. et al., 2018. Multidisciplinary Investigation of the Imperial Gates of the 17th Century Wooden Church in Sălișca, Cluj County, Romania. *Sustainability,* 10(5), p. 1503.

Neamtu, C., Popescu, S., Bere, P. & Comes, R., 2016. Innovative mechanical structure for hospital bed folding using a single actuator. *Acta Technica Napocensis - Series: Applied mathematics, mechanics and engineering,* 59(4), pp. 365-368.

Okabe, H. et al., 2003. Development and Performance Evaluation of High-reliability Turbine Generator. *Hitachi Review*, 52(2).

Parker Hannifin, 2011. *White paper - Cooling High Performance, Wind Turbine Systems,* s.l.: s.n.

Plowucha, W. et al., 2014. *Geometrical Product Specification and Verification as toolbox to meet up-to-date technical requirements.* Bielsko-Biala, Poland, s.n.

Polikarpova, M. et al., 2011. Thermal design and analysis of a direct-water cooled direct drive permanent magnet synchronous generator for high-power wind turbine application. *Renewable Energy & Power Quality Journal,* 1(9), pp. 992-997.

Popescu, D., Neamtu, C. & Racasan, R., 2009. *Course on measurement uncertainty developed in an international consortium.* Sibiu, Romania, s.n., pp. 359-362.

Porter, M. E. & Heppelmann, J. E., 2014. How Smart, Connected Products Are Transforming Competition. *Harvard Business Review,* November, 92(11), pp. 64-88.

Smith, D. J., 2002. Adequate Cooling of Generators is Essential. *Power Engineering*, 1 September.

SolidCreativity, n.d. *TRIZ40.* [Online]
Available at: http://www.triz40.com/TRIZ_GB.php
[Accessed August 2018].

spherikaccelerator.com, n.d. *Spherik Accelerator Program.* [Online]
Available at: https://spherikaccelerator.com/
[Accessed 3 November 2017].

Technical University of Cluj-Napoca, 2016. *Strategic plan 2016-2020,* Cluj-Napoca: s.n.

tetapolis.com, n.d. *TETAPOLIS Science and Technology Park.* [Online]
Available at: tetapolis.com
[Accessed 23 October 2017].

Tompa, V., Dragomir, M., Hurgoiu, D. & Neamtu, C., 2017. *Image processing used for the recognition and classification of coin-type ancient artifacts.* Rochester, NY, IEEE.

VDL Klima, n.d. *VDL Klima - Strength through cooperation.* [Online]
Available at: http://www.vdlklima.com/?page/4522282/Profile.aspx
[Accessed 2017 October 22].

Werner, T. & Weckenmann, A., 2012. Sustainable quality assurance by assuring competence of employees. *Measurement,* 45(6), pp. 1534-1539.